PLATE I.

THE "PENNSYLVANIA LIMITED" AT FULL SPEED.

THE RAILWAYS
OF
THE WORLD

BY

ERNEST PROTHEROE

AUTHOR OF
"THE ILLUSTRATED NATURAL HISTORY OF THE WORLD"
"EVERY BOY'S BOOK OF RAILWAYS AND STEAMSHIPS"
"IN EMPIRE'S CAUSE," ETC. ETC.

WITH 16 *COLOURED PLATES AND* 419 *ILLUSTRATIONS FROM PHOTOGRAPHS IN THE TEXT*

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PREFACE

The history of railways is one long record of courage, determination, and energy untiringly expended in vanquishing difficulties. The locomotive engine in appearance and purpose is more obvious than, for example, a steamship's propelling machinery. It is at once the visible embodiment of strength and speed ; it strikingly represents a great force that has rendered enormous service in the civilisation of the world, vitalising human affairs, and bringing untold benefits and joys to mankind.

Even those who have no knowledge of the technicalities of locomotive design are interested in the railway engine ; it seizes upon the fanciful mind of a child, and its appeal grows rather than lessens with the passing years, because the adult mind better grasps the far-reaching utility of a contrivance that has contributed more to happiness than any other invention. Nor has the advent of electric traction robbed the steam locomotive of any of its fascination. An electric train, with its comparative silence and smoothness, somehow appeals less to the imagination than one headed by a throbbing, panting monster, which seems alive in hauling its load against time.

It is sometimes urged against a book of this character, that necessarily it must get speedily out of date, but the same objection holds good in practically every department of human activity. Railway progress never ceases ; the old ever gives place to the new. Even while this work has been in preparation important projects have been completed and others commenced. There have been notable changes in the personnel of various large railway systems : honours have come to some officials, while others have been signalled to their rest—but the railways, being an integral part of the national life, go on without a pause.

Of the statistics quoted, generally none are older than the end of the decade 1910 ; but in any case the figures are chiefly for comparative purposes, and have been selected to illuminate particular points. Readers in search of the latest statistics always can consult the various annuals, of which *The Railway Year Book* is an excellent example.

Naturally the author has gleaned information from a variety of authentic sources; in the case of British railways the facts and figures, as set forth, have been revised by the various railway authorities concerned; and thanks are tendered to many officials, too numerous to mention, who have given useful aid with the subject-matter and illustrations. The coloured plates are by Mr. F. Moore, whose name is a sufficient guarantee of their accuracy. The illustrations in the text, as far as possible, cover every phase of normal railway working. They have been supplied largely by the railway companies themselves; those on pages 9, 13, 24, and 32 are taken from the Catalogue of the Mechanical Engineering Collection at South Kensington by permission of the Controller of His Majesty's Stationery Office; and most of the remaining photographs have been supplied by the Locomotive Publishing Company, and in this direction thanks are due particularly to Mr. A. R. Bell; while Mr. Walter J. Bell has rendered immense assistance in bringing expert knowledge to bear upon the proof sheets. Every effort has been made to ensure accuracy, but it is too much to expect that no error has crept in among so many pages packed with details.

It is hoped that the volume will stimulate not only the interest of boys in a subject that adds as much to general as specific knowledge, but that adults will find in its pages much useful information for consideration and reflection.

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CHAPTER I

INTRODUCTION

THERE is no more interesting subject for reflection and speculation than the manner in which man has dealt with his world heritage during the passage of the heaped-up ages. Originally man was condemned to labour as a curse, but surely his long tally of triumphs, fresh benefactions for the world, suggest that the punishment has been converted into reward.

Clamorous Labour knocks with its hundred hands at "the golden gate of the morning." It has knocked almost from the beginning of time, and will not cease until time shall be no more. In all the records of human achievements since the world began, it is labour that stands out pre-eminently, since it is by the persistent work of busy brains and active fingers that civilisation has grown from a puny infancy to vigorous maturity, ensuring ever-increasing comforts for the human race.

It was said of old that "many shall run to and fro, and knowledge shall be increased," and it is both interesting and profitable to consider some notable ways in which the ancient prophecy has been fulfilled. Man in himself is inferior to many of the beasts in strength and speed, but, thanks to his intellect, he learnt to subdue some of them into his service. It was certainly a great step in human progress when the horse was first used as a pack animal. A horse's tractive power is far superior to its weight-carrying capabilities, and consequently in the course of time there came into use sledges and litters for the transport of heavier loads.

The invention of the wheel as applied to vehicles was the commencement of a new era in the history of mankind, although doubtless their prime purpose was for use in war.

Wheeled carriages, or chariots, were in use in Egypt in very remote times. The small body, as a rule, would not hold more than two persons standing upright; and their size and comparative lightness enabled them to be driven at a great speed. Ancient sculptures, unearthed in Nineveh and Babylon, show that these vehicles were also used for hunting, as well as for warlike operations.

ASSYRIAN CHARIOT

A Persian war chariot was of more elaborate construction. The body was turreted, so that several men could shoot or throw darts from it, and sharp blades were affixed to the wheels, by means of which tremendous execution was worked amid the closely packed foe, when the vehicles dashed through them ; and other nations copied this death-dealing feature.

The Romans used chariots less for war than for driving contests in the arena. Eventually they were adapted for the conveyance of of persons in state, and gradually came into favour with the nobility and gentry ; but the crowded streets of the city of Rome forbade their use, except between sunrise and sunset.

The ancient Britons possessed chariots of marked difference in design, being open at the front instead of the back ; the pole was long and broad, and thus, when necessary, the driver could take his stand nearer the heads of the horses. A vehicle that was in common use in Britain, Gaul, and various northern countries was the *carpentum*, a two-wheeled carriage covered with an arched or a sloping roof, which was used by females of high distinction, sometimes drawn by mules and more rarely by oxen. Such vehicles were largely employed as baggage wagons in warfare, and when in camp they formed an exceedingly useful line of defence.

In process of time wheeled vehicles improved, but under the feudal system their use for the carriage of men was discountenanced, as conducing to their unfitness for military service ; and even the clergy were advised by their superiors to leave carriages to the use of womenkind.

In all probability the Earl of Rutland, in 1555, was the first to possess any vehicle approaching the modern carriage, either in appearance or utility ; Queen Mary had one constructed a year later ; and in 1564 Queen Elizabeth for the first time rode in a state coach. They were lumbering, heavy-wheeled vehicles, the bodies suspended by long straps to four corner posts erected upon the under carriage.

During the latter part of the seventeenth century the suspension straps gave place to steel springs in order to decrease the vibration, which enabled the dead weight of the carriage to be lessened considerably, reducing the draught for the horses, and enabling a faster speed to be achieved. Only a few years later Obadiah Elliott obtained a patent for a coach body hanging upon elliptical springs, for which the Society of Arts awarded him a gold medal.

The first public carriage, or hackney coach, for hire made its appearance in London in 1625, and by 1650 there were at least three hundred such vehicles in use in the city, although there had been an attempt to limit their number to fifty. Of early coaches

LORD MAYOR'S STATE COACH (18TH CENTURY)

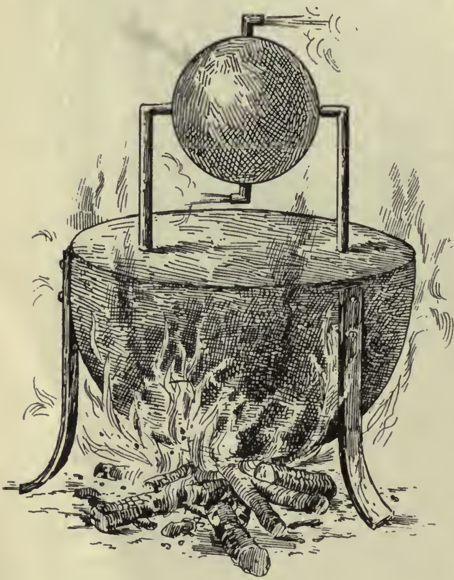
still in existence that possess historical interest, the two best known are the King's State Coach, which was completed in 1761, and the Lord Mayor of London's coach, which is three or four years older. In the case of the latter, the body of the vehicle is still hung on leather straps.

Stage coaches commenced running from London to such distant places as York and Exeter in 1673. A journey to Oxford, only 58 miles, occupied a couple of days; to Exeter, 168 miles, more than double the time was sacrificed; while a journey to Edinburgh could not be accomplished in less than a fortnight. Nowadays we can travel from London to Oxford in 70 minutes, to Exeter in 3 hours, and to Edinburgh in less than 8 hours.

The coaching business grew wonderfully; in 1820 over threescore coaches entered and left Brighton every day; and all the great highways were traversed by vehicles that kept astonishingly good time, except in bad weather; but at the best the average speed of a stage coach did not exceed eight miles an hour. Nevertheless the old-time prophecy was being verified, not only in our own country, but in all parts of the world. Wheels were quickening life, increasing the volume of trade, and contributing in no small degree to general happiness.

Of all inventions ever conceived by man, the steam-engine is incomparably the greatest ; the history of its slow development, the gradual improvements that had their birth in expensive mistakes, sum up a romantic story without parallel in all the records of human ingenuity and perseverance.

The power of steam was known to the ancients certainly as far back as a couple of centuries before the Christian era. Hero of Alexandria experimented with the application of heat to produce motion. He constructed various machines, which produced blasts of vapour that were utilised in opening the doors of the Egyptian temple.



ÆOLIPILE (150 B.C.)

The Romans had more than dim notions of the elements required to make a steam-engine, but they never gave themselves up to an ardent pursuit of the solution of the problem. The Greeks contrived an apparatus known as a whirling æolipile. From a closed boiler rose two columns, the upper ends being bent toward each other to form trunnions, between which was suspended a hollow sphere, from which proceeded in the line of its axis two short tubes, whose ends were bent in opposite directions. By means of one of the columns, which was hollow, steam passed into the sphere to which a revolving motion was imparted by the reaction of the steam as it passed out of the bent tubes. These crude engines were used in various simple mechanical operations that came within the scope of their limited capacity, but ages later their best service was for turning spits, chiefly in monasteries.

In olden times any subject that baffled the understanding was attributed to diabolic agency. The Egyptian priests utilised their knowledge of the properties of steam to impose upon their superstitious followers with various pretended miracles, and some of the pagan priests of the Middle Ages were equally unscrupulous.

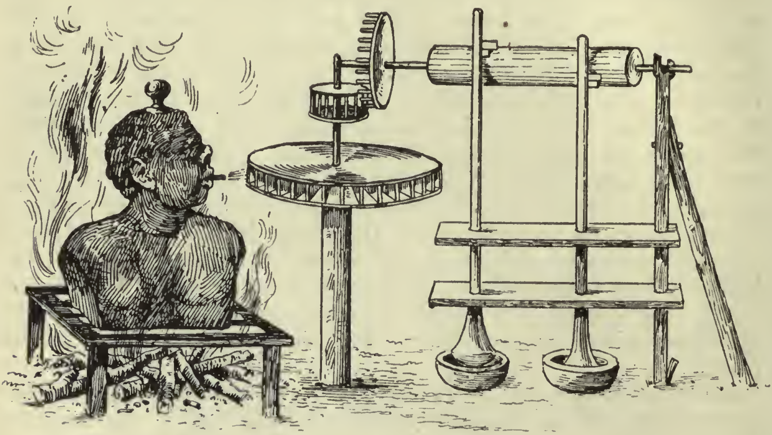
Busterich, a notable German god, often impressed evildoers with remarkable manifestations of his displeasure. Little did the worshippers imagine that the demonstrations were carefully planned by the priests. The figure of the god was a metal casting, the head being left hollow for the reception of water, which could be heated by a cleverly concealed apparatus. The eyes, which were movable, were well plugged, as was an aperture in the forehead of the image. The priests were able to judge to a nicety when the steam was approaching bursting point; and the worshippers were ushered into the sacred court just as the head could no longer restrain the steam, which violently expelled the plugs with a thunderous noise and enveloped the image in a white cloud, as if the deity refused to allow the delinquents to gaze upon him. The ignorant and superstitious worshippers were stricken with abject terror, only too glad to make their peace with the awesome god by liberal gifts, which went to swell the coffers of the ingenious priests.

Although steam was recognised as a great natural force whose power might be harnessed to render useful service to mankind, little advance was made in experiments during the course of hundreds of years. A period of mental darkness settled down upon the world, during which warfare more or less occupied the energies of man, whose inventive faculties were directed to the production of weapons for the destruction of human life, rather than seeking for the means of improving the conditions of existence.

In the year 1543 we find Blasco de Garay experimenting with a steamboat in Barcelona harbour in the presence of Charles V; and although it is impossible to supply details, there appears to be no doubt that the *Trinidad*, as the vessel was named, moved at the rate of three miles an hour by means of revolving wheels, which derived their motion from a "kettle of boiling water." Nevertheless, the invention does not appear to have been followed up, and certainly the Spaniards can claim no further credit for advancing steam navigation.

About the year 1628 Giovanni Branca invented a steam-engine that possessed indubitable points of practicable utility. The illustration speaks for itself and renders lengthy description unnecessary. The boiler, heated on a brazier, was constructed in the form of the body of a negro, from whose mouth proceeded a blast of steam, directed against vanes set on the periphery of a wheel, just as the wind acts upon the sail vanes of a mill, or water upon the buckets of a water-wheel. By means of toothed wheels and pinions motion was communicated to stampers, and the inventor also adapted the apparatus to the pumping of water.

In Branca's engine was more than the dawn of an idea, that only needed development to have caused engine construction to have proceeded upon very different lines to those eventually adopted, and that resulted in the invention of the reciprocating steam-engine in which the motion is alternately backward and



BRANCA'S ENGINE (1629)

forward, or up and down, as evidenced in the action of a piston-rod. In the year 1884 the invention of Parsons' steam turbine aroused world-wide interest. The original engine made 18,000 revolutions per minute; yet it is but a development of Branca's invention, whose principal defect was the lack of means to make the steam follow the vanes or pallets, and thus extract more of its energy.

Raising water by means of air pressure was described by Hero, but in later times experimenters devoted their energies to achieve the same purpose by the power of steam, which was confined in a vessel and then condensed, thus forming a vacuum, which would suck up water a distance of at least thirty feet, and, by the adoption of lifts, a very much greater distance.

Among modern philosophers the Marquis of Worcester occupied a foremost place. He spent time and a fortune chiefly in attempting to perfect a crude steam-pump, and in 1656 he had a "fire-waterwork" in action at Vauxhall, which raised a column of water to a height of forty feet; and a few years later Sir Samuel Morland was pumping water from the Thames to the top of Windsor Castle; but the most that can be claimed for either of these inventors is that they paved the road of progress with ideas on steam, which other men would fructify into real and lasting utility.

Christian Huyghens, a Dutch professor, in 1680 described a gas-engine in which were a cylinder and piston, a real epoch-marking invention. The air was expelled from the cylinder by a charge of gunpowder, and as the gas cooled, the pressure of the atmosphere caused the piston to descend. The engine was very far from practicable, but nevertheless the germ of the modern steam-engine was there, only awaiting the right man to carry the experiments a few stages farther.

It must not be imagined that the piston element was a new discovery, for Hero had mentioned it in one of his old-time publications; and in later days various philosophers had speculated learnedly concerning it, but did not permit their theories to crystallise into actual experiment and practice. It is a remarkable fact that engineers gave their attention to almost every imaginable contrivance, before they settled down and gave the piston proper opportunities of displaying its pregnant possibilities.

To Dr. Denys Papin, more than any other inventor, belongs the credit of producing a steam-engine in which a cylinder and piston were put to practical use, and having learnt the expansive force of steam, he also invented a form of safety-valve. The experimenter was a Frenchman who settled in England in 1675; and it was fifteen years later that he described his improved machine, in which he employed steam to create a vacuum by condensation. In Papin's apparatus was a truer conception of a successful steam-engine, yet he died in obscurity after enduring embittered years as a pensioner on the bounty of the Royal Society. In the world of invention and discovery it was ever so, for most successes are but the aggregates of small endeavours; and the last in the race reaps the reward of the lessons taught by the failures, or the partial successes, that have gone before.

About this time there entered the field three men, practical mechanics, each well endowed with the quality of dogged perseverance and destined to bring about a revolutionary advance in the progress of the steam-engine.

Thomas Savery in 1698 took out a patent for "a new invention for the raising of water, and occasioning motion to all sorts of mill-works by the impellent force of fire, which will be of great use in draining mines, serving towns with water, and for the working of all sorts of mills, etc." Miners, more than any other class of workers, were interested in pumping water, which entered the mines, and not only prevented the extraction of coal, but was also a constant menace to life. In anticipation of the benefits it was about to bestow, the new engine was termed the "Miners' Friend."

In model form the engine acted admirably, but in actual practice in mines it failed to realise expectations. Briefly, the invention consisted of boilers and furnaces with a wooden pipe for descending into the water that required to be raised. The pipe was furnished with valves and pipes opening into two metal receivers. Steam was admitted from the boiler to fill one receiver, and then the second receiver was similarly treated; while No. 1 was cooled by water and a vacuum formed by the condensation of the steam, and the water from the mine was drawn up into the receiver. The admission of fresh steam drove the water upwards and expelled it from the pipe, while the steam in No. 2 receiver was condensed and filled with water from the depths below. But there were defects that militated against complete success. The elasticity and expansive power of the steam caused injury to the working parts, and often the vacuum was imperfectly executed owing to the atmosphere and the steam counteracting the influence of each other during the cooling process. Above all, the lack of safety-valves prevented the use of steam at the necessary pressure, and to force water to a height of about a hundred feet was the limit of the engine's performance within the bounds of safety. In other directions Savery was more successful. His smaller engines drained fens and marshes with no little reliability, simply because less pressure was required; and they also proved useful for supplying towns with water.

Although many others were experimenting with the piston and cylinder, Thomas Newcomen, an English blacksmith, and his assistant, John Cawley, a glazier, were the first to devise a mechanical arrangement for transmitting the power from the piston, which they connected to a walking beam with a pump-rod connection at the opposite end. In the museum of King's College, London, there is a model of a Newcomen engine probably made about the year 1740. A copy of this model is shown at South Kensington; it differs in a few unimportant details from the original, which is now imperfect. In all probability it was not entirely a novel conception, and, in any case, it combined the "exhausted cylinder" that had appeared in a German inventor's air-pump, and produced a vacuum by the condensation of steam after the fashion employed in Savery's engine.

Savery was in no doubt upon that point, and required Newcomen and Cawley to take him into partnership, which they were forced to do on account of his holding the patent of 1698. The trio continued their experiments, and took out a new patent in 1705, and eventually a successful engine was set up at Wolverhampton.

Newcomen, in constructing his engine, was limited to the use of a very unsatisfactory boiler, and consequently dared to use steam only a little above atmospheric pressure, employing it to fill the cylinder so as to create a vacuum by condensing it by the outside application of water. The piston was brought to the top of the cylinder by means of a counter-weight, the part below the piston being filled with steam for condensation; when atmospheric pressure pushed down the piston, thus performing a stroke. Newcomen's "atmospheric engine" was capable of only four or five strokes a minute, until an accident suggested a vital improvement.

NEWCOMEN'S ENGINE (1712)

One day it was noticed that the engine was working at quite double its usual rate, and examination revealed the fact that a hole in the piston packing, which was used to make the piston as steam-tight as possible, allowed the condensing water to gain admittance to the cylinder, where it did its work inside quicker and more effectively than when the cooling was done by outside application. This led to the systematic injection of water inside the cylinder, with a marked increase in the efficiency of the engine.

So slow was the working of an atmospheric engine that the valves for admitting steam and water to the cylinder were opened and closed by hand, instead of by the use of any automatic mechanism. It could not be termed arduous labour ; but Master Humphrey Potter, a boy employed to attend to the valve and the injector-cock, desired some intervals to devote to play. He was of an ingenious turn of mind, and by an arrangement of cords he so contrived it that the walking beam opened and closed the valves automatically. Potter killed two birds with one stone ; he found his occupation gone, but the automatic valve motion was an accomplished fact.

Savery died in 1715, and Cawley a couple of years later. Newcomen lived until 1729, and died in the knowledge that his persistent struggles had resulted in an engine that would pump water out of the deepest mines ; while there was quite a small army of mechanics and philosophers eager to effect still more improvements.

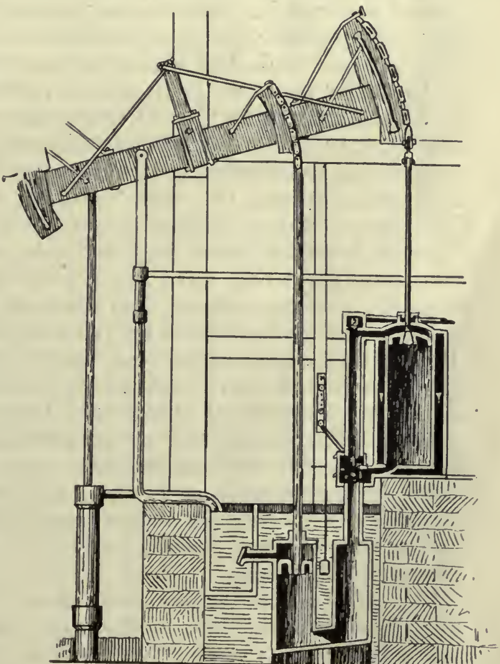
Henry Beighton and John Smeaton met with the greatest measure of success, the former concerning himself chiefly with various mechanical attachments that made for efficiency in working ; while the latter strove to obtain the greatest possible energy from the heat which operated the engine ; for example, he covered the cylinders in order to preserve the heat, and the water, which was used for condensation, he passed into the boiler again. Smeaton introduced steam-pumping machinery into Holland, where previously wind-power exclusively had been employed. He also produced a " portable " engine, which may be accepted as a dim suggestion of the locomotive, the wonderful invention that even in these days stands at the very apex of man's mechanical inventiveness.

For many years after his death Newcomen's engines retained their popularity, and in 1780 there were quite five-score of them at work in Great Britain ; a great many had been sent to the Continent, and some to the United States.

To James Watt, who was born at Greenock in 1736, is generally attributed the honour of being the inventor of the steam-engine, which is unfair to the memories and the labours of the Marquis of Worcester, Papin, Savery, Newcomen, Smeaton, and others, who were only the outstanding figures among scores of men, all labouring to attain the same end.

The marked defect in the Newcomen engine was the great waste of heat involved in cooling the cylinder each stroke. Engineers generally had recognised and deprecated this loss of heat, but Watt, by means of careful experiments, calculated to a nicety what the loss amounted to. His investigations also taught him, among other things, the evaporative power of 1 lb. of coal and the elasticity of steam at various temperatures.

It may seem strange that the undoubted genius of Watt did not suggest working an engine by the direct action of high-pressure steam; but the boilermaker of that day could not contrive a vessel which could be worked with safety at a pressure greater than 10 lb. above the atmosphere, as Savery and others had experienced to their cost by various disastrous boiler explosions. The inventor solved the difficulty by the adoption of a separate condenser, no longer utilising the cylinder, but condensing the steam in a vessel outside the cylinder, with which it communicated by means of a tube; and consequently there was no waste of steam from the necessity of cooling it, and the cylinder itself was kept to one uniform temperature. The result was a great saving of heat, which was an important consideration everywhere, but particularly in districts not supplied with cheap fuel.



WATT'S ENGINE (1775)

The component parts of Watt's steam-engine are shown in the illustration, the mechanism of which is not difficult to follow. From the boiler underneath, by means of a pipe, steam was admitted into the cylinder, alternately above and below the piston, which, fitting steam-tight within the cylinder, was moved up or down by the pressure of the steam below or above it, and thus communicating the movement by the rod to the machinery. Connected with the cylinder by a pipe was a vessel surrounded by cold water, with an air-pump to create the requisite vacuum and to draw out the cold water and condensed steam. An oscillating beam worked on a fixed centre, and a fly-wheel secured a generally uniform movement of the engine.

Watt patented his engine in 1769, heralding a series of remarkable inventions following each other with startling rapidity, and bringing about an industrial revolution. In 1770 James Hargreaves produced the "spinning jenny," capable of spinning many threads at once in place of the hand spinning-wheel, which only dealt with a single thread. Only a year later Richard Arkwright brought out a spinning machine worked by water-power; and within a few years Crompton patented the "mule," in which the principles of Hargreaves' and Arkwright's inventions were combined.

In 1785 Watt applied steam to spinning and weaving operations, with the result that in fifteen years the cotton trade alone trebled itself; while there was a corresponding development in the coal and iron industries, for the new inventions called for more metal in the shape of machinery, and more fuel to produce the steam-power to work it. In 1782 our population was about 8,000,000; our imports were £10,000,000 and our exports £13,000,000; and by 1792 our trade had just about doubled.

In earlier pages we have seen how wheels applied to locomotion had conduced to facility of intercourse; and how steam worked machinery wheels at a velocity hitherto unbelievable. Trade was expanding enormously; Britain at one bound had leapt to the first place among the manufacturing nations of the world, and increase of trade demanded improved facilities for transport.

With few exceptions English roads were notoriously bad; and consequently canals were introduced to unite neighbouring river systems, and to open up districts that were otherwise difficult of access. Canals were used by the ancient Egyptians, and in Great Britain they certainly did something to meet the call for additional facilities for the conveyance of merchandise, for in a barge a horse can draw forty times the weight that it can haul in a wheeled vehicle. The Bridgwater canal from Worsley to Manchester was opened in 1761, and within quite a short period no less than 3600 miles of canals were constructed. But inland water transit did not meet the necessities of our growing trade, and inventors began to consider the practicability of utilising steam to propel vehicles along the highways.

As early as 1676 railed roads were in use in Northumberland, near Newcastle-on-Tyne, to facilitate the conveyance of coals from the mines to the banks of the river. Rails of timber were laid "exactly straight and parallel; and bulky carts were made with four rollers fitting those rails, whereby the carriage was made so easy that one horse would draw four or five chaldrons of coal."

It was found that the timber rapidly showed signs of wear, and thus a hundred years later we find cast-iron rails employed, formed with a continuous ledge or flange on their inner edge, for the purpose of keeping the wheels on the track. These roads were called "tram-roads," so styled, it is often erroneously stated, because Benjamin Outram laid down more rails than anybody else; but tram-roads were in existence before he was born. Originally the

EARLY PLATE WAY (1799)

early coal wagons were called "drams" (Greek, *dram-ein* = to run), and possibly Outram was the cause of the word *dram* being changed to *tram;* but it is far more probable that the word was derived from "trammel," the wheel being trammelled to the track by the flange of the rail. In the illustration are shown specimens taken from the Ticknall tramway, which was connected with the Ashby canal, Leicestershire. Outram constructed it in 1799, and the line is still occasionally used. The switch has a wrought-iron tongue, fitted with a stem which dropped into a hole in the casting, that had to be moved by hand instead of by a mechanical device.

It was not until about the year 1800 that a recommendation was made to carry merchandise on a railroad, followed very quickly by the suggestion of a railroad scheme for the conveyance of passengers.

In 1803 Professor John Anderson, of Glasgow, wrote an eloquent plea for the adoption of railways, and there is no doubt that it made a marked impression upon public opinion. "If you can only diminish one single farthing in the cost of transportation and personal intercommunication," he wrote, "you at once widen the circle of intercourse; you form, as it were, a new creation—not only of stone or earth, of trees and plants, but of men also, and, what is of far greater consequence, you promote industry, happiness, and joy. The cost of all human consumption would be reduced, the facilities of agriculture promoted, time and distance would be almost annihilated; the country would be brought nearer the town; the number of horses to carry on traffic would be diminished; mines and manufactures would appear in neighbourhoods hitherto considered almost isolated by distance; villages, towns, and even cities would spring up all through the country, and spots now as silent as the grave would be enlivened by the busy hum of human voices, the sound of the hammer, and the clatter of machinery; the whole country would be revolutionised with life and activity, and general prosperity would be the result of this mighty auxiliary to trade and commerce."

The professor, looking into the future with the eyes of faith and courage, foretold a revolution to be invoked by a new partnership between human intelligence and energy; but even he could not realise how quickly the beneficent change would commence, and how even his wise anticipations would fall short of the moral, intellectual, and commercial progress that the iron road would achieve.

In the United Kingdom there are now, roughly, 24,000 miles of railways, worked by 23,000 locomotives, 52,000 passenger carriages and 20,000 miscellaneous passenger vehicles, 745,000 wagons of all kinds for the transport of goods, livestock, and minerals, exclusive of 21,000 miscellaneous vehicles and 650,000 wagons belonging to private owners. In a single year the trains travel 423,000,000 miles; they carry 1,278,000,000 passengers (exclusive of nearly 2,000,000 season-ticket holders), whose fares amount to £42,000,000, and 492,000,000 tons of goods, etc., from which the receipts amount to £58,000,000, while another £10,000,000 is derived annually from steamboats, docks, canals, hotels, etc.

It is almost impossible for the mind to grasp the meaning of such vast figures without some gigantic standards of comparison. Our trains in a single year travel a distance equivalent to seventeen times round the entire globe, or a return excursion to the sun. If the passengers were to line up four abreast, they would form three columns each 20,000 miles long; while the money they pay in fares provides a sufficient number of sovereigns to carpet a five-acre field. Before the advent of railways travelling by stage coach was expensive, and it is doubtful if more than ten million persons journeyed in them during a year. To have enabled the prophecy of old—"many shall run"—to be fulfilled, as nowadays, would have necessitated the use of hundreds of thousands of coaches and millions of horses.

To the railways we owe the inestimable benefits of the penny post. When the work of the Post Office was performed by about five-score mail coaches, the lowest charge for a letter sent from London to Birmingham was 9d., and from London to Edinburgh 1s. 1½d. There is no more powerful agent in promoting civilisation, orderly and kindly fellowship between man and man, than facility of intercourse; and intercourse by pen and paper ranks second only to intercourse by word. Consequently one of the most potent forces in promoting the moral and intellectual progress of the nation is due to the iron road and the snorting iron horse that unceasingly traverses it. It is borne in upon even the most casual observer that the steam-engine, and especially the locomotive, has proved one of the crowning triumphs of mechanical invention to the increase of knowledge and the building up of our national greatness.

What the locomotive has done for our own country it has done for many others. The European railway lines have a mileage of about 202,000, and North America (Canada, United States and Mexico) possesses 62,000 miles. Asia, the largest and most populous division of the globe, one-third of the land surface of the earth with one half of the human race, can yet boast of only 60,000 miles of railways, although it was the cradle and nursery of the human family. But even Eastern aloofness and suspicion cannot resist the iron horse, whose road is driven through all physical obstacles, linking one territory with another that otherwise would remain strangers. Africa, when Professor Anderson foretold the possibilities of railways, was practically only a coast-line to the white man. It was the "Dark Continent," the home of the blackest ignorance and superstition, of barbarism and cruelty too appalling to contemplate. Geographical discoveries have been followed by European influence, commercial enterprise, and all the appliances of civilisation, among which are 20,000 miles of railways, and every year there is perhaps a greater percentage of increase than in any other part of the world. South America owns 32,000 miles of iron road; and in Australasia there are 18,000 miles, making a total for the whole world of quite 612,000 miles.

In no department of human energy has the Briton demonstrated his superiority over other peoples more than in his inventive ingenuity; and we have every reason to swell with honest pride at the thought that the revolutionising railway originated in our own land. When we see one of our non-stop expresses hurtling past us with a deafening rattle and din, or even a mere rural train of far gentler pace, they are but typical of the many trains of the many nations at work under far different conditions.

Railways are now cosmopolitan, but many foreign lines have been planned by British brains, constructed under British supervision, and built of British materials; and even where this is not the case, many of the world's locomotive studs are regularly recruited from the workshops in the original home of the iron horse.

In no country, even to-day, are there any railway services equal to our own for reliability, general speed, and a safety that is almost proverbial. On our own lines we can observe practically everything in railway practice that is worth knowing. We need to go abroad only to note some of the greater triumphs of the railway engineer, who, "laughing at difficulties, spans majestic rivers, carries viaducts over marshy swamps, suspends aerial bridges above deep ravines, pierces the solid mountain with the dark, undeviating tunnel, blasting rocks and filling hollows; and, while linking together with its iron but loving grasp all nations of the earth," verifies in a literal sense another ancient prophecy—"every valley shall be exalted, and every mountain and hill shall be made low."

CHAPTER II

THE EVOLUTION OF THE IRON HORSE

George Stephenson quite commonly is regarded as the inventor or parent of the locomotive, but steam carriages were in existence long before his time. As early as 1680 Isaac Newton planned a road engine, a carriage in the centre of which he placed a circular boiler in which to generate the steam that propelled the vehicle and then escaped from a pipe in the rear of the coach. It was a wonderfully primitive contrivance, but it contained the general idea of the locomotive, even if nothing really practicable were to come of it for nearly one and a half centuries.

The first practical steam-propelled road carriage was produced by Cugnot, a French military engineer, in 1763. Six years later he built a carriage for the conveyance of four persons at two and a quarter miles per hour, but owing to the insufficiency of boiler-power

CUGNOT'S ROAD CARRIAGE (1770)

the supply of steam would only serve for periods of twelve to fifteen minutes. The French Government ordered an engine for use in the transportation of artillery, stipulating that it should carry a load of four or five tons. The machine was built in 1770 at a cost of £800; it was never tried, and is now preserved in the Conservatoire des Arts et Métiers, at Paris. This early traction-engine shows Cugnot's machine to have consisted of a heavy timber frame supported on three wheels and carrying in front an over-hanging copper boiler. The front wheel, with a broad, roughened tyre, was driven by two single-acting inverted vertical cylinders, 13-inch diameter by 13-inch stroke. A seat was provided for the driver, who, by means of gearing, was able to steer the machine, the boiler and engine turning together as a fore-carriage.

It was scarcely to be expected that the wonderful inventive faculty of James Watt would not be attracted to the subject of steam locomotion. He actually patented an engine, but eventually ceased to interest himself in the subject. In partnership with Matthew Boulton at their works at Soho, stationary engines were absorbing all his energies, and he did not approve of any member of the staff seeking to improve upon his own unsatisfactory attempts to produce a steam-driven vehicle.

At Redruth, in Cornwall, Messrs. Boulton and Watt had in their employ William Murdock, the inventor of gas-lighting, who was engaged in erecting the firm's engines, that were in great request among Cornish mines; and Murdock, free from Watt's discouragement, bent himself to the task of constructing a self-propelling carriage.

Murdock completed a model, a copy of which may be seen in South Kensington Museum; the original is exhibited in Birmingham Art Gallery. It carried a grasshopper engine, so called because its main feature was a beam, in action having something of the appearance of the leg of the insect. One dark night the inventor decided to test his machine on a well-rolled path leading to Redruth church. No sooner had he got up steam than the little locomotive started off at something like seven miles an hour, with Murdock in hot pursuit. The inventor was filled with pleasurable excitement at his success, until shouts of terror from ahead smote his ear. He found that the cries emanated from the parson and his wife, returning home in the dark to find themselves suddenly confronted by some mysterious object, snorting and zig-zagging along the road in front of them. Their fears were appeased when they learnt that Murdock was in charge of it, and the worthy couple agreed to keep his secret.

Murdock's invention was little better than a steam toy. A small spirit lamp was used to generate the steam, and the cylinder was $\frac{3}{4}$-inch diameter and 3-inch stroke. It was a capital miniature engine, but it is doubtful if it exercised any real influence upon the evolution of the locomotive, although it certainly would have led to something much better if its inventor had been free to follow it up.

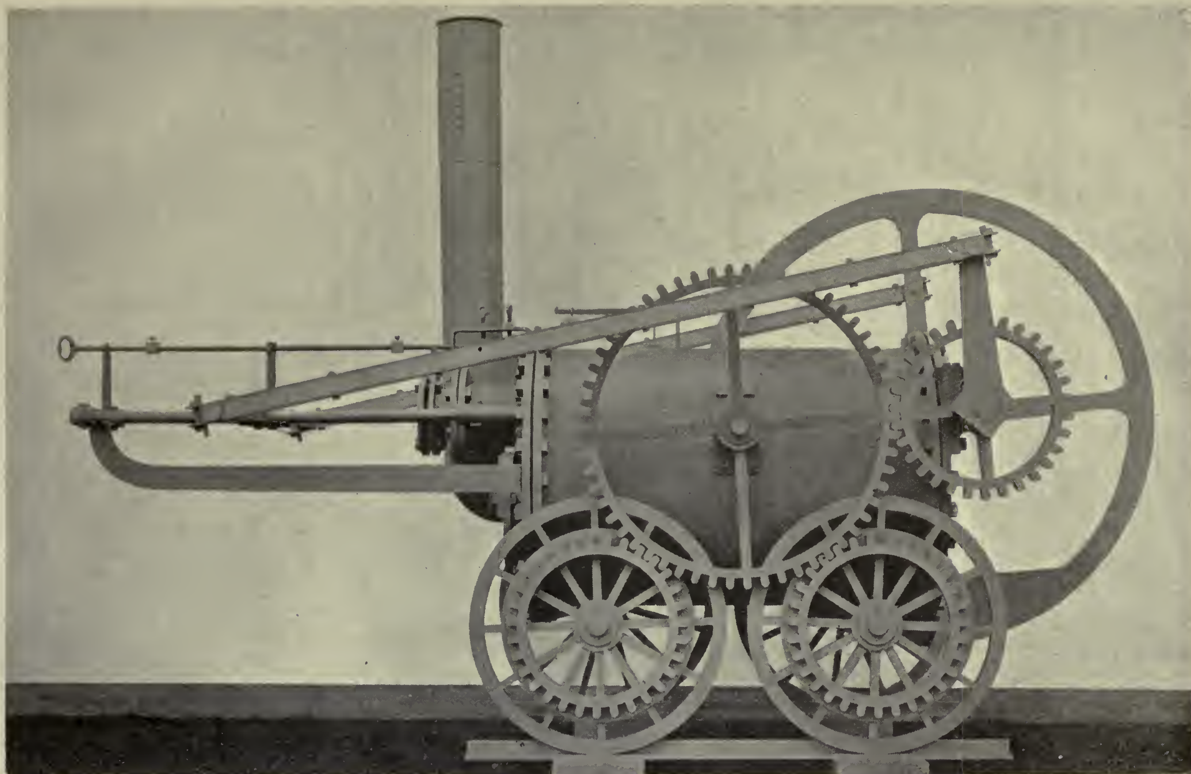
Murdock decided to take his steam-carriage to London to procure a patent for it, and at the end of August, 1796, duly took the coach to the metropolis, only to encounter Matthew Boulton at Exeter on his way into Cornwall. It did not coincide with the interests of Boulton and Watt to allow their best man to drift out of their service, and, consequently, Boulton prevailed upon the inventor to return with him next day to Redruth. In reporting the matter to his partner, Boulton wrote: "He hath unpacked his carriage and made it travel a mile or two in Rivers's great room, making it carry the fire-shovel, poker, and tongs. I think it fortunate that I met him, as I am persuaded that I can cure him of the disorder, or turn the evil to good. At least I shall prevent a mischief that would have been the consequence of his journey to London." In plain English, Boulton and Watt had little faith in steam-carriage, and induced Murdock to relinquish his experiments, which doubtless in time would have accorded him some of the greatest honours attached to the introduction of steam locomotion.

At Redruth lived Richard Trevithick, a born mechanic, who was devoting all his waking hours to effect improvements upon Watt's engines, as well as to produce a steam-carriage for service on common roads.

As several of Watt and Boulton's patents expired, the inventor was able to avail himself of many mechanical features, which hitherto he had not been free to copy. He took into partnership Andrew Vivian, and the year 1801 saw their first steam vehicle carrying a load of passengers. Trevithick and Vivian went on to secure a greater triumph. One of their steam road carriages ran along the highway from Camborne to Plymouth, a distance of nearly a hundred miles. At the port the engine was shipped to London, where it ran in the streets of the metropolis, to the huge amazement of crowds of sightseers.

In 1802 was patented a working model of a road locomotive, which is a treasured relic at South Kensington. This engine in no way resembled that of Murdock.

About this time Trevithick received a great incentive to produce something better. Samuel Homfray wagered £500 with his friend Richard Crawshay that he would convey a load of iron a distance of nine miles on rails by the power of steam alone, and he instructed Trevithick to build an engine capable of winning the wager; and consequently in 1803 "Captain Dick" supplied his patron with a locomotive that carried ten tons of iron the required distance on the Penydarren tram-road, near Merthyr Tydvil. To all intents and purposes it exhibited most of the elements of a practical modern locomotive, except the multitubular boiler, although its gearing was complicated and its stroke abnormally long. The boiler, 5 feet long, had a return flue, and was particularly effective for those days. It was carried upon two pairs of wheels of 52 inches diameter, and its one cylinder was 8 by 54 inches. After the steam had transmitted the power, it was passed into the smokestack to assist in improving the fire-draught. As the tramway was furnished with a guiding flange inside, the wheels of the engine were without flanges. The speed attained was five miles an hour, and, though the breaking of many of the iron plates, that formed the rails, caused the trials to be viewed as a commercial failure,



TREVITHICK'S LOCOMOTIVE (1804)
The first to run on a confined track

nothing better was produced in at least the succeeding twenty years.

The photograph shown was taken from a full-sized reproduction of this engine and a portion of the plate-way, which Mr. F. W. Webb constructed at Crewe in 1893. Trevithick's locomotive was the first to run on a confined track by the force of high-pressure steam, and it proved that smooth wheels were sufficient to provide the necessary adhesion.

In the year 1789 William Jessop, a pupil of Smeaton's, constructed a tramline between Nanpanton and the Loughborough canal. He employed cast-iron edge rails without guiding ledges, flanging the edges of the wagon-wheels instead, the rail being sufficiently elevated to allow the descending flanges to run clear of the ground. This may be regarded as the first real railway, consisting of rails in 3-feet lengths, of about 40 lbs. weight, with flanged feet, which were spiked down to cross sleepers. Probably this was the first occasion of a rail being laid on its edge, and was a great improvement upon the earlier plateways. Ten years later the rails ceased to be cast with feet, but were laid in "chairs," and thus, before the end of the century, there came into existence the main features of the permanent way as it exists at the present time.

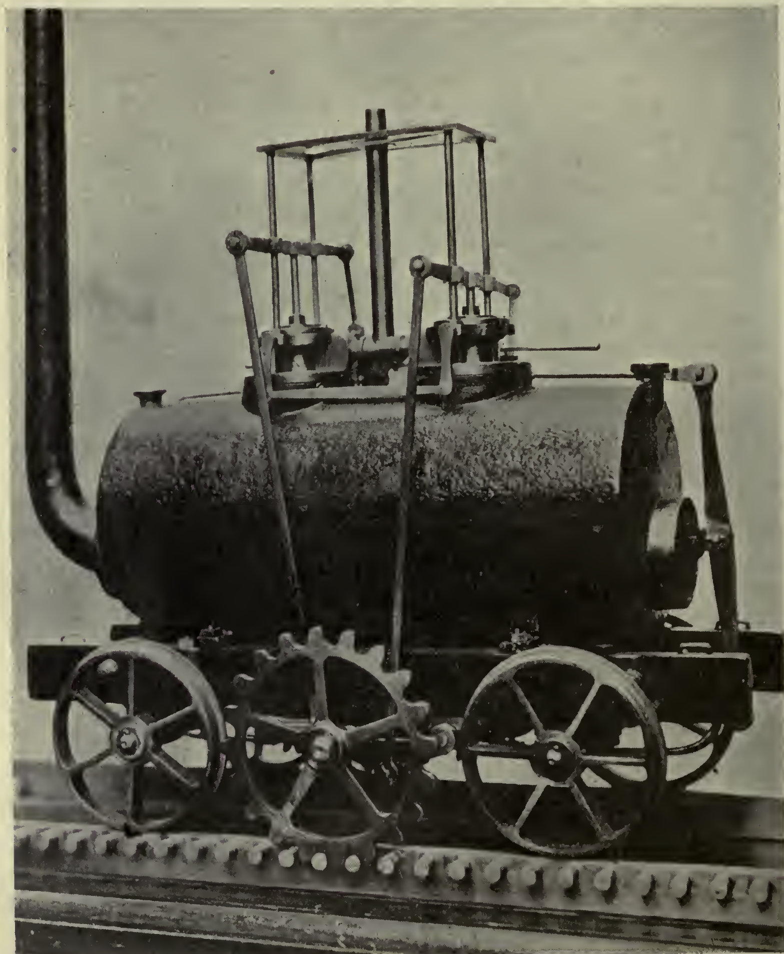
Most of these early lines had flat rails, or plates, and the men who laid them were called "platelayers," a term that is still applied to the men who fix the rails to the sleepers. The stone "sleepers" were so named because they were supposed to rest undisturbed in the ground under the chairs. In 1799 the Surrey Iron Railway Company was formed, obtaining its Act of Parliament in the first year of the nineteenth century. This was the first specific Railway Act, obtained by the first railway company, for the first public railway, which was to be constructed from Wandsworth to Croydon, via Mitcham Common, being the first section of a line from London to Portsmouth. This new line led to the projection of nearly a score of others in different parts of the country, all of which possessed very similar features. The wagons upon all of them were worked by horses, and the revenue was derived from tolls. An old toll-sheet to be seen at South Kensington shows that on the Surrey line coal was carried at the rate of threepence per chaldron (25½ cwts.) per mile. This early Surrey line proved to be a failure, and speedily lapsed into disrepair, and where it crossed high-roads became a public nuisance. In 1845 its thirty-two railway wagons and ten horses were sold by auction.

After winning the Homfray wager, Trevithick's engine was employed in drawing wagons on the Penydarren tram-road. Numerous other inventors were at work on entirely new ideas, or perfecting some of the partial successes. It was already certain that the steam-engine would eventually be applied successfully to the purposes of transportation ; and the locomotive engineers were but going through the trials and disappointments that had waited upon the inventors of the stationary steam-engines years and years earlier. Some engines were produced that were of fearful and wonderful construction, and one, indeed, was nothing less than a machine that walked on steam-driven legs ; it did not walk far, however, and certainly not to success.

Richard Trevithick in 1808 constructed an experimental circular railroad in London where Torrington Square now is, close to Euston Station. Upon this line he ran an engine which he called "Catch-me-who-can" at twelve miles an hour, drawing passengers who were only too pleased to pay a shilling a head for the novel experience. This engine also had smooth wheels, which it was demonstrated would run on smooth rails, although there were not wanting engineers who refused to be convinced that cog-wheels and toothed rails were not far superior. Trevithick's "Catch-me-who-can" lacked the fly-wheel, which was a conspicuous feature of some of his earlier engines. But the railway circus proved to be of only short duration, for eventually one of the rails smashed, throwing the locomotive off the line, and causing damage that the inventor had not means to repair.

John Blenkinsop, who was in the employ of the Middleton Colliery, and had to superintend the carriage of coals into Leeds, three and a half miles distant, set himself to the task of preventing the slipping of engine driving-wheels, which was a weakness in Trevithick's engines, that did not possess sufficient adhesive weight for the tractive power that they had to exert. Blenkinsop, therefore, patented the principle of the rack and cog wheel. The rails were smooth at the top, but half an inch from the upper edge of one of them was a series of lugs or teeth almost semi-circular in shape, upon which worked the twenty rounded projections of the one spurred driving-wheel of the engine, the four carrying-wheels being smooth. These engines were the first to have two cylinders, certainly the first to run on *five* wheels, and what was very much to the point, the railway was the first to be a real commercial and financial success. The trial trip took place on June 24th, 1812, the train consisting of eight wagons containing twenty-five tons of coal and more than two-score passengers. When the new engines settled down to their work, they commonly drew thirty loaded wagons, and did good service for nearly twenty years. As the engines only weighed five tons each, Blenkinsop's toothed rack was probably an absolute necessity. It was speedily proved that a cog-wheel and rack-rail were unnecessary for traction on fairly level roads, but in any case the inventor was practically the originator of our modern mountain-climbing railways.

Christopher Blackett, a newspaper proprietor and one of the principal owners of the Wylam Colliery, near Newcastle-on-Tyne, desired to abolish wagon horses in favour of steam, and obtained one of Trevithick's engines in 1805. This engine, which was constructed at Gateshead, was the first to possess flanged wheels, which were unsuitable for the Wylam wooden track, and conse-



BLENKINSOP'S LOCOMOTIVE (1812)

quently the engine for many years was worked as a stationary one for other purposes.

After the Wylam track had been converted into a cast-iron plate-way, Mr. Blackett desired to obtain another locomotive from

Trevithick, who was unable to comply with the request, owing to his time being occupied with other matters. Trevithick was a man of tremendous energy, and interested in many matters outside locomotion. He experimented with a steam-dredger ; he was the first engineer of the Thames Tunnel (1809) ; he constructed steam threshing-machines and ploughs ; and in 1815 he invented a screw-propeller for steamships, which was to be worked by steam generated in a water-tube boiler, in which the water passed through the tubes instead of heated tubes through the water, as in the locomotive boiler of to-day. With it all, Trevithick's Cornish pumping-engine was growing in favour, and three of them having been sent out to Lima, the inventor became interested in some Peruvian mines, and he left the British locomotive arena to go out to the New World, where in seven years he is said to have amassed a fortune of half a million sterling. A war, however, reduced him to poverty, and eventually he returned to England with Robert Stephenson, who also had been employed in South America, until he was recalled home to assist his father in building engines for the Liverpool and Manchester Railway.

Failing Trevithick, Mr. Blackett inspected the Blenkinsop engines, but not approving of the rack-rail arrangement, he left William Hedley, a " viewer " at the colliery, to see whether he could design a locomotive capable of performing the required work. It was a particularly anxious time in England ; wheat had never been so dear for a hundred years, and with fodder at famine prices, horse-traction was spelling ruin for tramways. The foreman of the Wylam blacksmiths' shop was Timothy Hackworth, and he built a locomotive to plans supplied by Hedley. Whether the builder or the designer were at fault it is impossible to say, but the engine was a failure. A second attempt in 1813, however, proved to be a success, and the identical engine, named " Puffing Billy," is still to be seen at South Kensington.

This specially interesting relic is well worth close examination. It had comparatively few complications, which could not be claimed on behalf of many of its successors. The furnace extended half-way into the boiler, and the gases given off in combustion passed to the smokestack by way of a return flue. The frames were of wood, and rested on the axles without any springs to relieve jolting. Inside gearing connected the four wheels, while a gear-wheel upon a separate axle transmitted the motion.

The two vertical cylinders were 9-inch diameter by 36-inch stroke, and the grasshopper beams transmitted the motion downward by vertical connecting-rods to a shaft with cranks set at right angles. The shaft bore a spur-wheel, and, in conjunction with four other spur-wheels, transmitted the motion to the four driving-wheels, which were 39 inches in diameter. The grate area was 6 sq. feet, and the total heating surface 77 square feet. The tender consisted of a wooden frame carried on four wheels, and containing a water-tank and coal box.

"Puffing Billy" as a four-wheeler was too heavy for the weak cast-iron plateway, and at the end of two years was rebuilt as an eight-wheeler, each group of four wheels being carried in a kind of bogie. About 1830 the Wylam track was relaid with cast-iron edge rails of the double-flanged, "fish-belly" type, which meant that the rail swelled out downwards; and the engine was altered back to four wheels, as it now appears upon specimens of the original edge rails, each 4 feet long and weighing 39 lbs. per yard. The

"PUFFING BILLY" (1813)

engine worked until 1862; a sister engine, "Wylam Dilly," worked until 1867, and is now exhibited at Edinburgh Museum. Upon their first appearance these early locomotives made a tremendous noise and vented palls of smoke that irritated persons in the neighbourhood into taking legal advice, which led to the abatement of the nuisance by passing the exhaust steam into a quieting chamber, before discharging it into the chimney.

While locomotives to run on railed roads made slow progress, steam-carriages for use on common roads were attaining a large measure of success. In 1827 Sir Goldsworthy Gurney patented a six-wheeled steam-coach, which was also furnished with struts or legs for hill-climbing. The vehicle accommodated six passengers inside and twelve outside, and is said to have travelled at fifteen miles an hour. In 1832 Mr. Walter Hancock, of Stratford, commenced a regular service of steam-omnibuses between Paddington and the City, and in the same year Mr. William Church's ornamental three-wheeled steam-coaches ran between London and Birmingham.

Meanwhile there was entering the field of locomotive invention and discovery another man, who was destined to make railway history in no uncertain fashion, although he was of very humble birth, and commenced to earn his living at eight years of age by herding cows at twopence a day.

George Stephenson, the son of a poor workman at Wylam Colliery, thought himself on the high road to fortune when he was appointed "picker" at the colliery, his work being to clear the coal of bits of stone, dross, and other impurities. The boy was passionately fond of engines, and great was his joy when he was permitted to assist his father in firing the engine that drew up the coal from the depths below. At seventeen years of age he was appointed engineman, which testified to his steadiness and intelligence. It is difficult to resist the temptation to tell of his struggles in succeeding years until he was appointed engine-wright at a pit at Killingworth at a wage of less than £2 a week, a reward for having freed a mine of water in five days, which numerous experts had failed to effect in a year.

Stephenson was acquainted with various tramlines in use at northern collieries, and was consumed by the desire to build a locomotive of his own, for he felt certain that he could improve upon even "Puffing Billy." His first model, built on a small scale, is still preserved in a museum at Chester. In 1814 he built "Blucher," his first locomotive, something like Hedley's, but with only a simple flue. At first the engine was unsatisfactory, but Stephenson's persistency always refused to acknowledge failure, and it was not very long before he turned the waste steam into the smokestack, doubling the power of the engine, and converting it into a success, and smoothing the way for a new locomotive the following year, which was employed at Killingworth. This engine at first had coupling-rods upon inside wheels between the cranks, but later the rods were replaced by chain-gearing as in a bicycle, because one of the crank axles got bent.

One of the chief troubles of the locomotive builder was the unsatisfactory rails upon which the engine had to run. The breakage of cast-iron rails was a frequent source of trouble, and tramway owners were chary of using malleable iron owing to its additional expense; but, nevertheless, wrought-iron rails were extending in popularity, until in 1820 John Birkenshaw introduced a method of rolling rails in greater lengths at a price that permitted their universal adoption.

The slow navigation of the Tees was a great hindrance to the northern coal trade, and, after much discussion whether a canal or a tramline between Stockton and Darlington would best serve the needs of the collieries, the decision was cast in favour of a railroad. In due course the line was surveyed, and in April, 1821, Parliament consented to its construction.

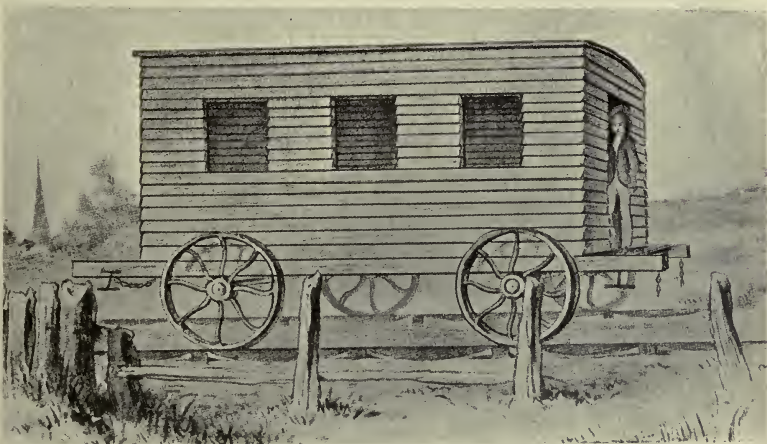
Edward Pease was one of the prime movers in the projected new line, which was to be worked by horse-traction, although the phrasing of the Bill said that vehicles might be drawn by "men, horses, or otherwise." George Stephenson paid a visit to Mr. Pease to suggest that the word "otherwise" might be translated into "steam"; and the gentleman was not only greatly impressed by a letter of recommendation from the manager of the Killingworth mine, but he was very much struck by the earnestness of Stephenson, who begged him to pay a visit to Killingworth to see how effectively his "Blucher" was working.

The final outcome was that Stephenson was appointed engineer of the new line; a fresh survey was made in which Robert Stephenson assisted his father; and the Company amended its Act so as to accord specific permission to use locomotives, and to carry passengers as well as coal and general merchandise. Stephenson's position was very far removed from a bed of roses, for some at least of the directors by no means shared in Pease's belief in their engineer.

The line was single with five-score loops in its length of twenty-five miles, with four branch lines that made the total track thirty-six miles long. Stephenson's estimate of the cost of the line was virtually four times as much as one of the original estimates, chiefly accounted for by the use of malleable iron rails instead of cast-iron, which latter he objected to use, although their adoption would have put £5000 into his pocket, as he held a half-share in the patent. After much opposition, Stephenson gained his point, and Birkenshaw's rails were used, fish-belly in pattern, 28 lbs. to the yard.

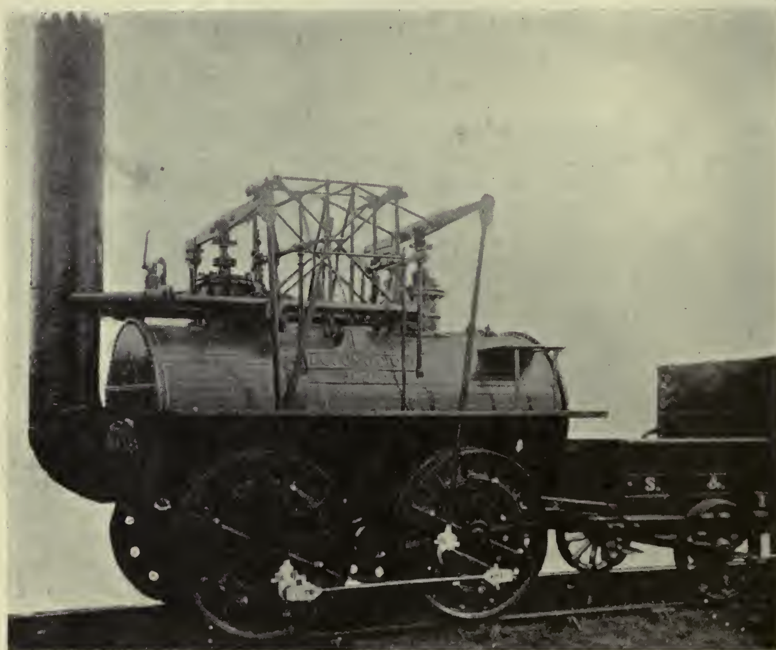
Another outcome of George Stephenson's visit to Edward Pease was the formation of a company to erect works in Forth Street, Newcastle, wherein to build locomotives and to engage in other engineering operations. The first two engines constructed by the Company were for the new line at Hetton Colliery, and early in 1825 was commenced the erection of the "Locomotion," the first of the engines to be used at the opening of the Stockton and Darlington Railway. Pease was unable to persuade his fellow-directors to order more than three locomotives, and a large number of horses was purchased to assist the engines in drawing their loads on the opening day. But Stephenson did not take this lack of faith in him very greatly to heart; he was assured that he would teach the directors a lesson they were not likely to forget, when doubtless the Company would be willing to sell off the horses for whatever they would fetch. The engineer was preparing a surprise for his sceptical employers in the shape of a special passenger carriage, built to his own design. This vehicle, which he called the "Experiment," was a kind of shed on wheels lighted by six windows, and with a row of seats along each side, and a deal table in the centre.

September 27th, 1825, the day of the opening of the Stockton and Darlington Railway, marked an important epoch in the progress of the world. Excitement was at fever heat, the enthusiasts assured of the triumph in store for them, the sceptics equally certain that the engine would blow up. The train consisted of the "Locomotion," with George Stephenson's hand on the lever, half a dozen trucks loaded with coal and merchandise, the "Experiment" with the directors and their friends, six wagons loaded with strangers, and then more wagons, that raised the number of vehicles to nearly forty, and the total weight to about ninety tons. The "Locomotion" splendidly answered its inventor's expectations, setting out from Darlington at about ten miles an hour, and attaining fifteen miles during some portions of the journey to Stockton, where the incoming train was welcomed by a cheering, gesticulating multitude. George Stephenson was a proud man when he stepped from the footplate to receive the acclamations of his friends and the warm commendations of those who had opposed him. There was only one flaw in the engineer's complete satisfaction; his beloved son, Robert, who had assisted in the construction of the successful locomotive, was not there to witness the victory; owing to poor health he had taken a post at a mine in South America. Neither



"EXPERIMENT"
Stephenson's first railway passenger coach (Stockton and Darlington Railway)

did Edward Pease share in the proceedings, the death of a son turning the day for him into gloom instead of joy. "Locomotion," the engine that achieved such a notable triumph, was in running for twenty-one years; and it is still treasured with care by the North Eastern Railway Company at Darlington. The engine had two vertical cylinders 10-inch diameter by 24-inch stroke, and the pair of driving-wheels, 4 feet in diameter, was driven by side connecting-rods. The boiler pressure was about 25 lbs. per square



"LOCOMOTION"
(Stockton and Darlington Railway)

inch, and two blast-pipes conveyed the exhaust steam from both cylinders into the chimney. The single-flue boiler was 10 feet long by 4 feet diameter; the heating surface was 60 square feet. The total weight of the engine in working order was 6½ tons. The tender, built of timber, carried 15 cwt. of coal, and an iron tank of 240 gallons capacity; it ran on four cast-iron wheels of 30 inches diameter, and with its load of fuel and water weighed about 4 tons.

Only a short time before the opening of the line, Stephenson assured Robert and a young friend, that the time would come when it must be cheaper for a man to travel by rail than to walk on foot; that every coach would be driven off the road; and that trains would be the one means of conveyance, whether for the king or his people. The new line speedily proved that it was the best means of conveyance for coal, for the price of the fuel in Darlington promptly dropped by 10s. per ton, and within only a few weeks the passengers demanding to use the line necessitated the running of at least one coach each way daily.

Throughout the country as a whole railway progress was viewed with much disfavour. The landowners feared that the lines would disfigure the countryside; the farmers were afraid that their livestock would be in a constant state of fright, and that no hay or corn rick would be safe from fire. In this last respect some of the earlier road engines had done nothing to alleviate popular alarm, for their smokestacks belched out flames and sparks in a manner terrifying to behold. But the later engines showed a vast advance in that respect, and it was certain that other improvements would follow, until little or nothing could be urged against them on the score of danger. Another large section of the public opposed to railways consisted of persons engaged in the coaching trade, and numerous occupations directly or indirectly connected with it. Drivers and guards, grooms, coachbuilders, and many others would undoubtedly find their occupations gone, and the innkeepers on the coaching roads would experience a sad lack of business; but railways would be instrumental in providing avenues of employment hitherto undreamt of. Our railways of to-day have over 621,000 persons in their employ, while hundreds of thousands of others are engaged in different trades that cater for the needs of the iron road.

The success of the Stockton and Darlington line caused a wide-spread revulsion in favour of railways, but chiefly only in the industrial districts; the landed proprietors and country folk still were prepared to offer the most vigorous opposition. Several years before the Stockton and Darlington project, it had been proposed to construct a railroad between Liverpool and Manchester, but the mere suggestion caused such turmoil and execration that the promoters were forced to abandon the idea. The striking success achieved by the Stockton and Darlington line revived the hopes of the committee in charge of the Liverpool and Manchester scheme; it was decided to take the necessary steps to obtain an Act of Parliament empowering its construction; and George Stephenson was asked to accept the post of engineer as soon as the requisite permission was granted.

When Stephenson set about surveying the ground, he found a hornets' nest about his ears. He was angrily warned off many estates, and in some cases the employés of specially rabid opponents damaged valuable surveying instruments, and threatened the engineer himself with personal violence. Stephenson, however, persevered, completed the survey in face of all obstacles, and the Bill was sent to Parliament, where it was assailed by the cleverest lawyers in the country, against whom was pitted the engineer to bear the brunt of the struggle almost alone. He was ridiculed and brow-beaten, and finally the Bill was rejected, chiefly because Stephenson maintained that a locomotive could run twelve miles an hour as easily as four. From that point the opponents of the Bill played a winning game, proving to the satisfaction of the Parliamentary Committee that it was unwise to trust any scheme to a man capable of believing in such manifest absurdity as displayed in his evidence.

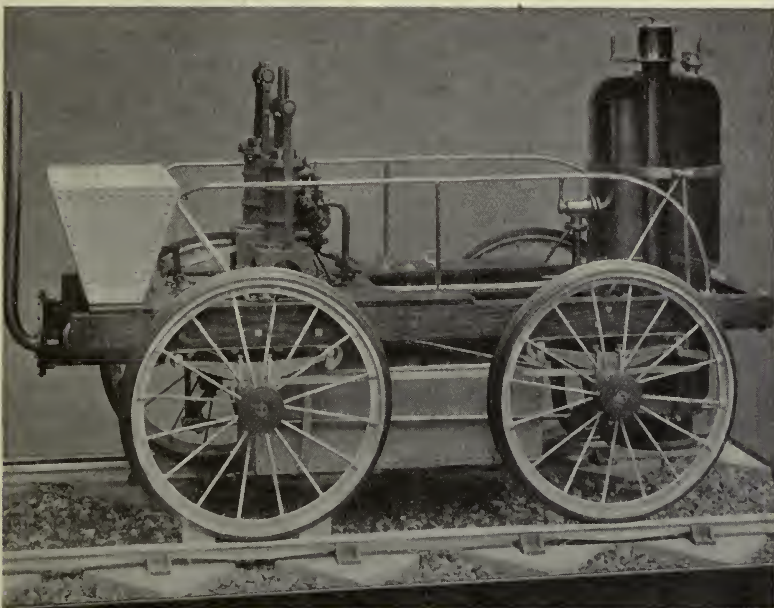
The promoters of the line found their faith in Stephenson shaken. He had been so reviled, and accused of almost downright madness, that they hesitated to trust their scheme further in his hands; and consequently, when an eminent engineer, Mr. Rennie, had made a fresh survey, and Parliament passed the Bill at its next meeting, Rennie was asked to undertake the construction of the line. He was unable to devote the necessary time to the undertaking, and shortly George Stephenson was reappointed.

Between Liverpool and Manchester lay Chat Moss, an extensive bog, that was only passable in the driest weather, while in wet seasons it was a quagmire to a depth of thirty feet. Although many eminent engineers declared that the swamp was an insuperable obstacle to a railway, Stephenson partially drained and solidified the morass, and threw his line across it at less expense than any other section.

The Liverpool and Manchester line was to be a real railroad and not a mere tramline, and the engineer's initial difficulty was to find men capable of carrying out instructions in laying down the permanent way. He found his workmen in the "navigators" (afterwards corrupted to "navvy") who formerly had been employed in the construction of canals; and Stephenson did not hesitate to wheel a barrow or wield a pick when showing his men how to obtain the maximum amount of labour with the minimum expenditure of strength. But while he was engaged on the line, the engineer was always afraid of matters going wrong at the Forth Street works, where new engines were in course of construction; and however well the line was laid, a breakdown in the locomotives would be ruinous. Fortunately Robert Stephenson's improved health allowed him to return home to give his father the assistance he sorely needed.

When at length the line was completed, the directors hesitated to use locomotives, rather favouring the idea of employing stationary engines at fixed points to draw the trains by means of ropes. Stephenson was staggered. He argued and pleaded, until the directors took counsel with various engineers, all of whom decided against Stephenson, who promptly demanded whether the conqueror of Chat Moss did not deserve the trial he asked ; the engineers had declared that a line could not be laid across the bog, and he had proved them to be entirely wrong. He was prepared to demonstrate that they were again in error.

The directors were impressed, and at length decided to offer a reward of £500 for a locomotive built upon certain indicated lines, its superiority to be proved by open competition, and the winning type would be tried upon the new line.



"NOVELTY" (1829)

This decision quite satisfied Stephenson, who promptly decided upon a greatly improved engine to be constructed at the Newcastle works under the superintendence of his son Robert ; and other engineers were hard at work building new locomotives to compete with it.

The trial ground was at Rainhill, where a track two miles in length was laid down, upon which each engine was to make twenty trips at not less than ten miles an hour. Four locomotives complied with the stipulated qualifications, viz. :—

" Rocket " (Mr. Robert Stephenson),
" Novelty " (Messrs. Braithwaite and Ericsson),

"Sanspareil" (Mr. Timothy Hackworth),
"Perseverance" (Mr. Timothy Burstal

These four engines entered the lists on October 6th, 1829, in the presence of an immense crowd gathered from all parts of the country. Stephenson's engine answered the most sanguine expectations without the least mishap; running alone, it attained a speed of twenty-nine and a half miles an hour, and when drawing a car with thirty-six passengers the rate was twenty-eight miles. This performance of the "Rocket" simply astounded those who had denied the practicability of locomotives, and caused additional interest to be taken in the trials of the remaining engines. The "Sanspareil," which proved to be too heavy, as well as wasteful in fuel, broke down on the eighth trip; the "Novelty" burst; and the "Perseverance" was withdrawn. The "Rocket" was thus left alone in the field, and the directors of the Liverpool and Manchester Railway unhesitatingly instructed Messrs. Stephenson to build engines and carriages in readiness for use on the new line.

The opening ceremony was fixed for September 15th, 1830, and additional *éclat* was given to the occasion by the presence of the Duke of Wellington, who was then Prime Minister, accompanied by several members of the Government, to meet whom several hundreds of guests were specially invited.

A grand railway procession started from Liverpool. The "Northumbrian," driven by George Stephenson, drew the train which carried the Duke of Wellington and his distinguished party; the "Phœnix," guided by Robert Stephenson, came next with a trainload of guests; and five other trains followed, the whole forming an imposing array. The speed attained was twenty miles an hour until Parkside was reached, half-way to Manchester, where a halt was called for the first train to be side-tracked in order that the Duke might review the grand procession. The railway pioneers were particularly anxious to impress the Prime Minister, for until the success of the "Rocket," he had viewed the iron horse with much distrust.

At Parkside some of the passengers alighted, although they had been requested to retain their seats. Among them was the Right Hon. William Huskisson, then M.P. for Liverpool, who went up to a carriage window to speak to the Duke of Wellington just as the "Rocket" approached at a rapid pace. Mr. Huskisson hesitated what to do for a moment, before attempting to clamber up into the Duke's compartment. In his haste he caused the carriage door to swing round, which threw him on to the track in front of the "Rocket," with the result that his leg was badly crushed. Although a train immediately conveyed him back to Eccles, a distance of fifteen miles, in twenty-five minutes, to receive medical attention, the unfortunate victim to the iron horse died that same evening.

THE MOORISH ARCH AT EDGE HILL

The opening of the Liverpool and Manchester Railway, September 15th, 1830

D

This unfortunate accident cast a gloom over the proceedings ; but the trains, in accordance with the programme, went on their way to Manchester to be received by a vast multitude, anxious to see the Prime Minister as well as the engines. Only fifteen years earlier the Duke of Wellington had won one of the greatest history-making battles ever known ; and now he was taking part in another, that would in the course of time change the outlook of the whole world.

On the return journey occurred an incident that formed no part of the pre-arranged plans. While four of the engines had gone several miles down the line to take in water, the Duke decided to return earlier than according to the programme, in order to escape the attentions of the crowd. His train at once put the light engines in a difficulty, for they could not return to Manchester without delaying the august visitor, and therefore they ran ahead all the way to Liverpool, leaving two engines to convey on the return journey the carriages that earlier in the day had been drawn by six.

Naturally, the death of Mr. Huskisson gave the pessimists an opportunity to point out the dangers attached to the new method of locomotion ; and there is no doubt that for some time it militated against confidence in the Liverpool and Manchester line. But, nevertheless, the triumph of the locomotive could not be gainsaid ; the line was worked without further mishap ; Parliament did not think fit to throw any unnecessary obstacles in the way of new railways that were under projection ; and shortly public attention was drawn favourably to the idea of an iron road to connect London and Liverpool.

The Canterbury and Whitstable Railway was opened four months earlier than the Liverpool and Manchester line. It was the earliest railway in the south of England, for the Surrey Iron Railway was worked by horses and was never a success ; and as the Stockton and Darlington line was primarily for the conveyance of minerals, the Kentish railway was really the first passenger line in this country. The first locomotive was the "Invicta," built by the Stephensons at Newcastle. The line was six miles long, and for two-thirds of it stationary engines and ropes were used on account of the steep inclines. The "Invicta" was only intended to work upon two miles of track, but part of this proved too much for the engine, which could only draw 20 tons at ten miles an hour on a level mile. In 1838 the boiler was altered—for the worse—for it was unable to get up sufficient steam, and the "Invicta" had to give place to horses. This interesting relic is now at rest in a public garden in Canterbury.

The railway pioneers and their work had been mocked and scorned, the Press had poured out vitriolic abuse upon the steam horse, the caricaturists had poked fun at the new evil that had been sprung upon a long-suffering world ; but by the year 1836 the few railways in existence were paying dividends of 10 to 15 per cent, and people interested in financial matters concluded that such profitable undertakings possessed at least one redeeming feature. Forthwith they revised their former adverse opinions, and proceeded to invest money in railways, with the result that a boom set in on the same ruinous lines as the famous South Sea Bubble. Money flowed in for wild-cat schemes that brought ruin to thousands; the industrial and financial balance of the country was wrecked for the time being; and if George Stephenson and a few other leading railway men had not stood aloof from the popular madness, the boom must have ended still more disastrously.

By 1843 there were 1800 miles of line open for traffic, and construction was making no inordinate strides, when there set in another wild gamble in railway shares. The mania endured all the next year, but in 1845 positively ran riot. In January nearly a score of new lines was registered, followed in a few months by over a thousand projections, only a small number of which ever stood the faintest prospect of receiving Parliamentary consent.

The whole country was in a state of turmoil; fraud and roguery of every description were practised on the public; bands of surveyors, guarded by carefully chosen ruffians, had hand to hand fights with opposing landowners, who organised parties to resist trespassers; navvies were viewed by countryfolk as absolute bogies; and cases of robbery and outrage were of frequent occurrence. The Stock Exchanges of London and other large cities were thronged with speculators, who tripped over each other in their anxiety to purchase worthless scrip. Of over five hundred Bills that were presented to the Commons not more than half received the Royal Assent, and still schemes were growing with almost mushroom rapidity.

The great boom was showing signs of weakness when a wearied Legislature announced November 30th, 1845, as the last day for depositing the plans of any additional new lines. That day happened to fall on Sunday, and the Board of Trade offices would close at midday. Many promoters could not get their plans ready until the last moment, and then had to run the gauntlet of opponents, who hesitated at no manœuvre to prevent the plans reaching the metropolis in time. In some cases railways refused to convey plans that threatened their own interests, and promoters could only secure their ends by artifice; it is related that one big roll of plans was placed in a coffin and taken to a station in a hearse, accompanied by mourners dressed in the trappings of deepest grief. The ultimate resting-place of the contents of the coffin was the Board of Trade offices, which for many of the schemes proved a very real cemetery so far as investors' money was concerned. Some plans started for London by coach, but never reached there, thanks to breakdowns or stolen horses, connived at by drivers and postboys, bribed by opponents. On the other hand, where a railway wished belated plans well, they were conveyed to London, so it is said, at eighty miles an hour.

The railway bubble burst! Persons reduced to beggary were to be counted by the battalion, and, to make matters worse, trade was at its lowest ebb. Some of the more sorely stricken ones took refuge in suicide, and there is no record of the numbers who found themselves in gaol until they liquidated their debts. Thus ended one of the greatest national misfortunes in the history of finance.

Nevertheless, the railway had come to stay. Stage coaches had been driven off the highways in hundreds. In the middle of 1843 only a dozen mail coaches left London for the country instead of about eighty. A couple of score of coaches that ran through

ROYAL MAIL COACH (1840)

Northampton daily were taken off the road within a few months of the opening of the line from London to Birmingham; the same story could be told concerning many other routes; and where the coaches still ran, in many cases fares had been reduced. The fares on the London to Birmingham coach, for example, had been 50s. for outside passengers and 30s. for inside. Competition with the steam horse reduced them by nearly a half, and reduction of coach fares followed even when a railway was only a competitor for part of a route. *Punch* suggested that persons interested in horse-traction might find scope for their energies in "Coachin-China."

Canal companies, too, were complaining bitterly of the ruinous competition, reducing their tolls to such an extent that £150 shares fell to £40.

People whose occupations were abolished or injured by the new means of locomotion quite naturally viewed railways as an obnoxious innovation; but, on the other hand, thousands of persons were engaged in new trades that sprang up on all sides. It is quite certain that, as a class, nobody had opposed railways more than farmers, and they were among the very first to acknowledge the benefits conferred upon them by the iron road. Norfolk cattle-breeders had hitherto sent their fat beasts to London by road. After spending about a fortnight on the journey each animal lost £3 in value by the time it reached market, to which was to be added wages of drovers, etc. The railway took the cattle to market in twelve hours without deterioration, as well as saving some of the other expenses. As early as 1843 the London and Birmingham company carried a thousand cattle, half as many again of sheep, and nearly a hundred pigs within the twelve months.

The receipts of most of the early railways were derived chiefly from passengers; on the London and Birmingham the fares amounted to £15,000 a week, or about five times the income from goods; in the mineral districts the converse obtained; but taking the country generally, the passenger traffic was about three-fourths of the whole, instead of a little less than a half as it is to-day.

The new era had commenced and commenced well. The railway was spinning its web of metal ribbons that would in the course of time embrace the whole country, from Penzance to Thurso, from Bantry Bay to Giant's Causeway. The network of iron roads would dominate the national life, double the working power of man, and prove a moral and intellectual force inseparably connected with an increase in comforts, wealth, and means of social intercourse.

When we survey the railway map of the present day with that of seventy years ago, we find that the mania for constructing lines by a large number of small companies was followed by an astonishing number of amalgamations, the Great Western Railway being a notable example in absorbing no less than a couple of hundred different lines in order to attain the largest mileage in the kingdom. There are only eighteen companies in England and Wales, each owning more than a hundred miles of line, five companies in Scotland, and the same number in Ireland. There are about two hundred existing companies, but in many cases their lines are "leased" or "worked" by bigger organisations; in the former case the small fry receive guaranteed dividends from the lessees, in the latter there is an equitable division of the receipts.

CHAPTER III

LOCOMOTIVES PAST AND PRESENT

ALL that has been said in earlier pages concerning the locomotive previous to the appearance of the "Rocket" may be viewed as a brief record of its infancy, during which it was subject to a whole host of juvenile complaints that the engineering nurses and doctors could not diagnose with any certainty. In many cases a kill-or-cure method was adopted, which resulted in a multiplication of aches and pains; but here and there arose a practitioner who eased a strained joint or brought relief to a suffering organ. George Stephenson was the physician who docketed the prescriptions of his predecessors and contemporaries, and extracted from them the specific cure that should set the child firmly on its feet, or rather wheels, with the assured hope of a prosperous youth.

In reviewing some of the more notable types of locomotive adopted by railway engineers it will be well to commence with the "Rocket," which undoubtedly possessed the chief elements of the modern locomotive. Its leading features were a multitubular boiler (twenty-five tubes); the use of exhaust steam to force the draught; and direct connection between the piston-rod and crank-pin secured to the driving-wheel. Neither of these features was Stephenson's own idea. The multitubular boiler had been used in the United States and France; Trevithick had increased the draught in the chimney by means of the exhaust steam; and the direct piston and crank-pin connection had been employed on several locomotives. No engine, however, before the "Rocket" had shown all three excellences, or had been so simple of design and without superfluous parts to get out of order.

But although Stephenson introduced the pioneer of a new type, his success could not rob Trevithick of the credit of being the first to produce a practical locomotive. It is, indeed, said that of the test engines at Rainhill the "Sanspareil," but for an accident, was really the best, and "the success of the modern railway system would have been nearly the same had the 'Rocket' never existed."

Coloured Plate II shows an exact model of the "Rocket," which was constructed at Crewe Works. By its side is depicted the man who rightfully is termed the "Father of British Railways."

Although the "Rocket" was a maker of railway history, its career was rather inglorious. Its lack of weight rendered it practically useless for anything but very light traffic. A month after the opening of the Liverpool and Manchester line the engine, tender first, was drawing ballast wagons on Chat Moss when a tender axle broke. The water supply was carried in a large barrel which fell from its position, killing a man who was sitting on a step at the back of the tender. Four months later the engine, although one of its axles was bent, was set to draw a passenger train. The axle broke, and the train came to grief in a cutting. In 1837 the "Rocket" was sent to work coal traffic on the Brampton Railway, but at the end of three years it was put aside. Eventually it was sent back to Stephensons' works at Newcastle, and in due course found its way to South Kensington Museum.

Within but a few months of the opening of the Liverpool and Manchester line the Stephensons built the "Planet," which drew the first goods train from Liverpool to Manchester. This locomotive contained the latest improvements known to engineers. The "Rocket" was a four-wheeled engine, the drivers in front receiving their power from outside diagonal cylinders. In the "Planet" outside frames were used for the first time, and the driving-wheels were behind, deriving their power through a cranked axle from horizontal cylinders located in the smokebox. Hackworth was the first to use horizontal cylinders, and Edward Bury had designed a crank axle with the cylinders in the smokebox as early as 1829; but the Stephensons set the fashion, and for many years our locomotives with outside frames were only variations of the "Planet" type, and as many of them were exported to the United States they exercised no little influence on the designs of locomotives in the New World. It is a remarkable fact that the "Planet" was capable of a speed exceeding fifty miles an hour.

In 1834 the Stephensons built six-wheeled engines for the Liverpool and Manchester Railway, as did Forrester of Liverpool, and in due course they became the general pattern for passenger engines for very many years. Forrester's engine was distinctive in several respects. Its outside horizontal cylinders (11×18 inches) were quite novel in British practice, and no other engine had been built with four eccentrics, wheels, or discs having their axis of revolution out of the centre of figure, and used in the valve gear for obtaining a reciprocating or alternate motion from a circular one. When travelling at high speed, these outside cylinder engines, without balanced driving-wheels (5 feet in diameter), were much given to oscillation, for which reason they were known as "Boxers."

When Daniel Gooch entered Stephenson's employ in 1836 he was at once set to work on the designs for half a dozen engines of 6-foot gauge required for Russia. The next year found Gooch, who was only twenty-one years of age, appointed locomotive superintendent of the Great Western Railway, whose first engines were a couple of those intended for Russia, which the Stephensons had refused to deliver owing to the doubt of receiving payment. Named respectively the "Morning Star" and "North Star," they had been altered to the 7-foot gauge to suit the new line, and the driving-wheels were enlarged from six feet to seven feet. The "North Star" was really the only reliable engine that the Great Western Company owned when the line was opened; it had a heating surface of 724 sq. feet, and attained a speed of

"NORTH STAR"
(Great Western Railway)

thirty-seven miles an hour. It was in service until 1870, by which time it had run about 430,000 miles.

In 1829 Messrs. Edward Bury and Co., general engineers, of Clarence Foundry, Liverpool, constructed their first locomotive. It was a six-wheeler, but, proving to be unsatisfactory, was altered to the four-wheeled type. It was tried upon several lines without success, and was dismantled. The second engine was a four-coupled goods. It ran its first trial on the Liverpool and Manchester Railway, and was then bought for use on the Petersburg railroad of America, where it did good service for several years. The third engine was built for the Liverpool and Manchester Railway. It was a four-wheeled passenger locomotive with a single pair of driving-wheels, 5 feet in diameter, driven by inside cylinders, 11-inch diameter by 16-inch stroke. Its total weight in working order was 10 tons, and its heating surface 324 sq. feet. Very noticeable features were the dome-shaped firebox and the bar framing. Engines of this type were used on various British railways, and some were exported to America; but eventually, about 1846, light four-wheeled engines became unpopular and gave place to the six-wheeled type.

In 1848 Mr. Gooch commenced building at Swindon a series of sixteen engines with 8-foot drivers. They were eight-wheelers, and the names of some of them will ever be remembered in railway annals, although perhaps the "Lord of the Isles" became the

A "BURY" LOCOMOTIVE
(Liverpool and Manchester Railway)

most famous. It was shown at the Great Exhibition in 1851, and ran nearly 800,000 miles before it was placed on the retired list. This broad-gauge flier, with a heating surface of 1800 feet as compared with the "Rocket's" 138 feet, frequently ran from Paddington to Didcot, 53 miles, in 47½ minutes, and upon one occasion performed the 77¼ miles between Swindon and London in 72 minutes.

Mr. Acworth relates that one of the Great Western engine-drivers offered to drive the "Lord of the Isles" from London to Bristol, 118½ miles, within the hour. He only stipulated that the Company should look after his wife and children if his race against time ended in disaster. The directors were quite satisfied with the engine's ordinary performances, and declined the proposal of the enthusiastic record hunter.

In this brief review of locomotive development attention is drawn only to a few of the outstanding efforts of various locomotive superintendents, who were endeavouring to find types best fitted to meet the requirements of their own particular lines. Many fine efforts of numerous locomotive builders will not even be mentioned at this stage, leaving them to be dealt with under their separate companies.

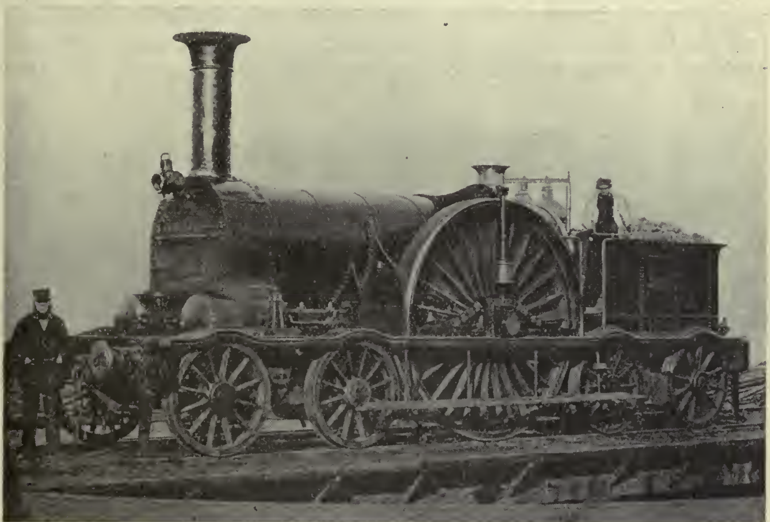
Messrs. Sharp Bros. in 1846 designed engines that came to be known as "Sharpies," and some were in use on nearly every standard-gauge railway in the kingdom. Probably no other pattern was ever built for so many different railways. A year later David Joy, the inventor of a famous valve motion, placed some celebrated locomotives, known as the "Jenny Lind" class, on the London and Brighton Railway. The cylinders were 15-inch diameter by 20-inch stroke; driving-wheels, 6-feet diameter; boiler, 11 feet long and containing 124 tubes. The heating surface was 780 sq. feet, and the steam pressure, as in Gooch's engines, was 120 lbs., which was then considered a very high tension and a great advance upon the "Rocket's" 50 lbs. pressure. Several companies claim to have possessed the original "Jenny Lind," but it seems certain that the first of this notable class was built for the York and North Midland, as described in later pages.

The rivalry between the exponents of the narrow-gauge and the broad-gauge systems led to continual improvements in their respective engines, although neither speed nor power of the locomotives themselves would settle the vexed question of gauge. Mr. F. Trevithick, in 1847, built at Crewe an engine that not only made its mark at the immediate time, but for many years afterwards. This engine was the famous "Cornwall," which is detailed in the chapter dealing with the London and North Western Railway.

There now came into practice locomotives which carried their fuel and water upon their own framing instead of on a separate tender. James Pearson's single-tank engines on the Bristol and Exeter Railway had 9-foot drivers, the largest driving wheels of any tank engine ever built, and also the largest of any locomotive that ever accomplished really useful work. These engines, working at 130 lbs. pressure, regularly attained a speed of 80 miles an hour, which for many years was reckoned the limit of any locomotive's capabilities. Tank engines, however, will be considered fully at a later stage.

McConnell's "Big Bloomer," on the London and North Western Railway, introduced another notable class in 1862, with cylinders 16×22 in., 7-ft. driving wheels, and 1150 sq. ft. of heating surface. In 1869 we find the Great Western Railway reverting to the "North Star" type, but with a modern boiler, cab, etc.

At this point it will be well to consider the question of compounding the cylinders, through each of which the steam passes before finally escaping as exhaust steam. In the high-pressure cylinder, which is small, the steam does the first part of the work, before it passes into the low-pressure cylinder to expand and exercise more force, so that by compounding more work is achieved by the same supply of steam. Compound engines were introduced into steamships in the middle of the nineteenth century, followed in a few years by the triple-expansion engine; and so satisfactory has the compounding of steam proved for marine propulsion, that quadruple-expansion engines have become quite common, affording an enormous access of power with a considerable saving of fuel.



EARLY TANK ENGINE, WITH 9-FT. DRIVING-WHEELS
(Bristol and Exeter Railway)

In 1850 two compound locomotives were built for the Eastern Counties Railway (now the Great Eastern). It was reported that they gave very satisfactory results, but compounds in Great Britain made little real progress until 1878, when Mr. F. W. Webb, of the London and North Western Railway, converted an old simple engine into a compound. Such good results were obtained that in 1881 an entirely new form of compound locomotive was constructed with two outside high-pressure cylinders, and one low-pressure cylinder underneath the smokebox between the front wheels. The first of these engines, No. 66, received the appropriate name of "Experiment."

The trial trip of the "Experiment" more than satisfied its builder. The engine assisted to draw a heavy express from Crewe to London, where Mr. Webb promptly coupled it to the Irish mail, which it took to Holyhead. So well had the "Experiment" behaved that it was attached next to the boat express, which it drew as far as Crewe, making a total trial trip of 528 miles.

Mr. Webb at once became convinced that compound locomotives would meet the particular necessities of the London and North Western line, and proceeded to build others, among them some with large cylinders and slightly smaller wheels, capable of drawing the Scotch express from London to Carlisle, and negotiating the Shap incline, with its gradient of 1 in 75 for five miles, without the assistance of the "bank" engine, that had hitherto been used to help trains up the hill. In these engines the wheels were not coupled; the low-pressure cylinder, working a crank on the axle, drove the front pair of the four

No. 66, "EXPERIMENT"
(London and North Western Railway)

driving wheels; the high-pressure cylinders drove pistons and crank for the hind wheels.

Locomotive engineers never did, and apparently never will, agree concerning compound engines. Mr. Webb maintained that the compound system gave a more powerful engine than the simple locomotive of the same weight, with a saving of about 6 lbs of coal per mile. What the latter means may be estimated from the fact that in a year London and North Western engines run 47,000,000 miles. If all the engines were compounds they would economise coal to the extent of 125,000 tons, sufficient to make a considerable impression upon the dividends received by the shareholders. Upon the other hand, opponents urge that a locomotive has no time to expand its steam more than is effected by the "cut off" early in the stroke, and it must be remembered that one stroke of the piston is only separated by a quarter of a second from the next. Only experts can attempt to assess such a theoretical objection at its correct value; but the practical objection is more understandable to the lay mind. A compound engine is more complicated, is more costly in building and to keep in repair; it consumes far more oil and tallow; the boiler, firebox, and boiler tubes wear more rapidly under the increased steam pressure; and these extra expenses are said not to be atoned for by the saving of fuel.

With the increasing weight in passenger trains, one pair of big driving wheels was found insufficient to afford the necessary adhesive weight, and consequently the coupling principle was applied to the wheels of passenger locomotives. In 1836 Campbell, of Philadelphia, patented an eight-wheel engine with a leading truck, one pair of driving wheels in front of the firebox and the other pair behind. This was the prototype of what afterwards became styled the "American" Locomotive, to be more or less copied on all the railroads of the world.

William Stroudley, of the London, Brighton, and South Coast Railway, in 1885 designed a series of six-wheeled engines known as the "Gladstone" class. He coupled the four leading wheels, which were 6-ft. 6-in. in diameter; and by decreasing the two trailing wheels to 4-ft. 6-in. he was able to increase the width of the firebox very considerably. The cylinders were $18\frac{1}{4} \times 26$ in., grate area nearly 21 sq. ft., and the total heating surface 1492 sq. ft.

The early railway engineers believed that driving wheels of large diameter were necessary to attain high speed, regardless of the size of the cylinders and an adequate supply of steam. During the "battle of the gauges" the champions of the rival systems considered that "big wheels" would decide the knotty problem. Brunel experimented with locomotives with single drivers 10-ft. in diameter, while some of those that had smaller wheels were geared up to produce the effect of wheels having diameters of 18-ft. These engineering monstrosities were absolute failures, but the narrow-gauge exponents replied with 8-ft. 6-in. drivers, as in Trevithick's "Cornwall" and Crampton's "Liverpool," which had 8-ft.-drivers. In the end Brunel adopted 8-ft. as the maximum practical size for single wheels, while the driving wheels on the normal gauge settled at 6-ft. or 7-ft., with a few notable exceptions, such as the London and North Western locomotives of the "Problem" type with 7-ft. $7\frac{1}{2}$-in. drivers, while the Caledonian went in for 8-ft. 2-in. and Patrick Stirling of the Great Northern adopted a diameter of 8-ft. 1-in.

It may be remarked that the speed of a locomotive's mechanism is relatively slower than is the case in many steam engines used for other purposes. A locomotive with 6-ft. drivers, when running at 60 miles an hour, makes less than 300 revolutions a minute, whereas a high-speed engine such as generates electric light will attain 400 revolutions; and if the speed of the locomotive be increased to 80 miles an hour the revolutions would still be lower than in other types of engines. Increasing the diameter of the driving wheels naturally decreases the revolutions per minute.

"GLADSTONE" (STANDING ON TURN-TABLE)

For the attainment of high speeds it is power, rather than size of wheels, that is the main factor, for four-coupled 6-ft. 6-in. wheels in actual practice have attained as high speed as any 8-ft. single wheeler, namely about 90 miles an hour. In some speed tests in Germany the driving wheels of a steam locomotive with only one twelve-wheeled car attached, in attaining a speed of 85 miles an hour, revolved 370 times per minute with an indicated horse-power of about 1500; whereas the wheels of an electric car, travelling 130 miles an hour, revolved about 1200 times per minute and developed twice the horse-power. In the case of this electric engine the whole of the machinery was revolving, as against that of the steam locomotive, partly revolving and partly reciprocating. It is quite evident that to obtain the highest speeds some form of electric motor, or possibly an adaptation of the turbine system, is necessary.

No. 123 (Caledonian Railway)

Meanwhile James Stirling did not hesitate to follow in Campbell's track more closely, for in 1873 he constructed engines with four connected wheels led by a four-wheel truck, or bogie, a feature of construction that has come into use in all modern passenger express engines, whether single or coupled.

The introduction of coupled wheels in passenger engines by no means ousted the single-driven type, which various companies retained for their fastest express engines; and even where coupled wheels had been introduced, the single was resuscitated on different lines, notably by Mr. S. W. Johnson in 1887, on the Midland Railway, where for a score of years or more coupled wheels had been the general rule. In 1886 the Caledonian Railway built a single-driven "flier," No. 123, which did excellent service in the 1888 race to Edinburgh, exemplifying the capabilities of the modern single, with improved adhesive weight and better sanding arrangements, that to a great extent modified the slipping, which was ever the inherent bugbear of singles. The Caledonian Railway did not follow up No. 123 with other engines of the same type, but Mr. Johnson built nearly a hundred new singles within the short space of three years. Mr. Mathew Kirkley's singles, which were abandoned on the Midland in 1865, were six-wheelers, with the drivers 6-ft. 8-in. in diameter, whereas Mr. Johnson's had a four-wheeled bogie instead of a single pair of leading wheels. The diameter of the driving wheels differed in various batches, the smallest being 7-ft. 4½-in. and the largest 7-ft. 9½-in. diameter.

The year 1888 was a notable one in British railway annals owing to the rivalry of the companies concerned in the passenger traffic to Scotland. The West Coast route from London to Edinburgh is via the metals of the London and North Western as far as Carlisle and thence onwards by the Caledonian Railway; and trains carrying third-class passengers occupied ten hours on the journey of 401 miles. In November the East Coast partners, viz. Great Northern, North Eastern, and North British Railways, commenced a third-class service of nine hours, which naturally had the effect of attracting passengers from the rival route. The West Coast companies waited until the last few days of the following July, when they announced that on August 1st they would run to Edinburgh in 8½ hours. The long journey was accomplished in schedule time, but upon that very day the East Coast people performed the journey in eight hours. Not to be outdone, the West Coast promised their patrons that the journey should be done in 8 hours, to which the East Coast replied with another reduction of 15 minutes; but the West Coast got to the journey's end in 7 hours 38 minutes.

If the West Coast partners thought that they had reached finality in the matter they were mistaken, for the East Coast train on the next day reached Edinburgh in 7 hours 32 minutes, stopping to make the usual calls, as if no thought of racing was in the minds of the officials. The West Coast, thereupon, cried *peccavi*; but the travelling public had occasion to be grateful for these speed trials, since on the East Coast the time was now permanently cut down from 9 to 7¾ hours, and via the West Coast from 10 to 8 hours.

During the next ten years there were constant improvements in engines and general equipment of our railway lines, many details of which will be given in later pages.

In 1895 the East and West Coast companies again caught the racing fever. The former ran a train from King's Cross to Aberdeen in 11 hours 35 minutes, and in June the West Coast proposed to quicken their service to 11 hours 40 minutes. The East Coast promptly accepted this as a challenge, and from July 1st decreased their own time by 15 minutes, and the West Coast went one better by doing the full distance in 11 hours. The East Coast route is sixteen miles the shorter, and there was apparently little difficulty in cutting their time down to 10¾ hours. But the West Coast were out for the honours, and, ignoring their own time-tables and treating the train as a special of specials, reached Aberdeen in 9 hours 59 minutes.

It took the East Coast officials several weeks to get over the surprise and to map out a plan of campaign, when they announced their intention of completing the whole distance in 9 hours 40 minutes, or 19 minutes better than their rivals. On the Monday night the West Coast train left Euston at 8 p.m., scheduled to arrive at Aberdeen at 7 a.m., although the officials knew the train would reach its destination as quickly as steam and good driving could take it along a road absolutely clear of traffic, in order that there should be no irritating delays.

The driver of the East Coast train received instructions at King's Cross to throw scheduled time overboard ; he was to get to Aberdeen on the wings of the wind ; and above all he was to get there before the West Coast train. He tried his best, but failed, for at three different places between London and York he was checked by signals that caused him to lose 2 minutes, and at Eryholme a full 5 minutes was lost owing to the error of a signalman. Nevertheless the train ran into Edinburgh (Waverley Station) six minutes ahead of the scheduled time. The Edinburgh station master had received no special instructions, and he refused to allow the disgusted driver to draw out of the station until the regulation time. At Dundee the train was again 6 minutes early ; again the station master delayed the resumal of the journey, and the East Coast train was out of the running for that trip.

Next night the East Coast racer found no signals against it, and at Edinburgh and Dundee the station officials did their utmost to assist the eager driver. All went well as far as Kinnaber, 33 miles north of Dundee, from which point the train left the North British rails to complete the journey by running powers over the Caledonian Company's metals. Here the West Coast racer got "line clear" by less than sixty seconds over the East Coast train, and consequently showed the way into Aberdeen.

On the night of August 21st the East Coast train, drawn by a Stirling 8-footer, set out to make hay of the West Coast record. It reached Peterborough, 76¼ miles, in 72 minutes, and drew up at Grantham, 105¼ miles, in 101 minutes, where another 8-footer took charge. Only 181 minutes were occupied for the 188 miles to York, where a North Eastern express 7-ft. coupled hitched on to run the train to Newcastle. Here a fresh engine of similar type took up the running, and averaged 66 miles an hour to Edinburgh, incidentally achieving a record of 6 hours 19 minutes for the 395-mile trip from London. From Edinburgh a North British engine, 6-ft. 6-in. coupled, carried the train to Dundee, where another of the same company's engines was attached for the last stage ; and eventually the train drew up at Aberdeen at 4.40, nearly a quarter of an hour in front of the West Coast "flier"—523 miles in 8 hours 40 minutes, 60 miles an hour for the whole journey, with several minutes in hand.

On the succeeding night the West Coast train, in lightest racing trim, 80 tons only behind the tender, made a purely exhibition run. From London to Crewe the train was drawn by a 7-ft. compound, the "Teutonic," and from Crewe to Carlisle by the "Hardwicke," the latter stretch of 141 miles being done at a little over 67 miles an hour. From Carlisle to Perth a Caledonian 6-ft. 6-in. coupled engine was employed, and a 7-ft. single drew the train for the remainder of the distance to Aberdeen, which was reached in 8 hours 32 minutes after leaving Euston, or at the rate of over 63 miles an hour for the full distance.

The "Race to the North" acted as a stimulus to other British companies to increase the number and length of their long-distance

NO. 777. A STIRLING EIGHT-FOOTER
(Great Northern Railway)

runs, and those already in practice were quickened considerably. Of special trial runs that were made three will suffice. On August 3rd the Caledonian Railway engine No. 90 ran the West Coast racing train from Carlisle to Perth, $150\frac{3}{4}$ miles, in 149 minutes, which was the longest run ever performed without taking up water on the road. On September 1st the London and North Western Railway engine "Ionic" ran a special from Euston to Carlisle, $299\frac{1}{4}$ miles, without stopping, in 353 minutes, which was a record British run. On November 3rd the Great Eastern Railway engine No. 1006 made *two* runs, one each way between Liverpool Street and Cromer, 135 miles, without stopping in either direction.

But the rivalry of the British East and the West Coast routes was to have an altogether unforeseen effect. Nowhere were the results watched with greater interest than in the United States, where the railway engineers accomplished runs of 436 miles at $64\frac{1}{4}$ miles an hour just by way of preliminary. Next they selected a longer track, viz. 424 miles from Chicago to Erie and then 86 miles farther to Buffalo Creek. The racing train, which had 136 tons behind the tender, ran at just over 63 miles an hour to Erie, where a change of engine had to be made. For some reason or other the organisers of the race utilised a goods engine with six-coupled wheels of 5-ft. 8-in. diameter and a leading bogie. British engineers would have considered such wheels as utterly hopeless for speed purposes, yet this engine ran to Buffalo Creek in a fraction over 70 minutes, averaging nearly 73 miles an hour, and raising the average of the whole run of 510 miles to 65 miles an hour.

This result savoured of the nature of a shock to the disciples of the big wheel, and forthwith British engine builders commenced to produce the American type of eight-wheeled engines, with the four-coupled drivers of considerably smaller diameter than heretofore. Rarely do they exceed 6-ft. 6-in. nowadays.

In September, 1895, the New York Central Railway attempted to break all speed records, and the report that 112·5 miles an hour had been achieved created no little stir in British railway circles. Examination of the claim showed that the trip from New York to East Buffalo, 436·32 miles, occupied 6 hours 52 minutes, or less than 64 miles an hour. On the second stage of the run from Albany to Syracuse another engine took the train of four cars, weighing 160 tons, and only succeeded in making an average of 81 miles an hour, but 112 miles an hour was made for only 1 mile, which was covered in 32 seconds on a descending grade of 15 feet per mile.

The increasing length of engines made a leading bogie an absolute necessity for engines intended for high speed, for there is a limit to the "fixed-wheel base," which means that if the distance between the centres of the wheels rigidly fixed to the main frames is too great, the engine would not traverse curves. The bogie truck with its smaller wheels is not fixed rigidly to the frames, but is connected by means of a "pin" around which the truck can swivel sufficiently to take a curve at a high speed, literally feeling and fitting its way, where rigid leaders would assuredly jump the rails.

From this time onward it is more than ever impossible within the limits of a single chapter to attempt to keep pace with the ever-varying products of the engine builder; and for anything like strict chronological order in locomotive practice the reader must be referred to the separate histories of various of our chief railway companies.

It will afford convenience to consider a systematic method of describing locomotives according to their wheel arrangements. A numerical nomenclature is easy to understand, the second figure denoting the driving wheels, and, if the figure exceeds two, it also shows the number of coupled wheels.

LOCOMOTIVE WHEEL ARRANGEMENTS

0 – 2 – 2 ..	Oo ..	4-wheel single, front driver
2 – 2 – 0 ..	oO ..	4-wheel single, rear driver
0 – 4 – 0 ..	OO ..	4-wheel, coupled
2 – 2 – 2 ..	oOo ..	6-wheel, single
4 – 2 – 0 ..	ooO ..	6-wheel, rear driver
0 – 4 – 2 ..	OOo ..	6-wheel, front coupled
2 – 4 – 0 ..	oOO ..	6-wheel, rear coupled
0 – 6 – 0 ..	OOO ..	6 coupled
4 – 2 – 2 ..	ooOo ..	8-wheel single
4 – 4 – 0 ..	ooOO ..	4 coupled, leading bogie
2 – 6 – 0 ..	oOOO ..	6 coupled, leading pony (Mogul)
0 – 8 – 0 ..	OOOO ..	8 coupled
2 – 4 – 2 ..	oOOo ..	4 coupled, leading and trailing pony
4 – 4 – 2 ..	ooOOo ..	4 coupled, ten wheel (Atlantic)
4 – 6 – 0 ..	ooOOO ..	6 coupled, leading bogie
0 – 8 – 2 ..	OOOOo ..	8 coupled, trailing pony
2 – 6 – 2 ..	oOOOo ..	6 coupled, leading and trailing pony (Prairie)
2 – 8 – 0 ..	oOOOO ..	8 coupled, leading pony (Consolidation)
0 –10 – 0 ..	OOOOO ..	10 coupled (Decapod)
4 – 6 – 2 ..	ooOOOo ..	6 coupled, 12-wheel (Pacific)

Tank engines are indicated thus: $\frac{0-4-4}{T}$, $\frac{4-6-2}{T}$, etc., and compound locomotives have the letter C affixed to the numerals, thus: 4–4–2 C, 2–2 – 2 C, etc.

The above list by no means exhausts the wheel arrangements of locomotives, but includes all the chief types used in the British Isles. Various other wheel combinations will be dealt with in considering continental and American practice.

In 1896 appeared some of Mr. Wilson Worsdell's new four-coupled bogie expresses (4–4–0) constructed for the North Eastern Railway, which were the largest engines built in the United Kingdom up to that time. The coupled drivers were 7-ft. 7¼-in. in diameter, the largest running on any British line. The cylinders were 20×26 in. The boiler was 11-ft. 6-in. long with a diameter of 4-ft. 4-in., and contained 201 tubes. The total heating surface was 1300 sq. ft. Some of the East Coast trains ran from Newcastle to Edinburgh without a stop, only rendered possible by extra water tanks to bring the capacity up to 4440 gallons. The new engines only carried 5 tons of coal and 4000 gallons of water, being fitted with a scoop to refill from new track troughs laid south of Berwick. The cab ensured better protection for the driver and fireman from the weather than on any other engines.

The London and South Western Railway put into running engine No. 136, which possessed a wind-cutter in the shape of a conical front to the smokebox. From the very earliest days of railways builders tried various experiments to give a "prow"-shaped front. The Great Western Railway in particular made elaborate experiments to ascertain the value of a tapering front. In reality head resistance of the atmosphere or wind counts for little compared to the effects of a side wind, which causes all the flanges of the wheels on the opposite side of the train to grind against the edge

NO. 1870. BOGIE EXPRESS LOCOMOTIVE
(North Eastern Railway)

of the rail. A corridor train, with the spaces between the long carriages covered in, also meets with less resistance from the wind than a train consisting of a great number of ordinary short carriages.

Mr. James Holden, of the Great Eastern Railway, constructed both passenger and goods engines to burn liquid fuel. Goods engine No. 611, built in 1896, will serve as a capital example. The leading dimensions were: diameter of drivers 4-ft. 11-in., cylinders 17½-in. diameter by 24-in. stroke. The boiler barrel was 10-ft. long and 4-ft. 4-in. outside diameter, and contained 130 "Serve" tubes 2½-in. external diameter with a heating surface of 880 sq. ft.; firebox heating surface 105·5 sq. ft.; and the grate area 17·9 sq. ft. The working pressure was 140 lbs. per sq. in. The tender carried 650 gallons of oil in two cylindrical tanks, from which it was conducted by a flexible connection to the engine footplate for delivery to the two patent burners provided for spraying the oil-fuel into the firebox above the layer of broken fire-brick spread over the grate. This method of firing is extremely simple, requiring no special constructions in the firebox to preclude the use of a coal fire without radical rearrangement of the furnace. The tender also carried 2640 gallons of water.

In Jubilee year, 1897, there were some great strides in locomotive construction, especially in the direction of larger boilers. The Caledonian Railway, for example, put out new engines with boilers more than 11 ft. in length.

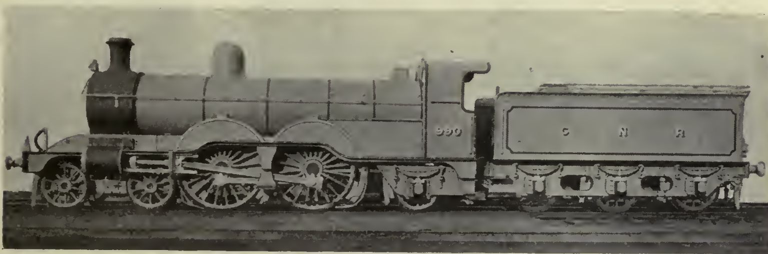
Some of the London and North Western Railway engines in 1897 showed striking deviations from regular practice, of which the "Hampden," No. 1532, may be cited.

NO. 611. LIQUID FUEL BURNER
(Great Eastern Railway)

Originally built in 1866 by Mr. Ramsbottom, it then had four coupled drivers 6-ft. 7½-in. in diameter and a single pair of leading wheels 3-ft. 7½-in. In 1892 it was rebuilt by Mr. Webb, who increased the coupled wheels to 6-ft. 9-in. in diameter and the leading wheels to 3-ft. 9-in. The working pressure was 150 lbs. per sq. in. In 1897 it made its appearance with an extended smokebox, and a novelty in the shape of a double chimney. One exhaust was discharged up each chimney, and a horizontal plate was fixed in the smokebox, dividing it into two chambers. One of the chimneys was carried down through the partition into the lower chamber, and the exhaust up this chimney consequently drew the fire through the bottom tubes, while the other chimney created a suction through the upper tubes.

Other notable engines of the same company were No. 1501, "Iron Duke," with four high pressure cylinders, and No. 1502, "Black Prince," a four-cylindered compound. In the latter the high-pressure cylinders were 15-in. diameter and the low-pressure cylinders 19½-in., the stroke of all being 24-in. A working pressure of 175 lbs. per sq. in. was afforded by 1400 sq. ft. of heating surface. The "Black Prince" and "Iron Duke," afterwards renamed "Jubilee," were each fitted with a double chimney, which were soon changed back to those of the ordinary type.

Very shortly the Americans again attacked the speed records. Upon the Atlantic City Railway the 50½ miles from New York to Atlantic City were accomplished in 50 minutes, or 66 miles an hour, and the engines proved themselves capable of doing it in 47½ minutes or over 80 miles an hour. These locomotives had a two or, more generally, a four wheeled bogie in front, four-coupled driving wheels, and two trailers. This wheel arrangement, which became known as the "Atlantic type," was afterwards adopted by British engineers in the hope that one powerful engine would prove sufficient to



NO. 990. "HENRY OAKLEY," THE FIRST BRITISH LOCOMOTIVE OF THE "ATLANTIC" TYPE
(Great Northern Railway)

draw the heavy corridor trains, which frequently called for the employment of a couple of locomotives, especially on difficult gradients.

Mr. H. A. Ivatt in 1898 brought out No. 990, "Henry Oakley," the first British engine of the Atlantic type (4–4–2), the forerunner of many more or less similar engines, put into running on various of our principal railways. The four coupled wheels were 6-ft. 7½-in. in diameter, while the bogie and trailing wheels were 3-ft. 7½-in. in diameter. The boiler was exceptionally large at that period, viz 4-ft. 8-in. in diameter. The heating surface was 1442 sq. ft.; working pressure 175 lbs. per sq. in.; and weight of engine 58 tons.

It is interesting to notice the speed attained by our best trains in the opening year of the twentieth century, remembering that the times do not represent the highest speed capabilities of the engines, but only the highest speed compatible with the general services of the respective lines. Railway racing has its value in affording the engineers useful data for future guidance, but enormous speeds are only possible at the expense of the ordinary passenger and goods services, which have to give way to the racing trains. Appended are a few of the more notable long runs, 100 miles and more, made by booked trains, of which there were nearly 120 on the various systems.

ONE HUNDRED MILE RUNS IN 1901

Railway	From	To	Miles	Shortest time hrs.	min.
L. & N.W.	Euston	Crewe	158	3	1
,,	Crewe	Carlisle	141¼	2	44
,,	Euston	Stafford	133½	2	40
,,	Stafford	Holyhead	130¼	2	40
G.W.	Paddington	Exeter	193¾	3	38
,,	,,	Birmingham	129¼	2	23
,,	,,	Bristol	118½	2	13
G.N.	King's Cross	Doncaster	156	3	1
,,	,,	Grantham	105½	1	55
Midland	St. Pancras	Nottingham	123¾	2	23
,,	Leeds	Carlisle	112¾	2	17
G.E.	Liverpool Street	Yarmouth	121¾	2	50
G.C.	Marylebone	Leicester	103	2	5
N.E.	Newcastle	Edinburgh	124½	2	22
Caledonian	Carlisle	Stirling	117¾	2	1

FASTEST BOOKED RUNS IN 1901

Railway	From	To	Miles	Min.	Miles per hour
Caledonian	Forfar	Perth	32½	33	59·1
N.E.	Darlington	York	44¼	45	59
G.N.	Peterborough	Finsbury Park	73¾	80	55·3
N.B.	Berwick	Edinburgh	57½	63	54·7
L. & S.W.	Okehampton	Yeoford	14½	16	54·4
Midland	Chesterfield	Leeds	49¾	55	54·3

Among various notable runs of that year may be mentioned a record run on June 5th from Southampton Docks to London (Waterloo), when a special train conveyed passengers from New York, *ex* s.s. *St. Paul,* for the Chamber of Commerce banquet. The train was worked by London and South Western engine No. 708, with four large bogie vehicles behind the tender. The 80 miles were accomplished in 76 minutes, averaging 63·1 miles per hour. Later in the month the Great Western ran a special from Paddington to Cardiff on the occasion of the Royal Agricultural Show. Engine No. 3387, "Roberts," left London at 9 a.m. with a load of six eight-wheeled vehicles. It was timed to reach Cardiff at 12.5, but, notwithstanding five minutes' delay caused by signals, the destination was reached at

11.50; and similarly good running was made on the return journey. In July King Edward visited Keele Hall, Staffordshire, travelling from London to Whitmore and back by special trains, which performed the journey of 147¾ miles without a stop. The engines used in these runs were No. 1915, "Implacable," and No. 1942, "King Edward VII."

In the succeeding twelve months the services on many of our principal lines were accelerated generally, for example, the London and North Western knocked off 6 minutes in the journey from Euston to Crewe; and the Midland ran from Leeds to Carlisle, and the Great Central from Marylebone to Leicester, each in five minutes' less time. The London and North Western services between London and Birmingham, Manchester and Liverpool were quickened considerably to 2 hours, 3 hours 45 minutes, and 3 hours 50 minutes respectively.

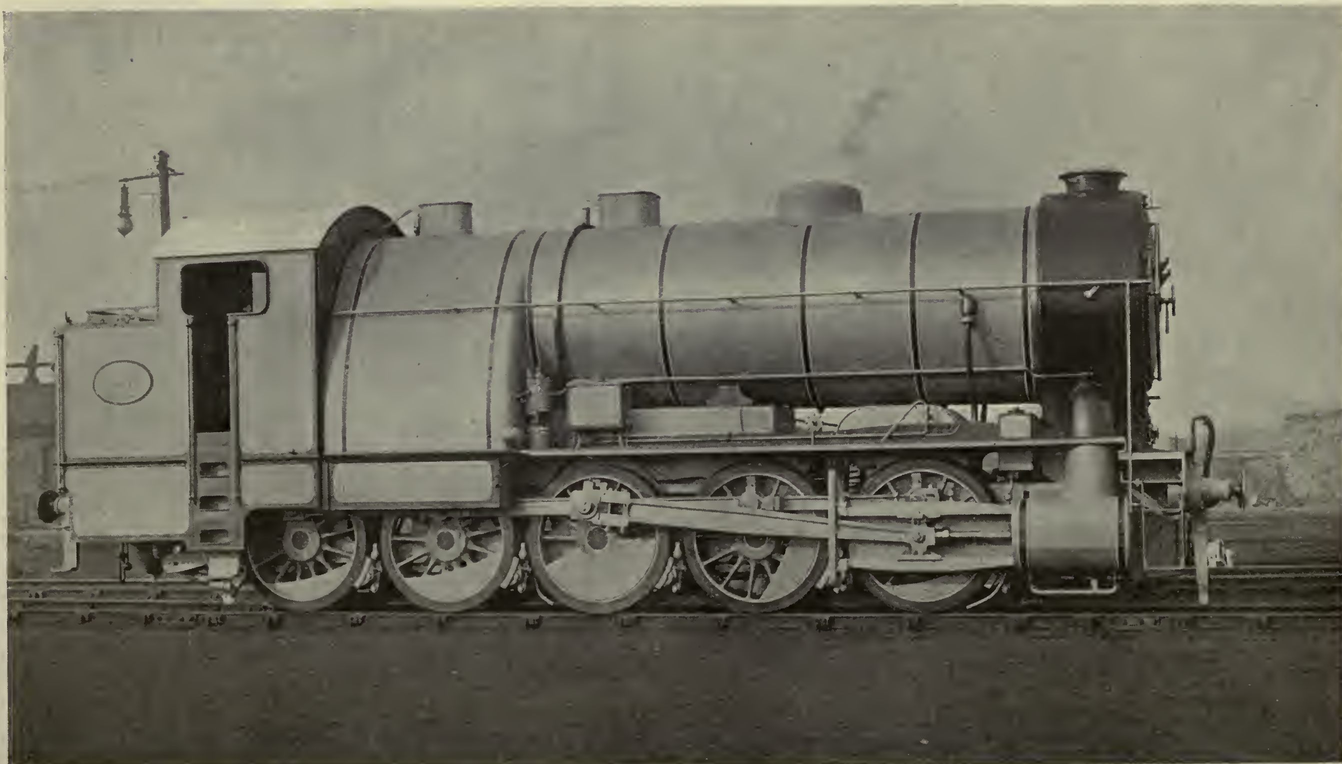
In the matter of fastest booked runs there were marked changes as shown below:

Railway	From	To	Miles	Min.	Miles per hour
N.E.	Darlington	York	44¼	43	61·7
Midland	Appleby	Carlisle	30¾	31	59·4
Caledonian	Forfar	Perth	32½	33	59·1
L. & N.W.	Birmingham	Euston	113	120	56·5
G.N.	Grantham	King's Cross	105½	114	55·5
G.W.	Paddington	Birmingham	129¼	140	55·4

By cutting down the run from Darlington to York to 43 minutes the North Eastern secured pride of place, being the first instance in England of a regular booking at over 60 miles an hour.

Mr. Ivatt in 1903 built an engine of practically similar dimensions to his first "Atlantic," except for a still larger boiler of 5-ft. 6-in. diameter and a heating surface of 2500 sq. ft. The firebox showed a marked departure from usual practice, being short and wide, instead of long and narrow, and extending over the frames. The extra girth of the boiler barrel necessitated raising it above the driving wheels, calling for a shortening of the chimney in order to meet the requirements of the loading gauge. The engine weighed 68 tons, or an increase of 10 tons over the first British example of the "Atlantic" type. The large barrel and squat chimney robbed it of anything approaching gracefulness of outline, substituting a massiveness that impressed even the lay mind. The tender carried 6 tons of coal and 3500 gallons of water, and when fully equipped weighed 53 tons.

To cope with the enormous suburban traffic in and out of Liverpool Street Station Mr. James Holden designed and built a massive "Decapod" tank engine, capable of attaining a speed of 30 miles an hour with a heavy load within 30 seconds. No British engine had ever been constructed of such massive dimensions, and various



"DECAPOD," A MONSTER TANK ENGINE FOR HEAVY SUBURBAN TRAFFIC
(Great Eastern Railway)

of the monster's arrangements called for a large measure of ingenuity. The boiler barrel, $15\frac{1}{2}$-ft. long and diameter 5-ft. 3-in. inside, had its centre line 9-ft. above rail level. The firebox extended over the wheels. The grate area was 42 sq. ft., or 15 sq. ft. more than Mr. Ivatt provided for his first Atlantic locomotive. In the boiler were 395 steel tubes, and the heating surface, all told, measured 3010 sq. ft. There were three cylinders, one inside and two outside the frames, driving ten coupled wheels of 4-ft. 6-in. diameter, the centre pair being unflanged. The total weight of the engine was 80 tons.

After amply vindicating its ability and power as a traffic hauler, Mr. Holden's famous "Decapod" proved to be too heavy for the permanent way, especially some of the weaker bridges, and was converted into an eight coupled goods with a boiler decreased

NO. 513, "PRECURSOR"
(London and North Western Railway)

to 13-ft. in length by 4-ft. 9-in. in diameter, and a reduction in the total weight of the engine from 80 to less than 55 tons.

In June, 1903, Mr. F. W. Webb relinquished the post of chief mechanical engineer at Crewe Works, where 4000 locomotives had been built under his supervision. He was succeeded by Mr. George Whale, who promptly commenced to scrap his predecessor's numerous compound-cylindered engines in favour of simples. His first non-compounds were four wheels coupled bogie locomotives (4–4–0), and intended chiefly for use on the express trains between London, Liverpool, and Manchester.

The first of these engines, the "Precursor," had the coupled wheels 6-ft. 9-in. in diameter, and the bogie wheels 3-ft. 9-in. The cylinders were inside, and were 19-in. diameter by 26-in. stroke The boiler, 5-ft. 2-in. in diameter, was pressed to 175 lbs. per sq. in.; and the total heating surface was 2010 sq. ft. In working order the engine weighed 59 tons; the tender carried 6 tons of coal, had a capacity for 3000 gallons of water, and was fitted with a water pick-up. In its trial the first of these engines drew a train of 412 tons behind the tender from Crewe to Rugby, $75\frac{1}{2}$ miles in 87 minutes. At the end of three years Mr. Whale had almost a hundred of these locomotives on the road. The reader may be reminded that Mr. Webb's Precursors, which appeared in 1874, were 2-4-0's. In the meantime a new "Experiment" class of ten-wheelers appeared, with six-coupled drivers of 6-ft. 3-in. diameter and a total weight of nearly 66 tons, specially designed for unpiloted service between Crewe and Carlisle.

On page 50 was shown an oil-fired engine carrying its oil tanks on the top of the tender. The accompanying photograph exhibits a tank resting directly upon the boiler. No. 708, as presented, was an old Stirling passenger locomotive which Mr. Ivatt equipped with

NO. 708, FITTED WITH THERMAL STORAGE TANK
(Great Northern Railway)

the thermal storage apparatus invented by Mr. Druitt Halpin. The main feature of the system consists of a storage tank in which the feed-water is maintained approximately at the same temperature as the water in the boiler. This is effected by injecting steam whenever practicable, as, for example, when the engine is standing, or carrying sufficient pressure to cause extensive blowing-off of the valves. The storage vessel is supplied with water by ordinary injectors, and the warm water is fed to the boiler by means of a special valve operated from the cab.

In 1845, on the Great Western Railway, the "Ixion" proved its capacity by running 62 miles an hour with nearly 80 tons behind the tender; and London to Exeter, $193\frac{3}{4}$ miles, was regularly accomplished in $4\frac{1}{2}$ hours. Great Western engines were always to the fore in the adoption of improvements, and played a worthy part in the evolution of the British locomotive. In 1869 was commenced the conversion of the broad-gauge lines to conform to those of Great Britain generally, a huge work that was not finally completed until 1892; and from that time the Great Western locomotives could be compared with those of other lines on level terms. In 1902 Mr. W. Dean, who had been locomotive superintendent for twenty-five years, retired, and was succeeded by Mr. G. J. Churchward.

What the Great Western narrow-gauge engines could do was shown in July, 1903, when the "City of Bath" drew a royal special, carrying the Prince and Princess of Wales, from London to Plymouth via Bath, 246⅝ miles, in 233½ minutes without an intermediate

NO. 3433, "CITY OF BATH"
(Great Western Railway)

stop. Ten months later the "City of Truro" and "Duke of Connaught" carried the American Mail Special over the same route; the first-named brought the train from Plymouth to Bristol, 128⅛ miles, in 128 minutes; the latter ran from Bristol to Paddington, 118½ miles, in 106 minutes—the whole journey occupying 3 hours 56 minutes. On May 9th all previous records were eclipsed, the total distance being covered in 226¾ minutes. Particulars of the running over the various sections are worth attention:

Plymouth (North Road) to Exeter	52	miles in	56 minutes
Exeter to Bristol (Pylle Hill)	75¼	,, ,,	64¼ ,,
Pylle Hill to Swindon	46¼	,, ,,	39½ ,,
Swindon to Paddington	77¼	,, ,,	60 m. 9 secs.

From start to stop the average running was 65 miles an hour, but at varying points during the journey the speed was 80, 90, and even 100 miles an hour.

In 1904 the leading companies went in for still further accelerations of speed, with the result that there was a greater number of booked runs at 55 miles an hour and over, than formerly there was at 50 miles. The run from Euston to Crewe (L.N.W.R.) was 10 min. shorter than in 1901, Euston to Stafford 18 minutes shorter; from Paddington to Exeter or to Bristol (G.W.R.) 13 minutes had been struck off; and the service from London to Leicester (G.C.R.) was improved by no less than 20 minutes. The fastest train still remained to the credit of the North Eastern Railway, with 61·7 miles per hour between Darlington and York; but the Great Western stepped into second place with 59·2 miles per hour between Paddington and Bristol; and the Great Central Railway rose to fourth place with 58·9 miles per hour between Marylebone and Leicester, the Caledonian Railway remaining third, as before, with 59·1 miles per hour between Forfar and Perth.

The first of a new series of passenger locomotives (4–6–0) designed by Mr. Dugald Drummond for the London and South

No. 330
(London and South Western Railway)

Western Railway made its appearance in 1905. Intended for the fast express services, this engine, No. 330, was among the most powerful ever built for British metals. It had four high-pressure cylinders, 16×24 in., and the six coupled wheels were 6-ft. in diameter. The inside cylinders drove the leading pair of coupled wheels. The boiler, with a diameter of 5-ft. 6-in., carried a working pressure of 175 lbs. to the square inch. No other British passenger express locomotive had ever possessed such an extensive heating surface, having a total of 2727 sq. ft. made up as follows: firebox 160 sq. ft; water tubes 357 sq. ft.; flue tubes 2210 sq. ft.; the grate area was 31½ sq. ft. In working order the engine weighed 73 tons.

The year 1906 witnessed the addition of numerous important locomotives to the studs of our chief companies, space allowing reference to only a few of those of outstanding merit. The Great Central series of new Atlantics (4–4–2) received a couple of experimental three-cylinder compounds, but otherwise identical with a score of preceding simple engines, except for a slight increase in firebox-heating surface, a higher boiler pressure, and an accession in weight: total heating surface 1931 sq. ft.; boiler pressure 200 lbs. per sq. in.; total weight of engine 71 tons; weight of tender, when carrying 5 tons of coal and 4000 gallons of water, 44 tons 3 cwt. One of the best known of these engines was No. 365, "Sir William Pollitt," which appeared a year later.

The Midland Railway also completed ten three-cylinder compounds (4-4-0); five of them were designed by Mr. S. W. Johnson, but the remainder were built by his successor, Mr. R. M. Deeley, who increased the boiler pressure from 195 lbs. to 220 lbs. per sq. in. On the North Eastern Railway Mr. Wilson Worsdell built four-cylinder compound Atlantic locomotives for hauling heavy loads at high speed between York and Edinburgh. These

NO. 365, "SIR WILLIAM POLLITT"
(Great Central Railway)

reversions to the compound system were chiefly for the purpose of exhaustive tests; if in working they proved to show no advantages to compensate for their slightly initial cost, their conversion to simples was a comparatively easy matter, and vice versa.

Locomotives frequently undergo marked changes within quite a few years. The Great Western "Albion," No. 171, was first built as a 4-6-0 locomotive, and afterwards was converted into one of the first Atlantics (4-4-2), taking the name of "Pirate." In 1907 it made its reappearance as a 4-6-0 with its original name, "Albion." Mr. Churchward similarly converted various of the Atlantics constructed by his predecessor.

No very startling records in running occurred in 1906, but a high standard of all-round excellence was maintained, with regular long non-stop runs becoming a growing feature. Those of over a hundred miles were as follows :—

Railway	From	To	Miles
G. W.	Paddington	Plymouth	225¾
Midland	Leeds	St. Pancras	196
L. &. N.W.	Euston	Edge Hill	192¼
G. N.	Wakefield	King's Cross	175¾
G. C.	Marylebone	Sheffield	169
Caledonian	Carlisle	Perth	150¾
G. E.	Liverpool St.	North Walsham	130
N. E.	Newcastle	Edinburgh	124½
L. & S.W.	Waterloo	Bournemouth	108

A very prominent development took place on the Great Western Railway in the opening of the Castle Cary and Langport line, by which the distance from London to Taunton and all stations beyond was shortened by exactly 20 miles. The London to Plymouth run was reduced to 4 hours 7 minutes, and London to Exeter (173¾ miles) to 3 hours.

For the summer traffic of 1907 the Great Western Railway built ten new four-cylindered express passenger locomotives (4–6–0) and named after the old broad-gauge "Star" class of nearly seventy years earlier. The boiler was of taper pattern; the four high-pressure cylinders were 14½×26 in.; and the engine in working order weighed 75 tons 12 cwt. The "Dog Star," the first of the class, was one of the most impressive-looking engines ever placed on the Great Western metals.

On Monday night, September 16th, 1907, the Great Western engine "Ophir," No. 3408 (renamed "Killarney" for this special trip), ran from Paddington to Fishguard in connection with a "day excursion" to the Killarney Lakes. The whole distance of 261 miles from London to the coast was run without an intermediate stop in 4 hours 58 minutes, an average speed of 52·7 miles per hour; on the return journey the time was 4 hours 54½ minutes, or 53·2 miles per hour. The trip was not a record for speed, and the London and North Western had exceeded it in point of distance, viz. London to Carlisle (299¼ miles) and London to Holyhead (264 miles). It was, however, the longest run on the Great Western Railway, the longest run ever made in ordinary public traffic, and it formed part of the longest "day" excursion on record—958 miles.

In 1908 the Great Western Railway put on their rails No. 111, "The Great Bear," the largest and most powerful express locomotive ever built in this country, and Britain's first engine of the "Pacific" type (4–6–2). It was a logical development of the "Star" class of 4–6–0 four-cylindered engines, with the same standard bogie and same size coupled wheels, that allow of a boiler of exceptional dimensions, in which chief interest centres. The barrel

PLATE III.

THE CORNISH RIVIERA EXPRESS.

London to Plymouth (225¾ miles) without an intermediate stop. (Great Western Railway.)

NO. 111, "THE GREAT BEAR"
(Great Western Railway)

F

was 23-ft. long, 5-ft. 6-in. in diameter at the smallest ring, increasing to 6-ft. at the largest one, with an intermediate ring forming the connecting "taper" or cone between the two sections. The Belpaire firebox had a grate area of nearly 42 sq. ft., and a heating surface of 158·14 sq. ft., to which must be added 22·22 sq. ft. contributed by four tubes, each 7-ft. 8½-in. long and 3⅜ in diameter, which extended from back to front of the firebox. In the boiler barrel were 141 fire tubes, 22-ft. 7-in. long and 2½-in. diameter. There was also a superheater in the boiler, extending the whole length of the barrel, and consisting of 21 tubes 22-ft. 7-in. long and diameter 4¾-in., each containing four steam tubes, 84 in all, of 1⅜-in. diameter, which were placed above the ordinary fire tubes, and altogether contributed a heating surface of 2673·45 sq. ft. The heating surface of the superheater tubes was 545 sq. ft., and of the whole boiler 3400.81 sq. ft. The four cylinders were 15×26 in., and the steam pressure was 225 lbs. to the sq. in. The huge engine weighed 97¼ tons, distributed as follows: on bogie wheels 18 tons 12 cwt.; on six coupled wheels 61 tons 7 cwt.; and on the radial trailing wheels 17 tons 6 cwt. The tender, so far as the Great Western Railway was concerned, was a novelty, being carried on two four-wheeled bogies; it was 9-ft. wide, and was fitted with an improved balance water scoop. It carried 6 tons of coal and 3500 gallons of water, and weighed 45 tons 15 cwt.

Meanwhile a new series of 4–6–0 four-cylinder superheated express passenger locomotives were being put also into running by the Great Western Railway. These formed the "Knight" class, which has rendered excellent service.

On the last day of June, 1909, Mr. George Whale retired from the position of chief mechanical engineer of the London and North Western Railway. In little more than five years he brought the company's locomotive equipment up to a high pitch of excellence. Nearly 200 passenger engines he consigned to the scrap-heap, and many others of doubtful efficiency he transformed into modern machines of undoubted utility. Among engines of his own designing, the "Precursors" and "Experiments" had made their mark on British locomotive practice. Of the former no less than 130 were running at the time of their constructor's retirement, with 45 of the latter class, together with about 130 of the 4–6–0 "mixed traffic" class. Only a few days before Mr. Whale left the Crewe Works two special trains, each weighing about 400 tons and carrying passengers and mails from the White Star Line s.s. "Cedric," ran through from Holyhead to Euston, 264 miles, in 4 hours 56 minutes, without an intermediate stop, the speed averaging 53½ miles per hour. This run was 71½ miles longer than the one from Liverpool to London, which hitherto had been the longest regular non-stop trip.

In the next month commenced a series of trials between London and North Western and Great Northern locomotives, the companies exchanging engines for the purpose. On the L. & N.W.R. the Great Northern Atlantic, No. 1449, started service by drawing a train from Euston to Stafford, returning in the evening with another train to London; and later the engine drew the Scotch express from Euston to Crewe. Similarly the L. & N.W. No. 412, "Marquis," was at work on the Great Northern main line. Each engine retained its own driver and fireman, with a home driver as pilot-man. About the same time the Caledonian engine No. 903, "Cardean" (4-6-0), was working the up Scotch corridor train as far as Crewe, returning to the north the following day; and a

NO. 1511, FOUR-CYLINDER EXPRESS LOCOMOTIVE
(Lancashire and Yorkshire Railway)

L. & N.W. 4-6-0 of the "Experiment" class was working the Caledonian traffic between Carlisle and Glasgow.

The Lancashire and Yorkshire Railway's four-cylinder 4-6-0 locomotives, of which in 1909 there was a score in service, are among our largest and most powerful passenger engines. They were built to cope with the greater weight of trains especially on the severe gradients on the Bradford, Huddersfield, and Sheffield sections of the line. In working order these engines weighed a little over 77 tons, while the loaded tender weighed nearly 31 tons.

On April 27th and 28th, 1910, the L. & N.W. engine No. 619, "Mabel" (2-4-0), took part in a historic event of a quite novel character. This engine was named after George Stephenson's mother, and represented the L. & N.W.R. at the Stephenson Centenary in

1881. It was now selected to accompany M. Louis Paulhan in his famous aeroplane flight from London to Manchester. When the aviator descended on the Wednesday evening, the engine was stabled at Lichfield, and resumed its journey when he started again early on Thursday morning. The speed of the aeroplane was sometimes so great that the engine-driver had difficulty in keeping level with it, while at other times the locomotive more than held its own. Whenever the aviator showed any disposition to deviate far from the railway, he was recalled by a use of the whistle on the engine. M. Paulhan's net time for the flight of 183 miles was 242 minutes, comparing quite favourably with railway timing, since until the last few years 255 minutes was considered good running from Euston to Manchester.

NO. 2663, "GEORGE THE FIFTH"
(London and North Western Railway)

The summer train services of 1910 afforded various points of interest, of which undoubtedly the chief was the opening of the new Ashendon-Aynho section of the G.W.R., by which the distance from Paddington to Birmingham and beyond was shortened by 18¾ miles. The London to Birmingham (Snow Hill) timing was promptly reduced to 2 hours for the 110¾ miles, agreeing with the timing of the L. & N.W.R. fast non-stop trains London to Birmingham (New Street). In later chapters attention will be drawn to the inter-running powers of various companies, such as was evidenced by a service inaugurated by the Great Western between Manchester and Bournemouth via Crewe, Market Drayton, Oxford, and Basingstoke. From Manchester to Crewe the Great Western coaches were attached to a L. & N.W.R. train ; from Crewe to Oxford the train was hauled by a G.W.R. engine ; and from Oxford to Bournemouth a L. & S.W.R. engine took the head.

The number of non-stop runs, over 100 miles in length and run daily, rose to 152, the most notable addition, perhaps, being the Midland non-stop run from Rotherham to St. Pancras, 162 miles.

When Mr. C. J. Bowen Cooke succeeded Mr. Whale at Crewe Works, he commenced building the first couple of a series of enlarged

"Precursors," although in detail they differed from the original "Precursors," as well as from each other. No. 2663, "George the Fifth," was the first engine on the L. & N.W.R. to be equipped with a superheater of the Schmidt type ; No. 2664, "Queen Mary," was of the same general dimensions, but without a superheater. These two engines, together with others of the "Precursor" and "Experiment" type, were set to the same work, so as to make comparative and conclusive tests of their efficiency.

EXPRESS PASSENGER LOCOMOTIVE "GEORGE THE FIFTH" (4–4–0)

Cylinders (2), 20-in. diameter × 26-in. stroke.
Boiler pressure, 175 lbs. per sq. in.
Wheels :
Truck wheels, 3-ft. 9-in. diameter
Coupled ,, 6-ft. 9-in. ,,
Truck ,, 6-ft. 3-in. centre to centre.
Coupled ,, 10-ft ,, ,,
Total wheel base, 25-ft. 1½-in.
Total heating surface, 1849.6 sq. ft.
Fire-grate area, 22·4 sq. ft.
Weight on each pair of coupled wheels, 19 tons.
Total weight of engine in working order, 59 tons 17 cwt.
Total ,, tender ,, ,, 37 tons.

So far there have come under review chiefly the passenger long-distance express locomotives with tenders ; but it must be borne in mind that on some of our greatest lines tank engines form half of the engine stud, and a large percentage of even the fast traffic comes within their daily work. Tank engines showed their capabilities as far back as 1853, when broad-gauge ten-wheeled engines with 9-ft. single drivers often attained a speed of 80 miles an hour in their ordinary work on the Bristol and Exeter line ; but these old-time fast tanks would cut a sorry figure nowadays, if they were set to draw a train well over 340 tons from London to Brighton, such as the modern tank engines run the 51 miles in 55 minutes.

In 1872 Mr. William Stroudley put into running the first batch of small six-coupled tank engines, which were known as the "Terriers." They had wheels of but 4-ft. diameter, a heating surface of only 518 sq. ft., and in full working order weighed less than 25 tons.

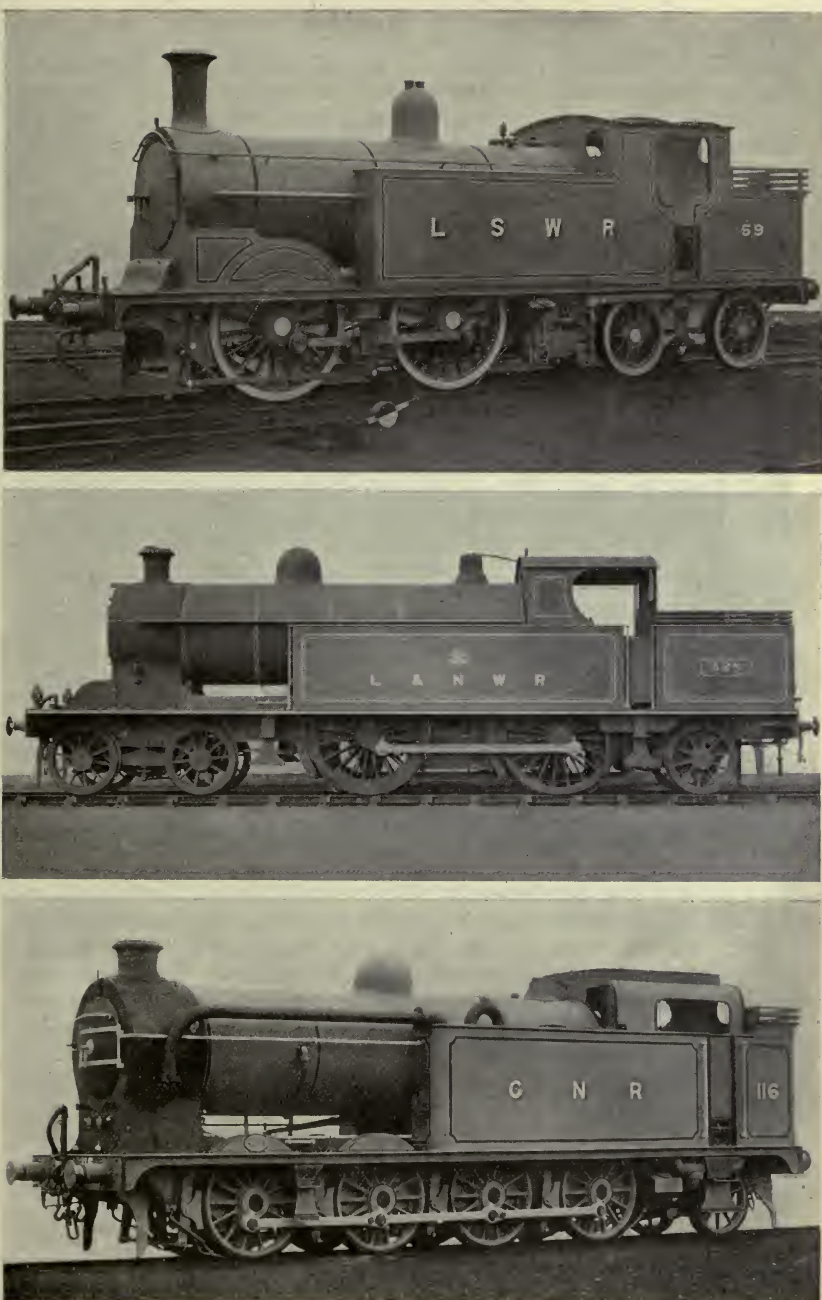
One of the most famous "Terriers" was the "Brighton," which was exhibited in 1878 at the Paris Exhibition, where it gained a medal, and for many years afterwards the honour was recorded on its sides. At that time the Ouest Company ran from Dieppe to Paris, and its services were not of the best. Some of the L.B & S.C. representatives suggested that a little more speed would be appreciated by the passengers on the boat trains between the coast and Paris. The French officials pooh-poohed the idea of effecting anything better than they were doing, and simply laughed to scorn the idea of any engine attaining a speed of 40 miles an hour, at least on their line. Frankly they did not believe that Mr. Stroudley knew what he was talking about, until he got permission to hitch the "Brighton" on to a French train, which the pigmy drew at nearly 50 miles an hour.

These famous little engines were followed by a class of 0–4–2 tanks with coupled wheels of 5-ft. 6-in. in diameter, while the trailers were 4-ft. 6-in. in diameter. The heating surface was double that of the "Terriers," the piston stroke was 24-in. instead of 20-in., the pressure was 150 lbs. to the sq. in., and the total weight of the

NO. 40, "BRIGHTON." A FAMOUS "TERRIER"
(London, Brighton, and South Coast Railway)

engine was almost 39 tons. This class must have proved exceedingly useful, or 125 of them would not have been put into service.

The present-day tank engines on the L.B. & S.C.R. are splendid examples of modern locomotive building. Towards the end of 1906 Mr. D. Earle Marsh, the locomotive engineer, introduced a new type of bogie tank engine (4–4–2) designed for working the fast heavy summer traffic, which often amounts to nearly 350 tons behind the tender, exclusive of the weight of the passengers. No. 21 of the I class had dimensions which in its drivers surpassed those of other tank engines in this country, and, in fact, the leading dimensions were practically the same as those of the standard L.B. & S.C. 4–4–0 express engines. No. 21 had 19-in. cylinders with 26-in. stroke; driving wheels 6-ft. 9-in. diameter; total heating surface 1627 sq. ft.; and a working pressure of 180 lbs. per sq. in. The tanks held 2100 gallons of water, and the bunker $3\frac{1}{2}$ tons of coal, which was sufficient fuel to run 200 miles. Other engines of this class, such as No. 22, and also of the class I_4, were fitted with



SIDE-TANK ENGINES

superheaters, causing differences in general construction, less heating surface, etc. In all cases the driving wheels were smaller.

These engines are capable of doing practically all the express work on the system, and have proved themselves most useful in traffic. They often work the famous Southern Belle train, and No. 22 for some time worked the continental boat train between London and Newhaven. No. 23, exactly like No. 22, has run through to Rugby with the "Sunny South" train, returning the next day right through to Brighton. Water was taken at Willesden on the down journey, and at East Croydon returning, the journey of 91 miles being accomplished on an average consumption of 20 gallons per mile.

It will thus be seen that though tank engines primarily may be intended for local and suburban traffic, there is practically nothing in reason that they cannot do. They may be used for comparatively long journeys, but long non-stop runs are impossible, owing to the limited coal supply. A newspaper and mail train that runs from Paddington to Bristol is generally drawn by a 4 – 4 – 2 tank engine, which runs the 117½ miles in 2 hours 55 minutes, including calls at five stations, yet averaging 40 miles an hour. In particular tank engines are extremely useful for working in and out of terminal stations. Being able to run equally well either backward or forward, there is no necessity for the engine to be turned round each trip, as is the case with a tender engine, for though the latter can run backwards, the tender interferes with the engineman's look-out, and the practice is inadvisable except for specially short distances.

Of 2 – 4 – 2 tank engines Mr. S. D. Holden, locomotive superintendent of the Great Eastern Railway, designed a series for the purpose of working light local and branch line traffic. The engine is very compact, and a special feature is the large window space provided all round the well-covered cab, which cannot help but be a boon to the enginemen.

Tank engines differ considerably in the method of carrying their water. In side-tank engines the water is stored in tanks resting upon the frame-plates immediately over the driving wheels, in well-tank engines the water storage is underneath the footplate. A more uncommon form than either is the saddle-tank, so called because the water receptacle rests upon the boiler barrel, much as a saddle is placed upon a horse.

The wheel classification of tank engines, as already stated, is signified numerically, as in the case of the tender engines, but with the addition of the letter T underneath, thus $\frac{0-4-2}{T}$ denotes a six-wheel, front-coupled tank engine; $\frac{4-4-2}{T}$, four-coupled, ten-wheel; $\frac{0-8-4}{T}$, eight-coupled, trailing bogie, or banking tank locomotive, such as is used to assist trains up specially difficult inclines.

Goods engines, in respect of their wheel arrangements, are more simple than any other, since their distinguishing feature is all-coupled wheels. Six-coupled (0 – 6 – 0) is the chief type for fast goods, and such engines are often employed for heavy excursion trains that call for nothing exceptional in the way of speed. Eight-coupled (0 – 8 – 0) is a typical heavy goods engine, and when it has a leading pony (2 – 8 – 0) it becomes the type known as "Consolidation"; such engines can set in motion a dead weight of about 800 tons, even where the start is on an incline of 1 in 150. A "Decapod" is a ten-coupled engine.

Timothy Hackworth's "Sanspareil" of 1829 had four coupled wheels, and in 1836 six-coupled engines were in use to draw the heavier goods trains. Of this style the Stephensons put the "Atlas"

A SADDLE-TANK ENGINE
(Great Western Railway)

on the Newcastle and Carlisle Railway. Its cylinders were 14 × 18 in., driving wheels 4-ft. 6-in. diameter; and it was specially interesting as providing the type of the present-day standard goods engine. A goods engine requires enormous power to put in motion a far greater weight than a passenger locomotive is set to draw. All coupled wheels are converted thereby into drivers to which the cylinders communicate power at the same time, and the engine's grip on the rails is correspondingly increased. Eventually the chief types for goods engines crystallised into six coupled wheels for fast traffic, sometimes with two or four smaller leading wheels; eight wheels coupled, and eight wheels coupled with a leading truck in front, this last for the heaviest mineral trains. The wheels of goods trains are sometimes as small as 3-ft. 6-in. in diameter, and seldom exceed 5 ft.

An early and popular type of locomotive on the L. & N.W. Railway was that known as the "Crewe" goods, of which many were built between 1843 and 1858. When larger and heavier locomotives came into use many of the earlier engines were converted into side-tanks, and remained in service for many years, the last one, No. 1979, being withdrawn in 1908; but as some of these once-famous engines were sold to collieries, ironworks, etc., it is quite possible to find an example still performing its daily round.

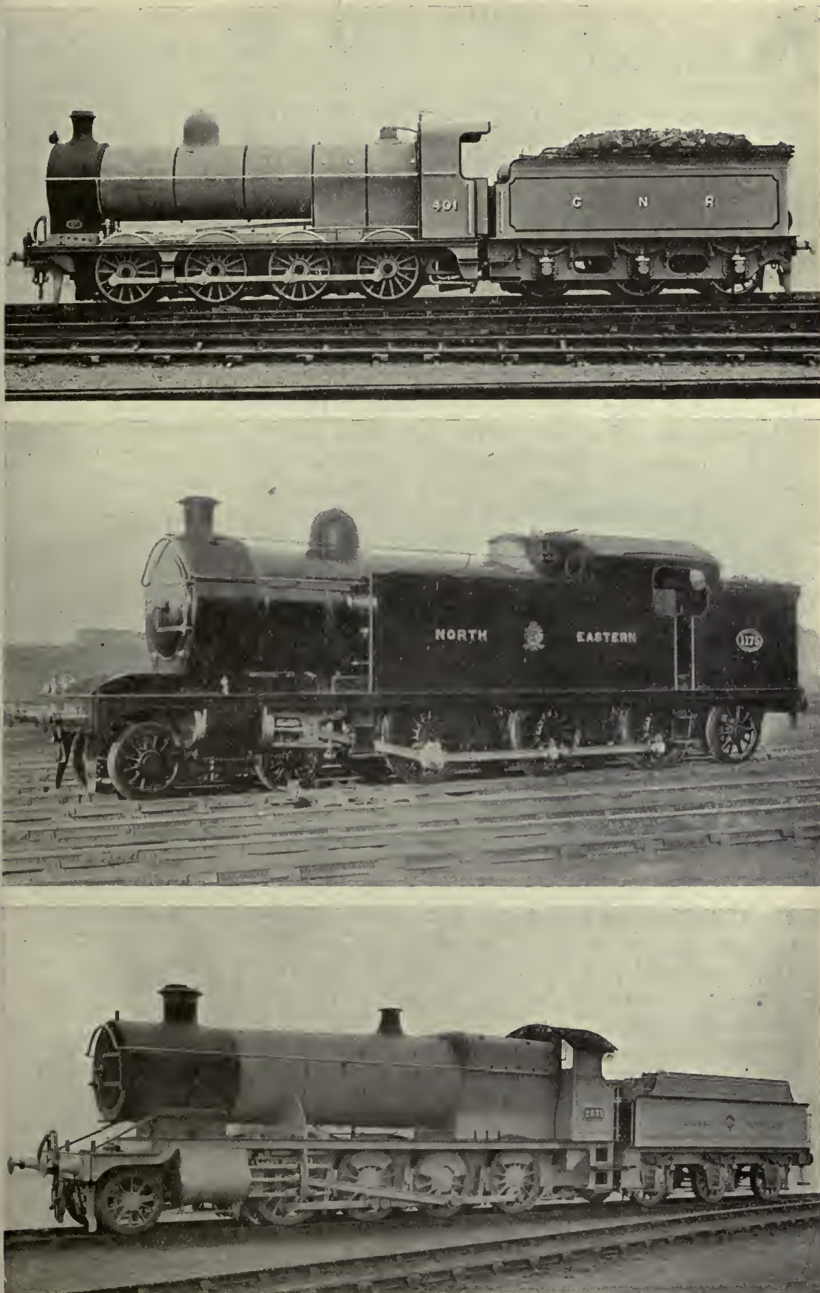
British locomotive designers never hesitate to give a trial to the wheel arrangements adopted in other countries. Various of our railways possess goods locomotives of the "Consolidation" type (2–8–0). Some of those on the Great Central Railway weigh over 118 tons with the tender, and the boiler develops 11,000 horse-power when using superheated steam. The Great Northern and the Midland have obtained engines of the "Mogul" type (2–6–0) from Baldwin's, of Philadelphia. Decapods and twelve and fourteen-

AN EARLY "CREWE" GOODS ENGINE
(London and North Western Railway)

wheelers are occasionally tried on British lines, but engines of the "Fairlie" type are rather a rarity in this country. Some years ago the Burry Port and Gwendraeth Railway used a couple of double-bogie tanks, remarkably powerful machines, capable of drawing heavy loads, and going easily round difficult curves. "Fairlies" are in regular use on the Festiniog Railway. But no matter what foreign examples may be tried experimentally, the main portion of our goods traffic is drawn by the six and eight coupled types, either tender or tank engines.

Whilst no very startling novelties were introduced into British locomotive design during the year 1910—if we except the remarkable "Reid Ramsay" steam turbine electric locomotive, which will be described in later pages—there was undoubtedly steady progress along lines which tend to improve the general efficiency of the steam locomotive, and which will assist it in retaining its position against threatened rivals.

The chief point of interest to be noted is the steady and con-



TYPICAL GOODS ENGINES

sistent advance in the use of superheated steam. Some years ago there seemed to be an equally pronounced movement in favour of compounding, but that was apparent rather than real. Compounding, in fact, never obtained any serious hold on British practice except on two railways, the L. & N.W.R. and the N.E.R., and, with changes in the locomotive control, we have seen the numerous two, three, and four cylinder compounds of those lines gradually diminish, either by conversion to simple, or by the more drastic way of the scrap-heap, until now they are almost rarities.

Superheating stands on a somewhat different plane. There can be no doubt of the advantages of using superheated steam, and the difficulties in lubrication originally attendant on its use have been met to a large extent, so that the only factor that tells against it is the cost of installation and upkeep of the elements comprising it. That this is not a prohibitive feature is amply evidenced by such experience as is forthcoming from the results of lengthy trials, and it is noteworthy that there are now very few great lines of railway on which the use of superheated steam has not been tried, whilst on some it has been adopted to quite a large extent.

One of the most notable features of the year 1911 was the building of larger tank engines to meet the growing requirements of the traffic departments. A new type lately tried on four different main lines is a large 4 – 6 – 2. An example is shown on page 75, viz. North Eastern, No. 1175, mineral tank locomotive, which is capable of drawing loads of 1000 tons and upwards on the level at 20 miles an hour, and specially adapted for working to and from collieries, not requiring to be turned, and thus avoiding the discomfort to enginemen of running "tender first." The North Eastern Railway has a score of these engines.

The design of locomotives of such power and weight constituted problems that appear to have been successfully solved, the wheelbase having sufficient flexibility to enable the engines to negotiate the sharp curves (often of 5 chains' radius) encountered in colliery sidings, whilst, with the necessity for ample adhesive power and the large supply of water and coal, the weight per axle and per foot run have been kept within the limits required by the permanent-way department.

These engines have the following leading dimensions: cylinders (3) 16½-in. diameter by 26-in. stroke; diameter of wheels, bogie 3-ft. 1¼-in., six-coupled 4-ft. 7¼-in., and trailing radial 3-ft. 9¼-in.; rigid wheel base 14-ft. 6-in.; length of boiler barrel 11-ft., outside diameter 5-ft. 6-in.; length of outside firebox 9-ft.; working pressure of boiler 180 lbs. per sq. in.; heating surface, firebox 140 sq. ft., tubes 1508 sq. ft., total 1648 sq. ft.; grate area 23 sq. ft.; capacity of tanks 2300 gallons, and of bunker 5 tons; total weight of engine in working order 87 tons 8 cwt., of which 20 tons 16 cwt. rest on the leading bogie, 55 tons 12 cwt. on the six coupled wheels, and 11 tons on the trailing wheels. The engines are fitted with 7½-in. piston valves operated by Stephenson link motion. The cab is roomy and comfortable, and the regulator handle and steam-brake valve are so arranged as to be easily manipulated by the driver while he is engaged in watching for hand signals from guard or shunters.

Other powerful tank engines are intended for express passenger services. Appended is an illustration of No. 325, "Abergavenny," (L.B. & S.C.R.), designed by Mr. D. E. Marsh, the locomotive, carriage and wagon superintendent. This engine is of quite exceptional dimensions and power, as will be gathered from the following particulars: it has cylinders 21-in. in diameter, by 26-in. stroke, and six coupled wheels of 6-ft. 7½-in. diameter, giving a tractive power at 75 per cent cut-off of 23,000 lb. The total weight

NO. 325, "ABERGAVENNY"
(London, Brighton, and South Coast Railway)

of the engine in working order, with 2300 gallons of water and 3 tons of coal, is 86 tons, of which 56 tons are on the coupled wheels. The boiler is of huge size, the barrel being 15-ft. 9½-in. long, with an outside diameter of 5-ft. 3-in., and its centre is 8-ft. 8-in. above the rails. It is fitted with the Schmidt superheater, comprising 21 smoke tubes of 4¾-in. diameter, in addition to 110 ordinary flue tubes; there is a total heating surface of 1865 sq. ft., of which the firebox contributes 125, the flue tubes 1398, and the superheater tubes 342 sq. ft.; the grate area is 25 sq. ft.

The chapter may close fitly with brief mention of the use of foreign-built locomotives upon British rails. A remarkable example was the five-thousandth engine built at the Baldwin locomotive Works, Philadelphia, in 1880. It was intended for fast service on the Philadelphia and Reading Railroad, between Jersey City and Philadelphia, 89·4 miles, which it was expected to cover in 90 minutes. Its drivers were 6-ft. 6-in., cylinders 18×24 in., and heating surface 1400 sq. ft. A marked peculiarity was an equalising lever, so centred that a steam cylinder, acting on the fulcrum, could alter the weight thrown on the driving axle for adhesion from $15\frac{1}{2}$ tons to 20 tons at starting, or on heavy grades.

In its trial runs the engine's best time was 98 minutes and, being thrown on the maker's hands, it was sold to the Eames Vacuum Brake Company, who fitted it with their brake apparatus and shipped it to England in parts. In February, 1882, it was fitted together at the Lancashire and Yorkshire Railway Works. To pass the English loading gauge the chimney had to be reduced in height, the whistle and lamp lowered, and the cab altered in shape. It made several trips on the Lancashire and Yorkshire and Great Northern lines to show the brake mechanism, and later made its appearance at an exhibition at the Alexandra Palace. For more than a year it was stabled at the Great Northern shed at Wood Green, occasionally making a trip to show the mechanism of the brake. In the neighbourhood of Wood Green and Hornsey it was known as "Jumbo," partly on account of its appearance and its "buzzer" or foghorn whistle. In April, 1883, it was sold to a scrap dealer, who broke it up on the spot. The bell, with the name "Lovatt Eames" engraved upon it, for some years hung over the door of the Great Northern Railway Locomotive Office at King's Cross shed, the only memento of an interesting experiment.

The foregoing engine was neither the first nor last of foreign origin to run on British rails. In 1839 the Birmingham and Gloucester Railway obtained seventeen American locomotives from Messrs. Norris & Co. This company was absorbed by the Midland Railway, which in the early forties purchased engines from Baldwin's to work trains up the Lickey incline, only to find that British engines of a new type did the work far better; and in the closing years of the nineteenth century engines were obtained from Baldwin's and also from Schenectady, when the Derby Locomotive Works could not cope with the company's requirements. In 1866 the Great Eastern Railway obtained sixteen engines from Messrs. Schneider, of Creusot. The Great Northern and Great Central each obtained "Mogul" goods engines from America within recent years, and the Great Western experimented with a French engine, "La France," a De Glehn compound. With but few exceptions our railway companies have relied upon native talent for their locomotives, in which have been incorporated all the best features in foreign engines so far as they would lend themselves to British practice.

CHAPTER IV

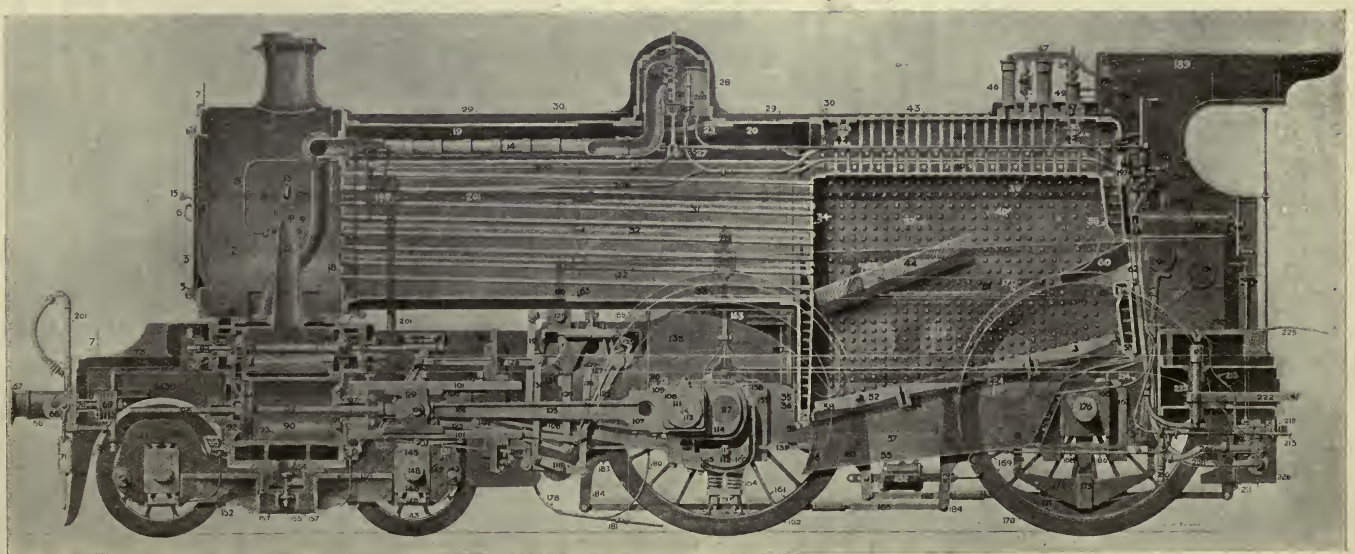
THE LOCOMOTIVE OF TO-DAY

THE locomotive steam engine, viewed coldly and critically, is merely a machine which may, in addition to propelling itself, haul other vehicles. But apart from its utility there is an attraction about a locomotive that appeals to human understanding with irresistible force. It is the embodiment of speed, and speed is fascinating alike to young and old. Even the most hardened traveller cannot repress a thrill at sight of the iron horse pounding along the gleaming metals at sixty miles an hour. Even viewed purely as a machine, the locomotive exceeds in interest many other inventions of marvellous intricacy. They may perform the most delicate operations with an exactitude that fills us with wonder, but in appearance and in action their purpose is not so obvious as that of the iron monster, in which are combined the utmost power and resistless motion that human skill can devise.

No machine is more curiously human than the locomotive. The merest tyro can put it into motion, or bring it to a standstill, merely by working a lever ; but to get the best out of it one needs to understand its varying moods when running under different conditions and circumstances.

Every part of the engine's anatomy has been conceived by master minds and shaped by master hands ; changes have been initiated by experience ; but the original imprint may still be traced. The locomotives on our great lines display a recognisable individuality ; and no amount of paint, or additional minor details, can hide the fact that an engine was cradled on the L. & N.W.R. at Crewe, the G.E.R. at Stratford, the G.N.R. at Doncaster, etc. Nationality too makes its unfailing mark, and generally it would be easier to identify a French locomotive, if placed on British rails, than it would be to recognise a Frenchman taking an airing in a London street.

Modern locomotives are exceedingly varied in type. They may be classified by their wheels ; or the number and position of the cylinders, inside or outside the frames. From that point we may adopt various sub-divisions according to inside or outside bearings, the valve gear, etc., or whether they are self-contained upon their own framings. In British engines the driving wheels are commonly either single, or four, six, or eight wheels are coupled, whereas abroad even twelve wheels are sometimes coupled.



FOUR-COUPLED BOGIE EXPRESS LOCOMOTIVE

Designed by R. M. Deeley, Locomotive Superintendent, Midland Railway

NAMES OF PARTS OF 4-4-0 EXPRESS ENGINE (MIDLAND RAILWAY)

1. Chimney.
2. Smokebox.
3. Smokebox Door.
4. Smokebox Baffle Plate.
5. Smokebox Door Fastening.
6. Smokebox Door Handle.
7. Lamp Irons.
8. Blower Pipe.
9. Blower.
10. Blast Pipe Nozzle.
11. Blast Nozzle Lever (on left-hand side).
12. Exhaust Pipe. [haust.
13. Vacuum Brake Ejector Ex-
14. Steam Pipe.
15. Front Hand Rail.
16. Hand Rails.
17. Steam Pipe T-piece.
18. Boiler Front Tube Plate.
19. Boiler Shell Front Ring.
20. Boiler Shell Second Ring.
21. Dome.
22. Dome Cover.
23. Dome Stiffening Ring.
24. Regulator Head.
25. Regulator Main Valve.
26. Regulator Starting Valve.
27. Regulator Rod.
28. Dome Casing.
29. Boiler Cleading Plates.
30. Cleading Bands.
31. Boiler Tubes.
32. Tube Plate Stay Rods.
33. Palm Stay.
34. Firebox Tube Plate.
35. Firebox Throat Plate. [ing.
36. Firebox Throat Plate Clead-
37. Inner Firebox Side Plate.
38. Inner Firebox Back Plate.
39. Inner Firebox Crown.
40. Firebox Shell Transverse Stays.
41. Firebox Crown Stay Bolts.
42. Firebox Crown Sling Stays.
43. Firebox Wrapper Plate.
44. Firebox Brick Arch.
45. Firebox Back Plate.
46. Ramsbottom Safety Valve Column.
47. Ramsbottom Safety Valve Lever. [Spring.
48. Ramsbottom Safety Valve
49. Direct Loaded Safety Valve
50. Whistle. [Column.
51. Expansion Bracket.
52. Firebars.
53. Firebars Bearer.
54. Firebars Bearer Bracket.
55. Ashpan.
56. Damper Door.
57. Damper Rod (on left side).
58. Foundation Ring.
59. Wash-out Plug.
59A. Ashpan Fixing Stud.
60. Firehole Deflector Plate.
61. Firehole Ring.
62. Fire Door.
63. Firebox Backplate Cleading.
64. Fire Door Gear.
65. Boiler Circumferential Seam.
66. Buffer Socket.
67. Buffer Head.
68. Drawbar Hook.
69. Drawbar Spring.
70. Drawbar.
71. Coupling Chain.
72. Buffer Beam.
73. Front Platform Plate.
74. Guard Iron.
75. Valve Chest (Front).
76. Valve Chest (Back).
77. Valve Chest, Exhaust Cham-
78. Piston Valve. [ber.
79. Piston Valve Front Ring.
80. Piston Valve Back Ring.
81. Front Steam Port.
82. Back Steam Port.
83. Valve Rod.
84. Valve Tail Rod.
85. Valve Chest Liner.
86. Front Valve Chest Cover.
87. Back Valve Chest Cover.
88. Valve Rod Packing (Me-
89. Smokebox Saddle. [tallic).
90. Cylinder.
91. Cylinder Back Cover.
92. Cylinder Front Cover.
93. Piston.
94. Piston Rings.
95. Piston Rod.
96. Piston Tail Rod.
97. Piston Rod Packing (Me-
98. Cylinder Cocks. [tallic.
99. Crosshead (left-hand side).
100. Crosshead (right-hand side).
101. Motion Bars.
102. Motion Plate.
103. Motion Bar Lubricator.
104. Crosshead Pins.
105. Connecting Rod (left-hand).
106. Connecting Rod (right-hand).
107. Connecting Rod Big End.
108. Connecting Rod Brasses.
109. Connecting Rod Strap.
110. Connecting Rod Cotter.
111. Crank Pin (left-hand).
112. Crank Pin (right-hand).
113. Crank Pin Reinforcing Pin.
114. Crank Web (left-hand).
115. Crank Web (right-hand).
116. Crank Bands.
117. Crank Axle.
118. Bottom Reversing Shaft.
119. Reversing Shaft Link.
120. Top Reversing Shaft Lever.
121. Top Reversing Shaft.
122. Reversing Rod.
123. Driving Link for Left-hand Expansion Link.
124. Driving Link for Right-hand Expansion Link.
125. Arm for Oscillating Right-hand Expansion Link.
126. Arm for Oscillating Left-hand Expansion Link.
127. Valve Radius Link (right-hand valve).
128. Valve Radius Link (left-hand valve).
129. Lead Arm (right-hand).
130. Lead Arm (left-hand).
131. Lead Arm Driving Link (right-hand).
132. Lead Arm Driving Link (left-hand).
133. Expansion Link for Right-hand Valve.
134. Expansion Link for Left-hand Valve.
135. Lifting Link (right-hand).
136. Lifting Link (left-hand).
137. Valve Spindle Guide.
138. Main Engine Frames.
139. Cylinder Cock Rod.
140. Cylinder Cock Gear.
141. Bogie Frame.
142. Bogie Cross Stays.
143. Bogie Wheels.
144. Bogie Tyre.
145. Bogie Axle Box.
146. Bogie Axle Box Keep.
147. Bogie Axle Box Guides or
148. Bogie Axle. [Horns.
149. Bogie Horn Stay.
150. Bogie Equalising Beam.
151. Bogie Spring.
152. Bogie Spring Hanger.
153. Bogie Centre Pin.
154. Bogie Centre Casting.
155. Bogie Frame Stretcher.
156. Bogie Spring Pin.
157. Bogie Swing Links.
158. Driving Axle Box.
159. Driving Axle Box Guides or Horns.
160. Driving Horn Stay.
161. Driving Wheel.
162. Driving Wheel Tyre.
163. Driving Wheel Counter-balance.
164. Driving Axle Springs.
165. Driving Wheel Splasher.
166. Trailing Axle Box. [Horns.
167. Trailing Axle Box Guides or
168. Trailing Horn Stay.
169. Trailing Wheel.
170. Trailing Wheel Tyre.
171. Trailing Wheel Counter-balance.
172. Trailing Axle Spring.
173. Trailing Axle Spring Buckle. [Hangers.
174. Trailing Axle Spring
175. Trailing Wheel Splashers.
176. Trailing Axle.
177. Sand Box.
178. Sand Pipe.
179. Sand Trap.
180. Sanding Steam Pipe.
181. Sand Ejector.
182. Brake Cylinder, Steam.
183. Brake Blocks.
184. Brake Block Hangers.
185. Brake Rods.
186. Brake Cylinder Steam Pipe.
187. Frame Stay. [Roller.
188. Reversing Rod Supporting
189. Cab Roof.
190. Cab Side.
191. Hand Hole Cover Plates.
192. Foot Board.
193. Regulator Handle.
194. Whistle Handle.
195. Pressure Gauge.
196. Cylinder Cock Handle.
197. Water Gauge.
198. Damper Handle (on left-hand side).
199. Vacuum Brake, Combined Large & Small Ejectors.
200. Vacuum Brake, Large Ejector Steam Pipe.
201. Vacuum Brake Train Pipe.
202. Driver's Combination Steam and Vacuum Brake Valve.
203. Vacuum Brake Small Ejector Steam Pipe.
204. Blower Steam Valve Handle.
205. Steam Sanding Handle.
206. Combination Injector Steam Valve & Clack Box.
207. Injector Steam Pipe.
208. Injector Water Delivery.
209. Injector. [and Coupling.
210. Injector Feed Water Pipe
211. Injector Overflow Pipe.
212. Injector Feed Water Handles and Cock. [Brakes.
213. Steam Pipe to Tender
214. Brake Exhaust Pipe.
215. Coal Watering Pipe.
216. Vacuum Brake Drip Valve.
217. Reversing Handle.
218. Reversing Screw.
219. Axle Box Lubricators.
220. Vacuum Brake Large Ejector Steam Valve.
221. Vacuum Brake Large Ejector Steam Valve Driver's Handle.
222. Tender Coupling.
223. Tender Coupling Pin.
224. Holes in Main Frames.
225. Hinged Footplate Flap.
226. Footsteps.

To describe the modern locomotive as it appears to-day, without being abstruse to the lay reader, is not an easy task, but thanks to an excellent illustration of a locomotive in section, and permission to quote largely from *The Locomotive of To-day*, it is possible to afford a good general idea of the construction and working of a machine in which is incorporated the tireless efforts of many dead and gone ingenious minds. In the main the descriptions relate to the details of British locomotives, but with occasional references to Continental and American practice for interesting comparison. Finally it should be remembered that whether the locomotive be a huge monster passenger engine of the " Atlantic " or " Pacific " type, a massive " Consolidation," a self-contained tank engine, or a pigmy shunter, the leading principles are the same in all.

A modern passenger express locomotive naturally falls into four sections, viz. the boiler ; the engine ; the framing, wheels, etc. ; and the tender, brakes, etc.

THE BOILER

The locomotive boiler possesses the advantage of quick steam production for its size and weight, and lends itself to forcing when occasion demands it, while its shape meets its particular purpose admirably ; but, nevertheless, it cannot be claimed that it is the most economical steam generator, and it remains expensive notwithstanding numerous attempts to evolve something less costly in construction.

Although more than eighty years have passed away, the boiler of the " Rocket " remains the accepted model of to-day, for notwithstanding the multiplication of details, and the increase in dimensions, there has been no really radical departure from Stephenson's early effort to produce a capable steam generator.

Briefly the locomotive boiler is of the internally fired, horizontal, multitubular type, made up of four essential portions : the inner firebox, the outer firebox or shell, the barrel containing the tubes, and the smokebox. Reference to the illustration shows that the fire is placed at one end of the boiler in the inner firebox, from which the heated gases pass to the smokebox and chimney at the other end by way of a number of tubes, or flues, arranged in the barrel. As the tubes usually number from 150 to 350, the heating surface in contact with the water is very large, but for the purpose of supplying the engine with steam the fire needs artificial urging to increase the rate of combustion. This is contrived by directing the exhaust steam that escapes from the cylinders to the " blast pipe " below the base of the chimney, and by contraction of this outlet varying intensities of draught can be obtained. Each piston stroke discharges steam into the blast pipe, creating a partial vacuum in the smokebox by withdrawing some portion of its contents with it, and in its turn causes a rush of atmospheric air through the fire to add to the rapidity of combustion.

In the early locomotives the inner firebox was cylindrical in form, but now it is roughly a rectangular box, entirely surrounded by water, except at the bottom, where the firegrate is placed. Copper inner fireboxes are used generally, chiefly because of its great resistance to oxidization, its conduction of heat, and its capability of bearing great strains, but in recent years steel ones have become quite common. The outer firebox or shell consists of three parts—the wrapper, one plate rolled to form the sides and top ; the front, which is called the throat or saddle plate ; and the rear plate, which has the firehole through it, and acts as a boiler end. The outer shell is riveted to the inner firebox.

BOILER IN COURSE OF CONSTRUCTION

Showing firetubes and the "Drummond" cross-water tubes in the firebox

The barrel is the portion in which the tubes are contained, and is generally made up of two or three plates riveted together ; it is parallel or telescopic according to the method of jointing. When a steam dome is used, it is situated on one of the barrel rings. This is the dry steam collector, and within it the regulator is commonly placed ; steam is also led from it by pipes to various valves on the boiler front. The dome may be of the same material as the barrel, or it is cast in brass, iron, or steel, and in some designs it carries the safety valves upon it.

As boiler pressures now vary from 120 to 220 lbs. per sq. in., all flat surfaces need to be strengthened by means of stays, and as far as possible hydraulic power is employed in riveting ; and joints and seams are mechanically caulked. Stays are of various kinds, namely direct, girder, palm, etc., varying in use according to the special necessities of the case. For example, when the fire is first lighted, the gases, passing through the tubes, heat the tube plate more than any other part of the firebox, which consequently expands more at that particular point, and therefore the stays must allow for this expansion, and permit an upward movement of the box, while they will resist collapse, if subjected to pressure.

Another form of firebox, largely in use and named the "Belpaire" from its inventor, is constructed so as to minimize the use of various stays which take up some portion of the heating surface of the top of the box. The outer wrapper plate is made flat on the top and the inner one parallel to it. A second advantage of this box is the easier arrangement for cleansing the top of it by the provision of side washing holes in addition to those at the back.

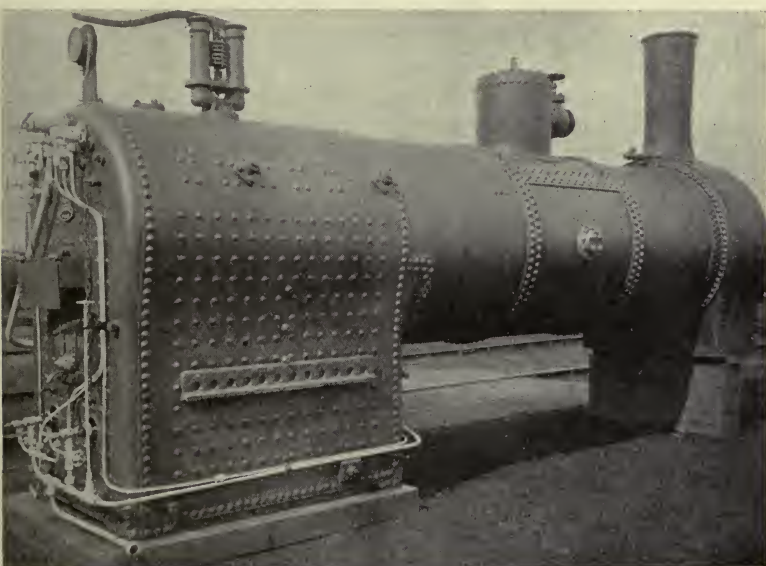
The exposed portions of the boiler are liable to a loss of heat by radiation, and are, therefore, lagged, or covered with a non-conducting material. Wood is commonly used, but felt, asbestos, mica, and silicate of cotton also find favour, but in any case the non-conducting material is covered with cleading plates of steel, which are held in position by means of metal bands. Sometimes non-conduction is assisted by only a layer of air, in which case the cleading plates must be of a particularly good fit.

Locomotive builders endeavour to make every part easily accessible in order to facilitate the periodical cleansings, and so that repairs may be effected cheaply and expeditiously. In fixing the boiler in the frames of the locomotive, the front tube plate is continued down below the barrel; in inside cylinder engines it is bolted to the back of the cylinder casting; and in outside cylinder engines it is secured to a distance casting and frame stay. At this end the boiler is rigid, which is not the case at the firebox end, where the barrel is carried by an arrangement of expansion brackets, leaving the boiler free to expand longitudinally, while the lateral steadiness is secured by a pin and socket arrangement, or a cross plate, at the firebox end. Formerly the barrel was supported on a saddle about midway of its length, but supports are not now of common adoption.

In all ordinary locomotives the position of the firehole is the same, placed so as to be easily accessible from the footplate. Concerning the doors there is considerable variety. They may be simply plain plates, hinged at the sides, which must be left partially open to admit air to the fire; hinged at the bottom so as to fall back on the footplate; made in halves, hinged top and bottom, downwards; or hinged at the top and opening inwards. Most of the doors act as deflectors for the air admitted during firing, and the amount of opening is regulated in nearly all cases by catches.

The diameter of the tubes, or flues, of the barrel in British boilers is usually from $1\frac{5}{8}$-in. to $1\frac{7}{8}$-in. outside diameter; and the metals used are copper, brass, iron, or steel. The conducting power of the first-named metal is nearly six times that of the last, but careful experiments show that in actual practice there is really little difference, especially if the water is of doubtful purity; but copper cannot long resist the abrading action of small cinders which pass through the tubes.

It follows that when the hot gases traverse the tubes, those on the outside will part with most of their heat, but through the middle of the tubes no little heat will pass to the smokebox unused.



BOILER FITTED WITH HOLDEN'S PATENT LIQUID FUEL-BURNING APPARATUS
(Great Eastern Railway)

To utilize the heat more fully various methods have been devised, among which may be mentioned the "Serve" tube, which is furnished with longitudinal, internal ribs. By this means the internal heat is increased about 90 per cent, the gases are broken up further, and more heat is abstracted from the centre. These tubes, however, are not without their disadvantages; being a trifle larger in outside diameter, their use entails a lesser number of tubes, and the spaces between the ribs afford lodgment for soot, which makes it difficult to keep the tubes clean.

The evaporative power of a boiler rests in the capacity of its heating surface to transmit heat from the products of combustion within to the water without, for which it relies on both radiation and contact. Heat is radiated more from the solid fuel than from the flame, and the hot gases radiate very little heat at all. Adding length to the tubes does not increase the evaporative power of the boiler to anything like the same extent as increasing the size of the firebox, where the radiant heat is principally given off, for the more violently the flame impinges on a surface, the greater the ebullition and formation of steam on the opposite side. Tubes internally heated are only effective for half their area, as, owing to hot gases rising, the heat is given off chiefly at the upper surface, and even this weakens as the distance from the firebox is increased.

In the preceding chapter it will have been noticed that as locomotive builders endeavoured to obtain more and more power, the boilers increased in size, causing a reduction in the length of the smoke-stack, which gives engines a more squat appearance than heretofore. It would be impossible to raise the height of the boiler and retain the long stack, because the British loading gauge for height in centre from rail upon no line exceeds 13-ft. 9-in., and the average is considerably less, especially upon branch lines. For width the gauge is usually about 9-ft. To obtain the power to haul increasingly heavy loads our locomotive builders could not adopt the giant engines that are common in some parts of the world, notably America, and therefore they sought other means of solving the difficulty, chiefly in the direction of increasing the efficiency of the steam.

There are various methods in vogue for superheating the steam before use by increasing its temperature above that corresponding to its pressure, so that a reserve of heat is available to evaporate water which would otherwise be deposited, or in other words to minimize or prevent cylinder condensation. By superheating the quantity of available steam is increased and given added velocity, with the result that the steam can be used more efficiently for larger cylinders with marked economy in fuel and water consumption. The steam, with better evaporation, becomes more a true gas, instead of steam and water mingled, and greater advantage can be taken of expansion in a single cylinder. Against the advantage of superheating must be placed the considerable first extra cost, and the additional parts call for more expense in maintenance and repair; but the steam economy and increase of power for given cylinder and boiler capacities quite compensate for these expenses.

In reality superheating in locomotives is not a recent innovation, although modern interest in the subject dates back only to 1895, when experiments were commenced on the Prussian State Railways with Herr Schmidt's apparatus; but superheating was practised on the London and North Western as far back as 1855, and on the Great Western several years earlier. Trevithick took out a patent for an arrangement of looped U-tubes in 1832, after four years of thoughtful experiment.

Superheating may be accomplished in several ways, broadly as follows: (1) A smokebox apparatus that does not involve any change in the boiler. (2) A smokebox apparatus requiring a very large single flue tube in the boiler. (3) A smokebox apparatus necessitating a series of firetubes in the boiler larger than the usual size, but not specially large. (4) An apparatus situated in the boiler itself.

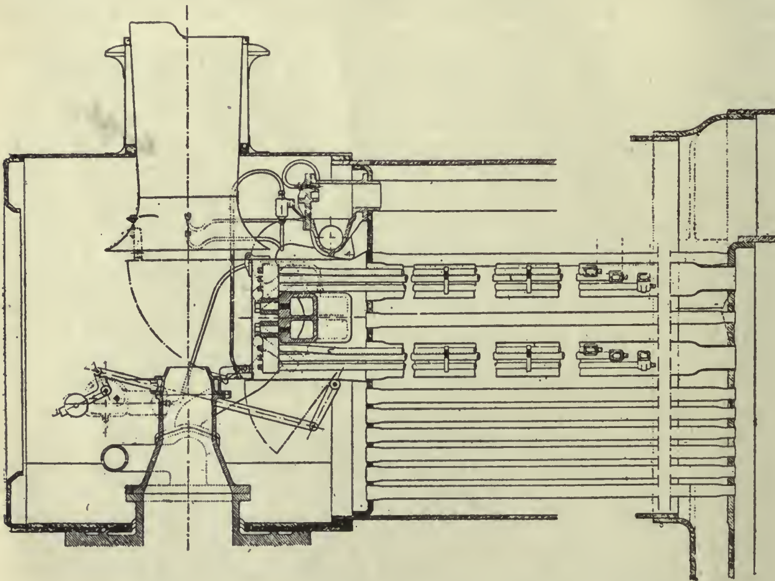
The use of a smokebox apparatus for low superheating of the steam between the high and low pressure cylinders of a compound engine shows less proportionate advantage than in a non-compound engine, and will not enter into the discussion.

In the first class are several designs that have been employed to a limited extent; one of them was used on the Lancashire and Yorkshire Railway some years ago. The best is undoubtedly the Vauclain superheater that emanates from the famous American Baldwin Locomotive Works, and already in considerable favour. It comprises upper and lower headers at each side of the smokebox, connected by several rows of tubes, the headers being chambered by partitions, which cause the steam to pass to and fro several times. In the second class is the original Schmidt smokebox apparatus with which most of the early experience was gained. Its main feature is a large fire tube of 10- or 12-in. diameter, located in the power part of the boiler, which leads the furnace gases, by way of deflectors and dampers, into the centre of pipe coils in the smokebox, from whence they pass up the chimney.

Most of the superheaters in general use fall into the third class, notably the Schmidt apparatus, usually referred to as the smoketube apparatus to distinguish it from the last-named. It comprises a chambered header from which a series of return U-tubes extend into the upper rows of boiler tubes, which are larger than usual, viz. about 5-in., and in the latest examples double U-tube lengths looped together cause the steam to traverse four tube lengths. Generally the superheater temperature is quite 250° F. above pressure temperature, and not infrequently it is considerably higher. By the end of 1908 about 3000 of this Schmidt superheater were in use in different parts of the world, and various British companies had either adopted it or had it under consideration.

The "Swindon" superheater, which belongs to the same class, had its birth at the locomotive works of the Great Western Railway, many of whose engines have been fitted with the apparatus. Briefly the two enlarged flue tubes each contains a set of six steam tubes arranged horse-shoe fashion, and held in position by plates at suitable intervals, which serve to retard and mix the combustion gases in their passage, and so increase the efficiency of the superheater. The horse-shoe arrangement permits the large flue tubes to be cleaned almost as readily as if they were the ordinary plain tubes.

Where the steam tubes emerge from the large flue tubes into the smokebox, the two upper tubes of the series are diverted from their original direction into U-shaped members, one set attached to, and projecting above, the header, and a similar set, inverted and projecting below. By means of connections with the boiler and engine respectively, the steam first passes into the header, and thence through the superheater before reaching the cylinder. Among general claims for efficiency, it is held that the " Swindon " apparatus affords better facilities than any other for cleaning the ordinary flue tubes, as well as those of the superheater itself.

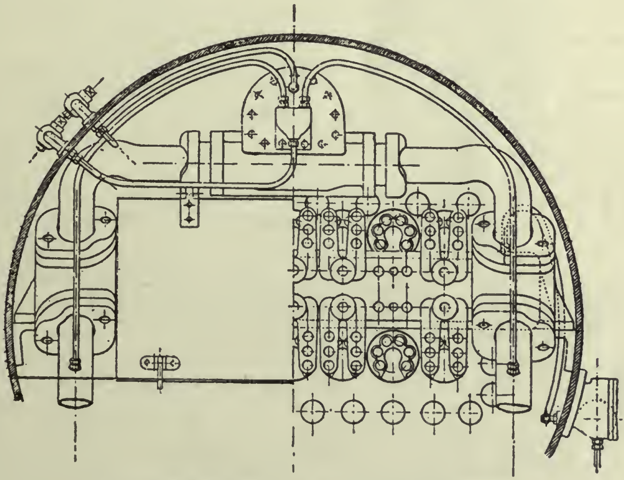


LONGITUDINAL SECTION OF "SWINDON" SUPERHEATER

In class four the Pielock superheater is the best known among several others, that are not in extensive use. Its main feature consists of a chamber in the boiler itself, and through which the boiler tubes pass, partitions causing the steam to be directed up and down, or to and fro several times. There is no need to go into further details, sufficient having been said to prove that the superheater is now a definite feature of twentieth-century locomotive practice.

In the firebox is a brick arch, which deflects and retards the passage of the gases to the tubes, thus giving more time for proper combustion, rendering it possible to use smaller and more numerous tubes to the increase of the heating surface. In the boiler the general circulation is upward at the firebox end, forward in the upper parts, downward at the front end and backwards at the bottom; and naturally the more freely this movement takes place, the more rapidly will steam escape, the jar of the engine when running rendering some assistance in this direction.

In locomotive boilers about 70 lbs. of water can be evaporated from $4\frac{1}{2}$ sq. ft. of grate area in one minute, or 13·5 lbs. of water per 1 sq. ft. of heating surface per hour. 8 lbs. of water per 1 lb. of coal is good evaporation, but much depends on the quality of the fuel, condition of the boiler, rate of combustion, and skill in stoking. A



TRANSVERSE SECTION OF G.W.R. SMOKEBOX
Showing "Swindon" superheater

main-line express engine consumes about 40 lbs. of coal per mile; a suburban tank engine 50 lbs.; and a heavy goods or mineral engine 60 lbs. per mile.

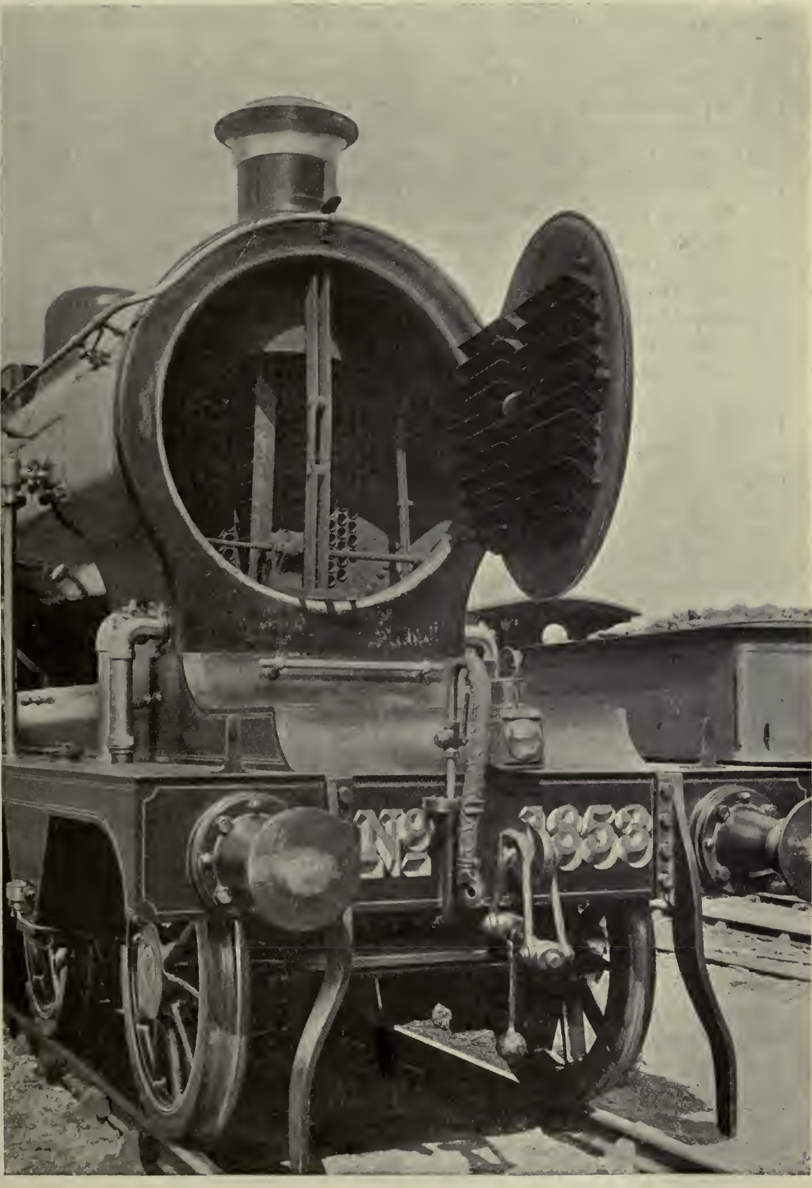
The fire-grate forms the bottom of the firebox, and consists of a series of bars arranged longitudinally, and spaced as to allow of the passage of air necessary for the combustion of the fuel. The grate may be horizontal or inclined, so that the jar of the engine shakes the fuel down to the front. In the United Kingdom it is the general practice for the firebox to be between the frames, and the size of the grate is restricted to the distance between the frames for width, and between the driving and trailing axles for length, and it is only by the aid of the exhaust steam draught that it is possible to burn sufficient fuel in so small a grate, in the limited time to produce steam in large quantities for the work which a locomotive has to perform.

The fire-bars are generally made of cast iron, for though they are liable to break, wrought iron will bend and twist with heat sooner. In America rocking or movable fire-bars actuated by levers, worked from the foot-plate, are frequently employed; but British coal is less liable to clinker, and rocking bars find little favour. Water grates are also in use, consisting of tubes passing from front to back of the firebox and connecting the water spaces together.

The ash-pan, box-form and about a foot in depth, fits under the firebox. Its purpose is obvious, namely to catch the ashes that fall through the fire-bars, and to prevent small ashes being blown out on to the motion and moving parts of the engine. The pan is furnished with doors or dampers, which the engine-men can open or close by means of levers, thus regulating the quantity of air admitted to the fire, as well as remove the ashes at the end of a day's work. In the case of express engines that run chiefly in one direction, the dampers open at the front end only; but for tank engines, designed to run either way, they are open at both front and back ends.

The smokebox at the front end of the boiler is provided with a door to allow of cleaning the tubes, repairs, etc. Generally it is circular in shape and dished to give it greater strength; and inside is a plate for protecting the outer door from the heat. Another form of door folds in the centre and is hinged on either side; while a third form is hinged at the top and opens from below. Passing through the smokebox to the steam chest is the main steam pipe; and the blast pipe stands vertically within, exactly under the centre of the chimney. The spark arrester, if used, may be fitted conically between the top of the blast pipe and base of the chimney, or arranged horizontally across the box, forming a diaphragm just above the top row of tubes. Either form of arrester prevents the small coal or sparks, drawn from the firebox through the tubes, being discharged through the chimney.

Of course all joints in the smokebox must be perfectly air-tight, in order that the blast of the engine may create a good vacuum, ensuring a rapid passage of air through the firebox to aid combustion. If atmospheric air entered the smokebox, its oxygen, combining with the unconsumed carbon drawn through the tubes, would set up fresh combustion and burn the plates. Extended smokeboxes are less used in British engines than in America and on the Continent. Increase in the cubical capacity of the smokebox causes a regular and steadier draught on the fire, which is particularly serviceable if the fuel is of poor quality. On the other hand, a smaller smokebox causes the blast to take a sharp effect on the fire, and often a bad steaming engine is improved by bricking up a portion of the smoke-box and thus diminishing its capacity.



OPEN SMOKEBOX, SHOWING PATENT SPARK ARRESTER AND ASH EJECTOR
(Great Eastern Railway)

The chimney is either tapering or parallel in shape, its length depending on the loading gauge, which in our country will not pass more than about 13-ft. above rail level. It is claimed that the tapering form, larger at the top than at the base, is the better, since that shape more approximately follows the outline of the escaping cone of steam from the blast pipe. The principal uses of the chimney are to carry away the smoke above the level of the driver and the train, and also to form an exhausting device in conjunction with the blast pipe ; its external shape is more or less a matter of the individual fancy of the designer.

The exhaust or blast pipe stands central with the chimney, the escaping steam discharging directly through it. In British engines the orifice is invariably circular in shape for all ordinary engines with cylinders of 16-in. diameter and upwards, about 5-in. being the ordinary diameter. The nozzle is generally fitted with a flange, which can be detached for cleaning the pipe, or to alter the size of the orifice. There are numerous designs of blast pipe, in all of which care is taken to make the cone of steam enter the lower end of the barrel of the chimney without striking its base, or otherwise interfering with the draught to impair the fire. Some blast pipes have the exhaust orifice variable, in some cases being effected by a cap hinged at the front, and worked by levers from the cab.

The blower generally consists of a ring formed round the outlet of the blast pipe with holes in its upper surface, through which steam escapes into the chimney to cause a draught. In some engines the exhaust air from the vacuum brakes is discharged through the blower ; live steam, however, is used in most cases, most frequently taken from the dome to ensure dry steam. The blower is entirely under the control of the engine-men, and is chiefly used to assist the fire when raising steam, or when the engine is standing at stations, etc.

The water space should account for about two-thirds of the internal capacity of the boiler, the remainder being the space for the collection of the steam generated. To add to the steam space without reducing the water too low in the boiler, which would increase the liability to "prime" or lift water, a dome is added. On the Continent large domes and steam receptacles are much commoner than in British practice, especially in the Polonceau system of reservoir, which consists of two large domes and an external steam pipe to connect them. This arrangement, it is claimed, renders a larger volume of dry steam always available ; the dome over the firebox collects steam in quantity, while that in the dome nearest the chimney is the best position for dryness.

The regulator controls the steam on its way from the boiler to the steam chest. It is usually placed in the dome, with the inlet at the upper part, so that steam is taken as far away from the surface of the water as possible. If there is no dome, a pipe 5 or 6-in.

in diameter, and running horizontally along the top of the inside of the barrel, collects the steam, the pipe being perforated at its upper side to allow of the entrance of the steam.

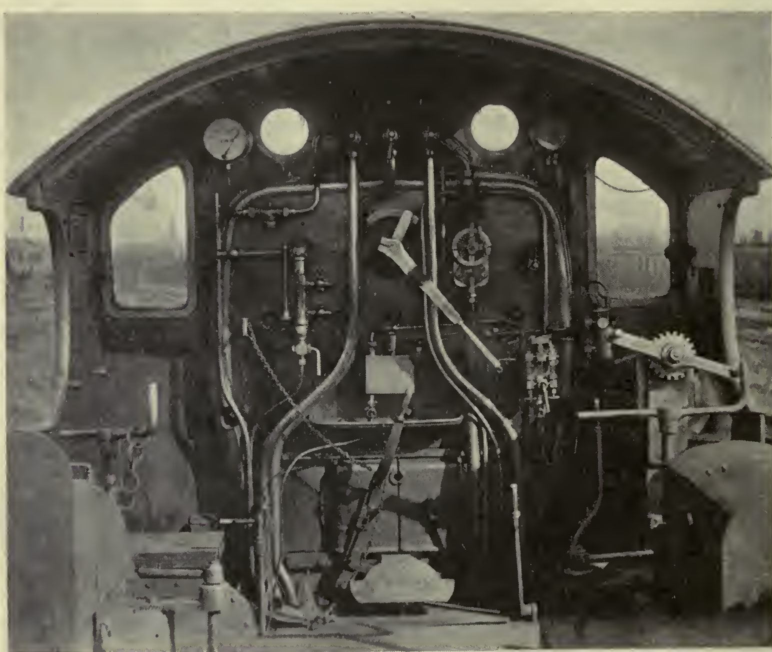
Safety valves prevent the boiler pressure exceeding the limit fixed upon by the designer, being adjusted to lift and allow the surplus steam to escape, and close again when the necessary reduction has been accomplished. Two valves, and sometimes three, are generally fitted to every boiler, so as to reduce the danger of an explosion through excessive pressure caused by sticking valves.

The standard British safety valve is the one known as the Ramsbottom type introduced in 1855. Originally it was constructed of brass, but now generally consists of two hollow cast iron pillars, standing vertically upon a circular plate, and in communication with the boiler at the base, the valves closing them at the upper ends. The valves, usually 3-in. in diameter, are held down by means of a spring pulling on a lever, which crosses and rests upon the pillars. This safety valve is simple and effective, is difficult to tamper with, and is in great favour with drivers generally.

Another form of safety valve is the spring balance, once very popular, but now not nearly so common as the Ramsbottom type. It is usually placed on the dome and consists of two valves similar in shape to those last described, but provided with a spring for weighting down the lever. The arrangement is not sufficiently automatic, and there is the possibility of it being held down to secure increased pressure. The "Pop" safety valves are very sensitive and give a more rapid release of steam than other spring loaded valves, and, moreover, will do it at the exact figure at which they are set; whereas the Ramsbottom safety valve usually commences blowing at 5 to 10 lbs. under the figure, lifting fairly at the point agreed on, and blowing off hard at 10 lbs. above.

The pressure carried in the boiler is indicated by a steam gauge, of which the Bourdon gauge is a very common form. A pointer indicates on a dial the pressure per sq. inch. The case contains a flattened tube, connected at one end to a casting, which has a union for a siphon pipe from the boiler upon it, and closed at the other end with a hinge for attaching a connecting rod, which actuates a lever on the spindle carrying the pointer. The pressure within the pipe tends to straighten it, the closed end with the connecting rod moves outwards, and turns the pointer round on the dial. This pattern of gauge has numerous variations, but the principle involved in them all is practically the same.

Water-gauge columns at the back of the outer firebox enable the level of the water in the boiler to be discerned. They consist of brass mountings, the upper one communicating with the steam space, and the lower with the water, a glass tube connecting the two. If the water disappear below the bottom of the glass, the crown plate of the firebox is in danger of over-heating, and if the level of the water cannot be raised, the fire should be drawn or at least smothered with earth or ballast. If a glass break, there is considerable danger of the engine-men being scalded by the water, and thus there are devices for closing the water and steam ways automatically, when such a mishap occurs. The boiler is also provided with a test cock to test the water level, if the gauge-glass fail.



CAB OF THE "KNIGHT" CLASS
(Great Western Railway)

Glasses will not stand in cold countries, where it is customary to use three or four test cocks. In order to allow the water to escape from the boiler for cleansing, a blow-off cock is usually fixed at the lowest point possible.

The water supply to the boiler is maintained by means of injectors or pumps, the former worked by steam, and the latter generally from some moving part of the engine. A jet of steam issuing from a contracted nozzle possesses more velocity than a corresponding jet of water at the same pressure; and if a jet of steam suddenly come in contact with a flow of water, a portion of the steam is condensed, imparting its velocity to the water sufficiently for the combined steam and water to lift the clack valve and enter the boiler. The colder the water, the better the injector will work ; but the introduction of cold water causes local straining, due to expansion and contraction, and various improved injectors will introduce warm and even hot water into the boiler. Giffard invented the earliest form of injector in 1859, and modifications of it survive to the present day. The various types of injector need not be detailed, since they all make use of the principle described above.

Steam whistles are of various forms, but more or less similar in action. A common type consists of a gun-metal base reversed with its mouth downwards, and with its sharp edge immediately over an annular opening in the base, through which steam issues and impinges on it, causing the bell to vibrate violently and give out sound, the shrillness or deepness of the tone depending upon the size of the bell. Many railways fit two whistles on their locomotives, one for signalling purposes, and a second for warnings only.

The general construction and most prominent details of the boiler having been explained as briefly as anything like lucidity will allow, and having shown how steam is generated, we can examine the mechanism by means of which the energy of the steam is transformed into useful work.

THE ENGINE

Primarily the engine consists of cylinders in which the steam moves the pistons, whose reciprocating motion through the medium of connecting rods is transformed into a rotary motion at the crank axle, propelling the engine either backwards or forwards as desired. As there are usually two cylinders, there are correspondingly two cranks, to each of which one of the pistons is connected. These cranks are arranged at right angles, so that when one is at the end of its stroke and doing no useful work, the other is working at its best advantage.

The cylinders are the real heart of the whole machine. They may be placed between the frames, when the engine is called "inside-cylindered," or on the outside of the frames, when it is known as "outside-cylindered." In Britain the first-named is most common ; on the Continent the latter is largely adopted, and in America is almost universal. Inside cylinders, acting as a stay, give the whole structure greater rigidity, steadier running, and the width over all is less ; but the cranked axle is somewhat of a disadvantage, while large cylinders tend to cramp the steam chest. Outside cylinders may be larger, and the greater accessibility of all the parts is an important consideration.

Cylinders in size range from 8-in. diameter by 10-in. stroke to 20-in. diameter by 26-in. stroke ; many sizes between these are used, and some examples are smaller or larger. The steam chest is placed between the two cylinders, which are often cast in two portions and then faced up and bolted together, but if the cylinders are cast in one piece a troublesome steam joint is obviated. Numerous details of construction and building must be omitted, only emphasising that the greatest nicety in both must be observed to prevent any movement of the cylinders, whether inside or outside the frame plates, the effect of which would militate seriously against successful running.

The pistons up to 17 inches are usually made of cast iron ; for larger sizes cast steel or wrought iron is employed on account of the greater strength. The rim of the piston is widened and turned up to $\frac{1}{32}$-in. less in diameter than the cylinder, and has recesses turned in it for the reception of one or more rings ; small pistons take one ring, but in larger ones two or three rings may be used. The employment of more than one ring affords greater flexibility, while reducing the liability of the steam passing.

The piston rods, made of steel or wrought iron, and from $1\frac{1}{2}$ to $3\frac{1}{2}$ in. in diameter, are passed through a stuffing box at the back end of the cylinders. Many means have been devised to allow the rods to work through the stuffing freely without permitting steam to pass. Hemp or a preparation of asbestos was formerly the usual material for packing, but in recent years metallic packing has largely replaced it, the extra first cost being the only drawback to place against various advantages.

The slide bars keep the movement of the piston rod in a straight line, as the crosshead is fixed to the end of the piston rod, to which the small end of the connecting rod is attached. There may be one, two, three, or four slide bars to each crosshead, according to the preference of the designer.

The connecting rods are the mediums through which the reciprocating motion of the crossheads is converted into rotary motion at the cranks, and consequently the wheels. Various designs and shapes for the ends are in vogue, experience having taught that the end of the rod nearest the crank is the most liable to breakage when working, and therefore this end is always made the stronger, and being the larger of the two it is known as the "big end," whilst the other, or crosshead end, is called the "small end." Cast steel is largely employed for connecting rods, and it is most important that none but the best metal and workmanship be allowed in these important members of a locomotive, the breakage of which is liable to be one of the most disastrous failures that can occur to an engine when running.

It is the slide valve that controls the admission of steam to the cylinders on either side of the piston, and the discharge of the exhaust steam from the opposite end. This is effected by the valve moving over the face of ports in the steam chest, so that alternately they are opened and closed to steam or exhaust.

The cycle of operations for each revolution of the crank is as follows: First steam is admitted to the cylinder, called "admission," then the valve closes, termed "cut-off"; the steam shut in the cylinders then exerts its pressure by "expansion." Next the valve opens to exhaust, called "release"; the distance between the cut-off and release, through which the piston is propelled by the expansion of the steam, is known as the "expansion period." The valve closes the port to the exhaust at the end towards which the piston is moving before the piston reaches the end of its stroke, and the steam left in the cylinder is compressed, forming a "cushion," to assist in bringing the piston to rest without shock, and as the valve here opens a little to live steam called the "lead," the piston is ready to perform its return stroke as soon as the crank has passed its "dead centre." Admission, cut-off, expansion, and release then take place from the other end, bringing the piston back to the point of starting. All the above operations are repeated for each revolution of the driving wheels.

By "cut-off" is meant the cutting-off of the passage of steam from the steam chest to the cylinder, when the piston has moved through part of its stroke, so as to allow the remainder of the stroke to be made by the expansive force of the steam already let in.

The necessary movement is imparted to the valves by means of the "motion," or valve gear, of which there is a great variety of types. On the first locomotives, which only ran at some four or five miles an hour, for starting the engine it was necessary to observe the position of the cranks and move the valve rod by hand, so that the steam could be admitted to the required side of the piston, after which the engine took up the movement automatically. No advantage could be taken of the expansive properties of the steam, as the full steam pressure was maintained throughout the stroke. When the success of the locomotive was assured, and its speed increased, the need for improving the valve gear became apparent, and amongst the advances leading up to the present motion was the employment of a single eccentric for each valve and cylinder, loose upon the axle, and having catches at the side to engage studs upon the axle when moved laterally.

The next advance was to fit the engine with two eccentrics for each cylinder, and have forks at the ends of the eccentric rods with means by which they could be raised or lowered, so as to engage or disengage with pins upon the valve spindles, either fork could then at will be made to communicate its motion to the valve; by having the lever in mid position neither acted, and the valves remained stationary. These forks were found to be a continual source of trouble and expense, as they broke off frequently, and to improve the gear the two rod ends were connected by a curved link, so that the valve spindle was always coupled to the link, and the raising and lowering of the rods and links brought the valve under the influence of either eccentric as required. This, with modification, is the "link motion" most commonly used to this day for locomotives. It is called the "shifting link" or "Stephenson" motion, because it was introduced by the firm of Messrs. R. Stephenson & Co., in 1843, and fitted to the engines built by them.

A second link motion is the stationary link invented by Daniel Gooch in 1843. It has a link hung with its curvature the opposite way to that described above, and to reverse the engine the valve rod is moved up or down, the link remaining hung in one position vertically, but free to vibrate backwards or forwards about the centre of a suspension link. All the earlier Great Western Railway engines were fitted with this form of motion; but it is now little used in British locomotives and rarely in America; but is still largely popular on the Continent.

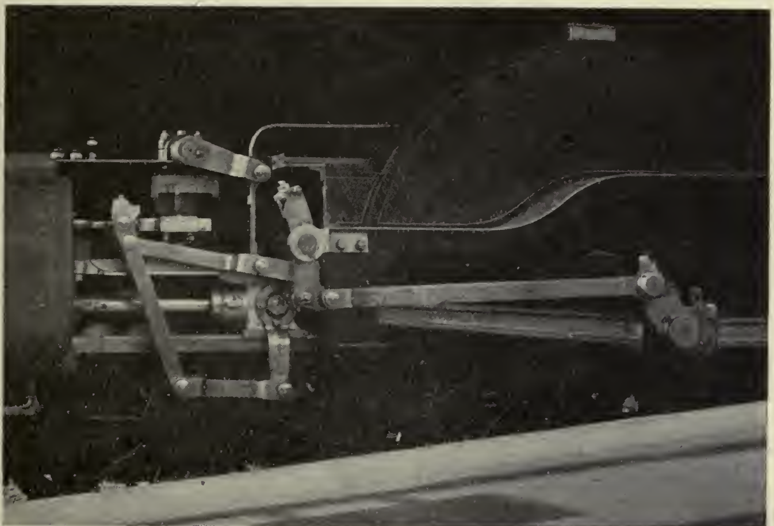
An objection to both the stationary and shifting link motion is, that as the centre of motion of the valve is moved farther and farther from the centre of the link, due to the link or radius rod respectively being raised or lowered, the distribution of steam in the forward stroke is different from that in the backward stroke.

The "straight link" or "Allan" motion, from its inventor's name, is a compromise between the two foregoing motions. In this gear the link is made straight, and has a limited vertical movement; the valve rod is also provided with a lift, so that to reverse the engine the link rises and the valve rod falls, or *vice versa*, as the case may be. This motion is used extensively in Britain and on the Continent, but is not favoured in America, as, like the stationary link, it requires a long distance for the radius rod, making it difficult to use in conjunction with a rocker, which is common in American practice.

Some motions dispense with eccentrics wholly or in part, and are commonly known as radial gears. In Joy's motion the valve movement is taken from the connecting rod through a system of levers.

For this gear many advantages are claimed—it is simple in construction and maintenance, the dead weight of the whole is less, and it is generally more correct in working, as, if the centre lines of the various levers, etc., are properly set out, a valve path diagram is given, in which the lead and cut-off are exactly equal for both ends of the cylinders, and they remain so for all grades of expansion to mid-gear. The valve opens more rapidly than when actuated by link motions, the cut-off being prompt and the release of the exhaust quick, whilst it moves slowly during the expanding and exhausting periods. These qualities are very desirable for a locomotive slide valve, when obtained without any undue lead, compression, or too early exhaust. The cut-off point is not limited by the throw of eccentrics, etc., but the reversing depends upon the angle to which the quadrant block guides are inclined, so that it would be only necessary to allow these to be carried over past the point usual for a full-gear cut-off of, say 75 per cent, to obtain a cut-off of 80 or 90 per cent ; thus the starting power of the engine can be greatly increased, and the trouble sometimes necessary of reversing to get it into a more favourable position dispensed with.

In Walschaert's motion, which is not, correctly speaking, a radial gear, as no ellipses are described by it, the valve has its travel controlled from two perfectly distinct movements, one that of the



WALSCHAERT'S GEAR

crosshead, the other that of an eccentric fixed upon the crank axle, these being combined by a system of levers, so that the motion of the slide valve is the same as that derived from the stationary link. A slot link is used for enabling the motion to be reversed from fore to back gear as required. It is less difficult to arrange the design of this motion for equal points of cut-off at each end of the cylinder than it is with either the shifting or stationary link motions, owing to the very intimate relationship which exists between the piston and valve positions and movements through the combination lever. The general accuracy of the movements of the valve, when actuated by this gear, is not liable to be deranged by wear, slack at the bottom of it being lessened very much at the top, and its effect almost nullified.

This motion is not largely used in Britain, but is very extensively employed on the Continent owing to the ease with which it can be fitted to, and its suitability for, outside cylinder engines. When used on these it is usual to employ a return crank fixed to the crank pin instead of an eccentric, and in many engines, where there is a difficulty in putting the reversing shaft and its connections in position, the radius rod is prolonged and carried beyond the quadrant link, for the reversing arm to be coupled to it.

There are many locomotives fitted with a modification of this gear, in which the distance between the centre of driving axle and valve is too small to allow of such an arrangement ; in these, the quadrant link is hung up with its curvatures reversed, and the radius rod laid between the link and driving axle, the valve rod being lengthened to suit, and connected as before by means of the combination lever to a projection below the crosshead ; this arrangement gives equally good results.

In Morton's gear the motion is taken from the connecting rod and crosshead, no eccentrics being used. The connecting rod has a boss formed on it about the middle of its length, which carries a small crank with cheeks on either side ; from these bearings project, for the attachment of a floating lever, which takes the radius rod at the top, anchor links just below, and a combination link, which connects it to a projecting arm from the crosshead, at the bottom.

The various valve motions described are operated from the foot-plate by the driver, who can not only reverse the engine, but regulate the expansion of the steam admitted to the cylinders by adjusting the cut-off to any point of the stroke as the work to be done may require.

The reversing lever works by means of a rod and catch sliding in a guide, and engaging in slots or notches. When the catch is in the central notch the engine is out of gear ; raising the catch and pushing the lever over towards the front puts the motion into fore gear ; while pulling it back works the reverse. There are many arrangements of reversing gears, some working by steam or compressed air.

THE FRAMING, WHEELS, Etc.

The carriage and running gear next present themselves for consideration. The engine and boiler are fixed upon a framing supported by the wheels and axles. The two inner or main frames in European practice are inside the wheels, and extend the whole length of the engine. They are stayed in the strongest manner possible at suitable positions in their length, the method of accomplishing this being dependent upon the type of engine, arrangement of wheels, etc. The two outer frames, which are lighter, support the foot-plates, splashers, etc. Formerly it was the custom to make "sandwich" frames, consisting of planks of oak upon which were bolted plates of iron, but now invariably they are of steel plate.

The buffer plate, or beam, is usually a single steel plate, thicker than the main frames, but some builders still prefer a beam of oak plated on each side, with a view to reducing the shock upon the frames when the buffers strike. Attached to the frames in front of the engine are guard-irons, reaching down to within about 3-in. of the rails, to remove any obstruction likely to derail the engine.

To gain flexibility in the wheel base of an engine not fitted with a bogie and having single leading wheels, it is a common expedient to make the axle box a loose fit in the guides, so that the wheels may move sideways to an extent when the engine takes a curve. On an engine with a long wheel base, as the side play must be large to gain sufficient lateral movement, therefore some form of controlling gear is necessary; some makers use springs and some swing links for this purpose, but the most common method is to form the top of the box into inclined planes, and have the bottom of the cover plate of a similar shape to suit. The wheels are made of wrought iron, cast iron, or cast steel. The first-named metal, however, has now been replaced to a large extent by the second for goods and shunting engines, and the third for passenger and express engines.

To ensure smooth running and even wear of tyres and the engine generally, it is necessary to balance the reciprocating and revolving weights of the motion, and with cast iron wheels it is usual to cast the weights in place. In inside-cylindered engines, the driving wheels on the crank axle have the balance weights placed on one side of the centre line of the axle and crank pin, the reason for this being that the power is applied to a point somewhat removed from the plane of the wheel. If the weight was exactly opposite, it would not correctly balance, as the other crank, which is at right angles, has an influence upon it. The exact amount of offset is ascertained when the wheel is designed.

In outside-cylindered engines the balance weights are placed exactly opposite the crank pin, as the power is here applied approximately in the plane of the wheel, and the influence of the other crank is not felt.

With wrought iron wheels the weights may be forged in place, but it is more usual to fit them in afterwards and fasten by rivets passing through them and plates on the outside and inside of the spokes.

Tyres are of open hearth, crucible or Bessemer steel. The tyre is heated to a black heat, placed upon the wheel and allowed to cool, but not quenched in water, as this might make it brittle and liable to crack. Other methods of securing the tyres on the wheels are employed in addition to the shrinkage, such as studding or bolting them on, or springing them into a groove provided in the tyre.

The outside diameter of the tyre is made up of the flange upon the inner side and the tread which bears upon the rail. In the usual British form the flange projects down a little more than one inch. The driving tyres of six-coupled and single express engines are generally made with flanges of reduced thickness, in order to allow a certain amount of flexibility to the engine and save the crank axle from some of the side shocks received from striking the rails. For the same reason in engines with long wheel bases some of the tyres are made "blind," that is, with no flanges at all. They are then about 6½-in. wide, so that freedom to pass curves is obtained, and yet the wheels do not lose their alignment with the other wheels to which they are coupled.

Axles are also of open hearth or Bessemer steel, and are subject to severe tests before being accepted from the contractors, the ultimate tensile strength to be 32 tons per sq. in. A piece is taken from the forging and machined to 1¼-in. square and bent double whilst cold without sign of fracture. With crank axles one is often taken from the parcel and tested to destruction; and they are usually taken on the condition that the makers replace at their own cost any that may fail before they complete 200,000 miles. The breakage of a crank axle is one of the most serious mishaps that can occur to a locomotive.

Crank axles are sometimes built up of separate pieces, which are screwed together instead of being in one forging; and further, in order to relieve the cranks of strain to induce bending, four bearings are often provided, one on either side of each wheel.

Owing to weaknesses of the road, etc., it is not always possible to put all the weight necessary for adhesion on one pair of driving wheels, consequently two or more pairs are connected together by means of coupling rods working upon crank pins projecting from the wheel bosses of inside-framed engines, or from outside cranks of those with outside frames.

The coupling rods are either of iron or steel, being usually made in one piece without welds. The ends vary somewhat in shape, but the solid eye, with a bush inserted in it to take the wear upon the crank pin, is very largely used. In engines with more than four wheels coupled it is necessary that there should be freedom allowed for the rods to give vertically in their length as the different pairs of wheels are moving over varying levels in running, and if they were in one rigid length they would be liable to be broken. This movement is afforded by the provision of a joint; or one rod is forked and the other is formed with a large eye to go between the jaws of the fork.

The wheels and axles are connected to the frames of the engine through the medium of springs, so that any shocks received by the wheels in running may be reduced and their effect lessened, and the liability of damage to the mechanism of the engine and to the road bed reduced ; further, the engine has not the tendency to mount the rails that it would have if the wheels and frames were rigidly fastened together.

The springs are of various designs, those built up of long flat plates one upon the other being known as " laminated," whilst two of such springs placed one on top of the other, but with their curvatures reversed, are termed " elliptical " ; those coiled out of flat section steel, with different diameters at top and bottom to accommodate the one coil inside the preceding one, " volute " ; while round bar or " Timmis " section, of equal diameter throughout, are called " helical " springs.

Steel of the very best quality is invariably used for this purpose, and the completed springs are well tested in a scragging machine before they are put under an engine to work.

As all the axle boxes fitted with independent springs are permanently loaded with the full weight to be carried by them, it follows that, as the wheels pass over inequalities of the rails, this weight per axle may be largely increased for the time being ; therefore many engines have two or more pairs of wheels fitted with compensating or equalising levers or beams, so that the rising and falling of the wheels mentioned may be accommodated without causing an undue load to be carried by any one box. With these beams every shock to one wheel and spring will be in part taken by the next to which they are coupled, thus lessening the injurious effects. This equalising is common in Britain and on the Continent, and is universal in America.

To obtain lateral flexibility in the wheel base various means are adopted. With coupled wheels which are necessarily rigid, being all connected by rods, some are occasionally provided with blind tyres or reduced flanges, as has been already mentioned. When the driving wheel base is not too long, as in four wheels coupled engines, the remaining wheels are provided with one of several methods of allowing lateral play : firstly by a four-wheeled bogie or truck, secondly by a two-wheeled bogie or pony truck, thirdly by radial or sliding axle boxes.

In some cases, especially in engines fitted with a four-wheeled bogie, all the flexibility is provided at one end ; but when the other means are employed, they are often placed at each end of the engine with the rigid wheel base between them.

The four-wheeled bogie is made in various ways, the simplest being in the form of a frame having four axle boxes to take bearing on the axles, and a top with a large hole in the centre, through which a pin fixed to the main framing of the engine passes, and about which the bogie works. This arrangement has only freedom to move as a pivoted structure, for being unprovided with lateral displacement, the flexibility of the engine is entirely obtained by the bogie partially turning.

Another method of obtaining a flexible wheel base is by means of a radial axle box, which allows a movement similar to the above, but in a different way. Instead of the movement being controlled by a centre pin about which the wheels radiate, the axles are fitted with boxes which are of such a form that they can slide in curved guides, attached to the engine frames, and are thus prevented from partially revolving about the centre of the pair of wheels.

We will now consider some of the miscellaneous fittings necessary for the running equipment of the locomotive. The hauling power depends upon the tractive force, that is, the power exerted by the steam acting upon the pistons in the cylinders transmitted through the mechanism of the engine to the drivers operating in conjunction with the adhesion, the latter representing the frictional resistance due to the weight placed upon the driving wheels. This must always be greater than the former, or the wheels will be made to revolve upon the rails, and "slip" without moving the engine at all. With sufficient adhesion the wheels will revolve, and instead of slipping, the whole engine and train to which it is attached will move along the rails in the direction desired.

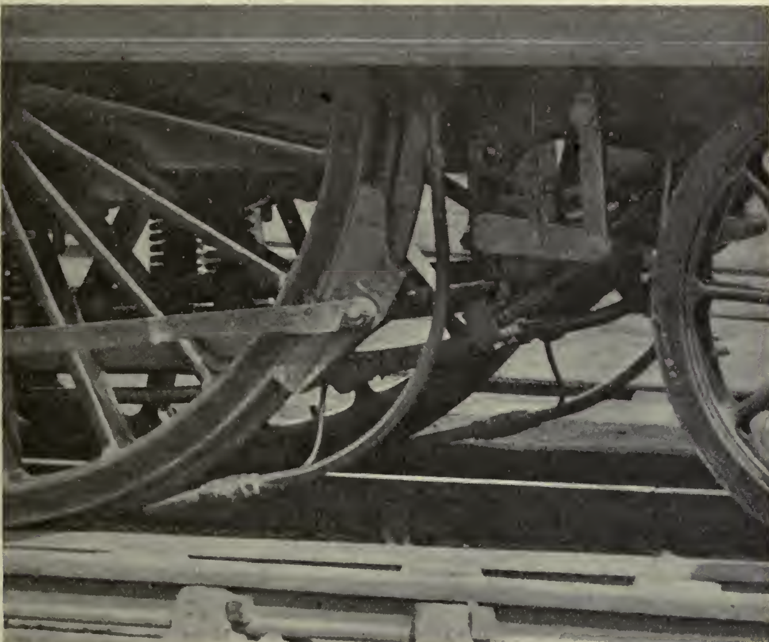
The adhesion or resistance to slipping may therefore be said to be dependent upon the weight placed upon the drivers, but qualified by the condition of the rails. The friction between these two varies very considerably according as the latter are wet, dry, or greasy. When dry and clean a tractive power exceeding one-fourth of the adhesive weight will cause slipping, when dry and sanded about one-third; in wet and frosty weather the friction is reduced to about one-sixth.

In order to be able to work under the most advantageous conditions, and obtain as much adhesion as possible, it is the practice to fit sand boxes upon the engine in convenient places for allowing sand to run upon the rails, when there is a tendency for the drivers to slip.

A common sand box suitable for an engine with coupled wheels is of cast iron, and is formed in one with the wheel splasher. The sand is filled in through the oval cover at the top, and is allowed to fall out by partially revolving a small "butterfly" valve at the bottom, which uncovers two holes over the sand pipe leading to the front of the wheels. The gear necessary for working the valve is worked from a lever in the cab, and the sand is allowed to run on both rails at the same time, the rod passing across between the sand boxes, under the boiler, and operating both sand valves simultaneously.

When there is a strong side wind, or when the engine is running round a sharp curve, it often happens that the sand falls clear of the rails; or if the engine slips and cannot be moved at all, the sand will not go under the wheel, and the fireman must get down and push it under with his shovel. To overcome these difficulties it is now usual to fit up a steam sanding gear, so that the sand may be driven under the wheel to the point of contact with the rail.

The buffers, with which all engines on the standard gauge railways of this country are provided, next claim our attention. They are attached to the buffer beam with their centres about 3-ft. 5-in. above the level of the rails and 5-ft. 8-in. apart, centre to centre, to meet those of the carriages and wagons forming the train.



STEAM SANDING GEAR
(South Eastern and Chatham Railway)

A common form of buffer consists of a hollow plunger fitting easily in a casing which has a bottom plate riveted to it; this has a hole through which a centre pin passes. Within the plunger is a block of hard wood and coiled steel spring. There are innumerable other designs of buffers, but the principles underlying all of them are the same. Many have indiarubber cushions instead of steel springs, this material being very suitable for withstanding the severe and sudden shocks to which the buffers are subjected in service, and which often prove fatal to steel springs.

Having dealt now with practically all the working parts of the mechanism of the engine, reference must be made before concluding the section on the running gear, etc., to that necessary item, lubrication. The lubricating medium—oil, grease, or tallow—has to be delivered to the exact part intended by means of one or other of the various forms of lubricator. For oil the simplest is the oil cup. It is of cast iron or brass, and has a tube inside it reaching nearly to the top, and leading down to the bearing requiring the oil; the top of the cup is slightly reduced in size by having a lip cast round it to prevent the oil from splashing out when the engine is running. A wick trimming is placed in the tube, of such a fit that the oil may pass in the desired quantity to the bearing.

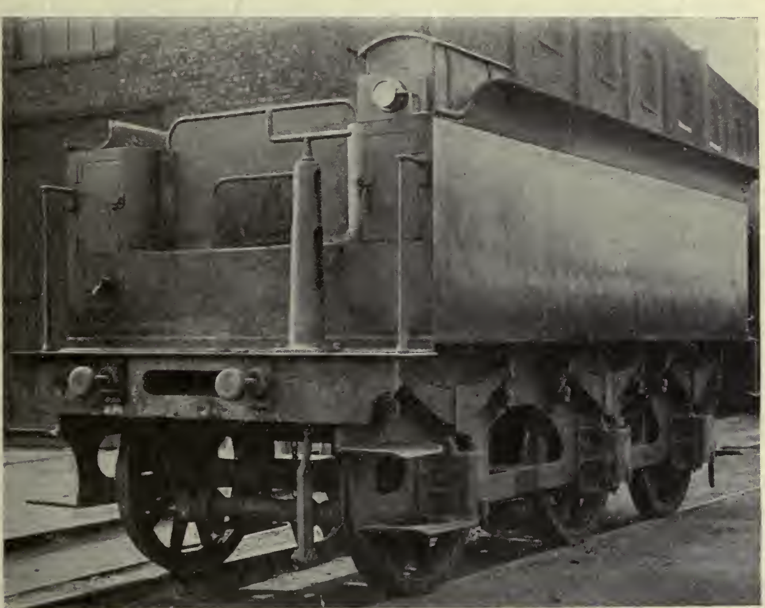
Although the lubricator last described is still in common use, locomotives of recent build are fitted with sight-feed lubricators fixed in the cab, where they are easily accessible to the driver. In these the oil is placed in a chamber to which steam is conducted and allowed to condense, the oil being thereby displaced; this then flows down a pipe where a small jet of steam meets it and carries it to the steam chest or cylinders. The displaced oil passing, drop by drop, up through a "sight tube" filled with the condensed water is visible—hence the name "sight feed" lubricator. The advantages of this method of oiling are—greater safety for the men, as there is no need to go round the platform when the engine is running to see if the lubricators are at work, as is sometimes necessary with the other kinds; economy of oil, as only the required quantity need be supplied; and, further, the oil driven in in this way, finely mixed with the steam, is spread over the whole surface, and therefore lubricates better than when allowed simply to drip into the valve chests or cylinders.

Four pints of engine oil for general lubrication, and one pint of cylinder oil per 100 miles run is a fair allowance for an express locomotive and tender.

THE TENDER, BRAKES, ETC.

Engines that only engage in short runs are provided with tanks for water and bunkers for coal upon their own frames. Water tanks may be placed on the foot-plate on each side of the boiler and connected by a large pipe passing under the latter, while the coal bunker is also upon the foot-plate behind the boiler, the cab being between them. If two side tanks will not hold the requisite supply of water, a third one is placed below the bunker. Where the third tank is provided it is given free communication with the other two, so that the same level of water is maintained in each, and the equilibrium of the engine preserved. In the tanks wash-plates are fitted, extending from side to side to steady the bulk of water and prevent it washing from one end to the other, especially when the brakes are applied or released. Chiefly only in smaller engines, the tanks are made semicircular in shape to fit on the top of the boiler. If the so-called " saddle " tank be large, it gives the engine a top-heavy appearance.

Tank engines, as remarked in an earlier chapter, run equally well in either direction, and are to be preferred where there is no call for high speed or long runs. The tanks carry a water supply up to 2000 gallons, and bunkers hold 3 tons of coal; if more water and fuel are required an engine with an independent tender will be employed. Tenders carry up to 5000 gallons of water and six or seven tons of coal, but the common capacity is much less.



END VIEW OF TENDER

Tender engines should only be run at great speed engine first, thus necessitating turning round at the end of each journey. The number of wheels carrying a tender is usually six, but in some cases it is eight.

The tender is coupled to the engine in various ways. Commonly, two buffers placed at the front end bear against the back plate of the engine, and assist in steadying both engine and tender in running. The attachment is made by a large draw bar in the centre with an eye at each end for a pin, with smaller bars, one at each side, for emergency. The buffers at the rear of the tender and the draw hooks and couplings resemble those upon the front of the engine.

The sides are stayed together by plates which extend completely across and form washplates, large holes being cut through them of sufficient diameter to allow the water to circulate freely, and to permit of the men passing when making and repairing the tanks. Longitudinal wash-plates are also fitted in some cases; these are especially necessary when the tender is running upon lines which abound in sharp curves, as they help to keep the water from accumulating at the outer side of the curve by centrifugal force and from throwing an undue weight upon the springs and bearings at that side.

For long runs it is necessary to adopt large tenders carrying 4000 gallons of water and over, sometimes running upon two four-wheeled bogies, which are, however, unlike those of the engine, as they are not fitted for side play, but only move about the centre pin with circular motion. Very often the tenders attached to engines that engage in long non-stop runs are fitted with a water picking-up apparatus. There are various designs to effect the same end, but in any of them there is little difference in their main features. A hinged scoop is provided, and fitted so that it can be lowered into, and raised from, a long, narrow trough, placed midway between the rails and filled with water. When passing over this at high speed the tender tank is filled by lowering the scoop into it, and when a sufficient quantity of water has been taken, the scoop may be lifted up clear of the trough and of any other obstructions.

The scoop may be lowered or raised by the engine-men working hand levers in the cab or on the tender front; but as the raising of it out of the water trough, especially when travelling fast, is rather an arduous task, means have been adopted to effect the raising expeditiously by the use of steam, or compressed air from the brakes.

The pipes conveying the feed water from the tender to the engine are necessarily flexible to allow of movement when running; they are often made of indiarubber, canvas, or other suitable material, but as it is customary to pass steam through them from the boiler when standing, or when it is desired to heat the feed water, this hose is not altogether satisfactory, therefore flexible metallic connections have been designed.

A hand brake is fitted, and blocks bear upon each wheel, and for goods engines this is often the only brake provided, but with passenger engines the continuous brake adopted is also either coupled direct to the mechanism, or the steam brake of the engine applies the tender brake simultaneously with that of the train.

In order to retard the speed and assist in stopping, the wheels of both engine and tender are fitted with brake blocks which bear upon the periphery of the tyres. When pressure is applied to these, the friction prevents the wheels from freely revolving, and, if carried to excess, stops them completely. It is not always customary to brake the wheels of the engine, but when they are so treated the coupled wheels are chosen, and in the case of an engine having single drivers, the trailing carrying wheels in conjunction with the driving. On engines for heavy service it has become the custom to fit all the wheels of both engine and tender with brakes. A stout shaft is carried in a suitable position across the engine and fitted with arms, one for the attachment of the pull rods, another for the hand-brake gear, and a third for the connection of the cylinder operated by steam, air, or vacuum, as the case may be. For either of the mechanical systems a steam cylinder is fixed at one end of the shaft. This is coupled to one lever, and operates it by means of steam, which is admitted to one end of the cylinder to drive forward the piston and apply the brakes.

Brake blocks are usually of cast iron, and being of softer metal than the steel of the tyres, they therefore take most of the wear, being easier to replace when worn out. The proper length of block is between 1 ft. and 1-ft. 6-in.; if made less, it is liable to get very hot when applied hard. No advantage is secured by exceeding this length, as blocks which are too long and are applied at the centre have a tendency to bend, only bearing hard opposite the point where the pin is situated.

Nearly all the brake blocks upon British engines are made to bear upon the tread of the tyre or that part which runs upon the rails. Thus two wearing influences both tend to wear out the tyre at the same place, and cause a hollow section, consequently necessitating frequent re-turnings, hollow tyres being not safe for any great speeds, owing to the liability of the flanges fouling any of the points, etc., and thus causing derailments. It might be good policy, therefore, to copy American practice in this particular, and provide blocks made approximately to the shape of the tyres, but hollow at the tread, so that the blocks wear away the portion of the tyre that the rails do not touch, that is, outside of the tread and the flange itself. The tendency is then to keep the tyre to its original shape, and obviate re-turning for a time. The brake, when operated by hand, is a slow method of stopping a train, and when important that the stop should be made quickly, a more rapid power appliance must be provided. It is therefore now compulsory to fit all passenger trains with a continuous automatic brake, but, unfortunately, owing to the method of working our goods trains with slack couplings, etc., it is impossible at present to apply a satisfactory continuous brake to them, and the hand brake has survived on the freight service, although goods engines are now being rapidly equipped with steam, air, or vacuum brakes.

In the Westinghouse Automatic Brake the power is obtained from compressed air. By means of a continuous pipe, passing down the full length of the train, compressed air is supplied automatically from a main reservoir on the engine to a reservoir placed upon each braked vehicle. To each auxiliary reservoir is attached a valve and cylinder, the piston of which is connected to the brake gear. To apply the brake a small quantity of air is released from the train pipe, which causes the valves to move and allow air to flow from the auxiliary reservoirs into the brake cylinders, thus exerting pressure on the pistons and brake blocks. To release the brake, compressed air is admitted again to the pipe from the main reservoir, which

I. VACUUM BRAKE EJECTOR. 2. WESTINGHOUSE PUMP

moves the valves into such a position that the air escapes from the brake cylinders to the atmosphere, and at the same time allows air to pass into the auxiliary reservoirs, thus restoring them to their original pressure. The air pressure is kept up automatically by a steam-driven pump on the engine. The steam pipe which supplies this pump is fitted with an automatic governor, which admits steam and sets the pump in action, when the air pressure in the reservoir falls below a certain point, and stops the action as soon as the correct air pressure is restored.

In the Vacuum Automatic Brake, under each vehicle there is a cylinder with a piston in it. Under normal circumstances there is a vacuum maintained on each side of the piston. When the driver wishes to apply the brake, he admits a little air to one end of the cylinder, and, as there is a vacuum at the other end, the air forces the piston up and puts on the brake. To release the brake the air is withdrawn again; an ejector on the engine withdraws it and maintains the vacuum.

The cylinders under the vehicles are connected together and to the engine by means of flexible pipe couplings. If a train should part in two, or the flexible couplings get severed in any way, the brake is applied automatically by the inrush of air.

Lamp irons or brackets are fitted to the backs of the tenders as well as to the front of the engine in order to display lamps by night and disc-boards by day, which are a guide to the signalmen and staff as to the type of train and its destination.

In the last chapter reference was made to the long life of the locomotive "Lord of the Isles," which ran for thirty years without being renewed. Trevithick's "Cornwall" worked on the London and North Western Railway from 1847 till 1905, but the engine had been rebuilt. The life of a locomotive boiler averages from eight to ten years, during which time the engine will probably have run over 300,000 miles. Driving wheels require re-turning after running 50,000 miles, but bogie wheels will call for re-turning after running only half the distance, because, being about half-size, they revolve twice as many times as the drivers. The life of a modern locomotive may be set down at from fifteen to twenty years, during which it will have been rebuilt once, and sometimes twice.

The engines on British lines are painted far more fancifully than is the case abroad; almost all the colours of the spectrum are adopted, and certainly no such variety is to be found elsewhere. In the early days of railways locomotives were usually painted green, but now, red, blue, green, yellow, and black, etc., all have their patrons, and in most cases the main colour is enlivened with varicoloured linings. A light colour gives an engine a less weighty appearance, although a darker one is less expensive and calls for less attention to keep it in good condition. Good painting at least serves two purposes; a smart appearance is a good advertisement and attracts passengers, and the more handsome the engine, the greater the pride in it of the men who drive it, with the result that the steed gets many a "wipe-down" that otherwise it would not receive.

It is only when one arrives at this stage that there comes full realisation of the difficulty of attempting to compress satisfactorily into a single chapter subject-matter sufficient to fill a volume; but many further interesting points will be dealt with incidentally in later chapters, especially when describing various types of locomotives at work in different parts of the world.

CHAPTER V

THE CRADLES OF THE ROLLING STOCK

THE railway traffic of the United Kingdom calls for an enormous number of locomotives, carriages, wagons, and miscellaneous vehicles to compass the business that is carried on by day and by night on the 23,209 miles of line, or 53,669 miles of metals, if we reduce the lines to single track, and include the mileage of the lines in the sidings.

The total number of locomotives, carriages, and wagons has been given elsewhere, but we may tabulate the whole of the companies' rolling stock in greater detail for the year 1910 :—

	Locomotives.	Passenger carriages.	Other vehicles attached to passenger trains.	Wagons for minerals, merchandise and live-stock.	Other miscellaneous wagons.	Total vehicles, exclusive of locomotives.
England & Wales	19,390	44,893	16,258	574,148	18,541	653,840
Scotland . .	2,495	5,971	2,539	150,798	1,797	161,105
Ireland . .	893	2,055	1,227	20,402	943	24,627
Total . .	22,778	52,919	20,024	745,348	21,281	839,572

It must be pointed out that huge as these figures are, they do not include a large number of more or less small shunting engines owned by collieries, ironworks, dock companies, etc., nor quite 650,000 wagons and vans belonging to private owners, who use them for the conveyance of their own commodities.

In the classes of persons employed on our railways it will be noticed that the mechanics and artisans outnumber any other class very considerably. All the principal companies, and not a few of the smaller ones, construct their own locomotives, carriages, and wagons, and most of the remainder at least effect repairs and renewals in their own workshops. Some companies go much further. The London and North Western manufactures all its own signalling apparatus, and in its own works can produce 50,000 tons of steel per annum. It is often maintained that from a profit-earning point of view it is a mistake for railway companies to operate immense manufacturing establishments, since the officials have not to meet the keen competition of rivals in business, and thus there is no inducement to introduce the most approved tools and the latest methods of production, upon which depends good value at lowest cost. We have to take matters as we find them, and hence proceed to consider the actual construction of railway rolling stock, paying visits to a few well-known centres in order to note the genesis of the fine engines, carriages, and wagons that pass on to our lines in never-ending procession.

The London and North Western Railway Locomotive Works at Crewe are the largest in the kingdom. The ground upon which the works stand is about 1½ miles long, and its area is 137 acres, of which 45 are covered in. In this huge industrial hive employment is given to about 10,000 men, to whom may be added over 700 engine drivers, firemen, and others at the steam sheds at Crewe Station, which is the most important junction on the London and North Western system.

There is great similarity in all locomotive building establishments, and what may be said of one company's methods applies generally to all others, but no railway works except at Crewe possess a complete steel-making plant. In the Siemens-Martin House there are seven 25-ton and two 35-ton steel-melting furnaces, and the gas for these, as well as for the reheating and other furnaces, is provided by means of fifty-eight Wilson gas-producers. Each furnace is fitted with powerful hydraulic machinery for handling the ladles into which the molten metal is run before it is poured into the ingot moulds.

The rail ingots, as cast, are 3-ft. 4-in. long and 14-in. square. After reheating they are passed through the cogging mill five times, which reduces their section to 10-in. by 8-in. They are then run directly to the three-high rail mill, whence after thirteen passes they emerge as rails over 60-ft. long, their weight being 90 lbs. per yard. During the last few passes the top and bottom of the bar flatten out and the middle becomes thinner. When the rail emerges from the last pair of rollers it is passed to a circular saw, where the ends are cut off square. From the time that the ingot enters the first pair of rollers until a perfectly finished rail is produced is only about two minutes.

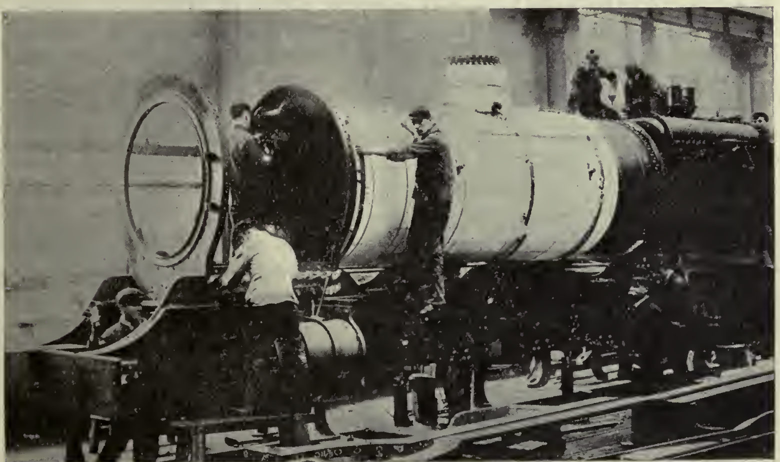
The steel forge is an exceedingly interesting department fitted with the following tools and plant: two powerful hydraulic forging presses—one of them being furnished with an electrically worked "turning-over" gear, which greatly facilitates the handling of the large steel slabs when under the press; four vertical steam hammers ranging from 8 tons to 50 cwts.; one plate and axle mill with four sets of rolls; a tyre mill which will roll up to 8-ft. 9-in. in diameter; twenty hydraulic and hand-power cranes, lifts, and hoists; various

2000 TON HYDRAULIC PRESS, CREWE WORKS

(London and North Western Railway)

punching and shearing machines; and two 7-ft. diameter circular saws for hot metal.

The action of a vertical steam hammer is too well known to call for description, but a duplex hammer is well worth attention. A mass of white-hot metal is pounded by two blocks each weighing 30 tons, which are driven horizontally to and from each other by steam power. Steam hammers are not only objectionable on account of their vibration, they are inadequate to deal with ingots of any considerable size, because a hammer blow, while extending the surface of the ingot, scarcely affects its centre. The hydraulic press establishes quite opposite conditions with its non-vibrating



LAGGING A BOILER
(Great Western Railway)

squeezes of tremendous pressure. A 300-ton press very effectively works metal of 10-in. diameter, or 8-in. square, or 12×6-in.

At Crewe, in addition to the manufacture of locomotive parts, large quantities of steel girders are made for warehouses, roofs, bridges, etc. As an instance of what can e done in a short time, it may be mentioned that 42 girders, each 32-ft. long, were made, i.e. the steel was manufactured, rolled, and worked within seven days. This work was done to replace the Llandulas viaduct on the Holyhead line, which was washed away in a storm.

The building of a locomotive involves a great number of highly interesting operations calling for the use of wonderful labour-saving machines. Not a few of the departments of any locomotive works are practically identical with those of ordinary engineering establishments. A stranger visiting any railway works is struck by the noise and the strenuous labour that at once surrounds him. At every step he perceives strange machines that treat metal with as little ceremony as a baker extends to yielding dough. Hammers batter, presses squeeze, and rolls lengthen or broaden glowing slabs of iron or steel into the requisite shapes. In the full-page illustration is shown a steel bloom under a 2000 ton hydraulic press. The shaping of heated metal is understandable to the lay visitor, but the cold plate undergoes succeeding processes that fill him with wonder. A planing machine will pare cold steel without even the noise attached to a carpenter's plane passing over wood ; remorseless shears snip and cut it as though it were cardboard ; a punching machine cuts holes in a cold plate 1½-in. thick. We are told that at the Great Eastern Railway Works, Stratford, nine men working four of these last-named machines, punch over 7 million holes in a year, the weight of the punchings alone amounting to nearly 250 tons. Saws driven by special engines will cut through 9-in. of metal in less than half a minute.

A boiler shop is a perfect pandemonium, thanks to dozens of hammers smiting the heads of red-hot rivets as fast as the arms of the operatives can wield them ; while pneumatic riveters tap with the rapidity of gatling-guns. There are, however, other methods of riveting in great contrast to this riotous noise. Entering the boiler shop at the Great Eastern Railway Works at Stratford, we see a vertical rolling machine, somewhat suggestive of a huge domestic mangle, standing on its side. Great plates of steel, which have previously been planed and drilled or punched, are passed between the rolls, which bend the plates into barrel shape. When the barrel is bolted together, with its rings and straps, an overhead travelling crane conveys it to an "iron man" worked by hydraulic force. The 6-ft. jaws of the machine, with a pressure of 41 tons, "close up" the red-hot rivets, which are placed in position by the workmen. For riveting the less accessible parts portable hydraulic machines are used with equal effectiveness. The silent but determined grip of the crab-like claws is a decided improvement upon the incessant clatter that ever accompanies hand-riveting. The pneumatic compression riveter shown in the photograph is one of the machines in use in the shops of the Great Eastern Railway, Stratford, Essex.

The boiler shop at Crewe is the largest in the kingdom, and lacks no modern appliance requisite for building and repairing boilers. About 200 new locomotive boilers are turned out here per annum, and in addition are effected the necessary repairs for the boilers of over 3000 locomotive engines. The work in any department of a railway works depends entirely upon the size of its locomotive stud and rolling stock generally.

The principal feature of a flanging shop is the hydraulic flanging presses. At Crewe are machines of this kind with rams up to

2-ft. 6-in. in diameter and working at pressures of 2000 lbs. By means of these presses steel firebox plates, 6-ft. 6-in. × 4-ft., can be flanged at one operation. The total pressure which can be exerted by the largest press is 650 tons. The red-hot plate is conveyed from the furnace and secured between two iron slabs smaller than the plate itself. The ram rises and puts pressure on a shaped die in contact with the exposed parts of the plate and turns up the edges all round. A flange of 3-in. is produced noiselessly in less time than one can describe it. Flanging is an exceedingly economical operation; for example, in a locomotive side tank, with angle irons instead of flanges, 700 rivets are required, but the substitution of flanged plates reduces the rivets by one half, to say nothing of securing additional strength.

PNEUMATIC RIVETING AT STRATFORD WORKS
(Great Eastern Railway)

It is perhaps in the turning and wheel shops that one best realises why modern locomotives are so more dependable than the early engines that ran upon our rails. Improvements are not due to changes in great principles, nearly so much as to the extraordinary and perfect tools now available for constructing the numerous delicate mechanisms that are incorporated in the locomotive of to-day.

Every shop in a locomotive works possesses tools as interesting as they are effective, but those in the turning shops perhaps bear the palm for being wonderfully adapted to the work they have to perform. Concise descriptions of a few of the principal operations must suffice.

A turret-head boring and turning machine is as ingenious an apparatus as one can conceive. One of these tools will bore out the insides of cylinders, and at the same time will turn the outside of them. The same machine can also be used for various turning and boring operations, mere rotations of the turret-head allowing roughing out, sizing cutters and reamers to follow each other. By means of the turret-head various special tools can be brought to bear upon metal for consecutive operations, such as turning and parting-off piston rings from a barrel casting.

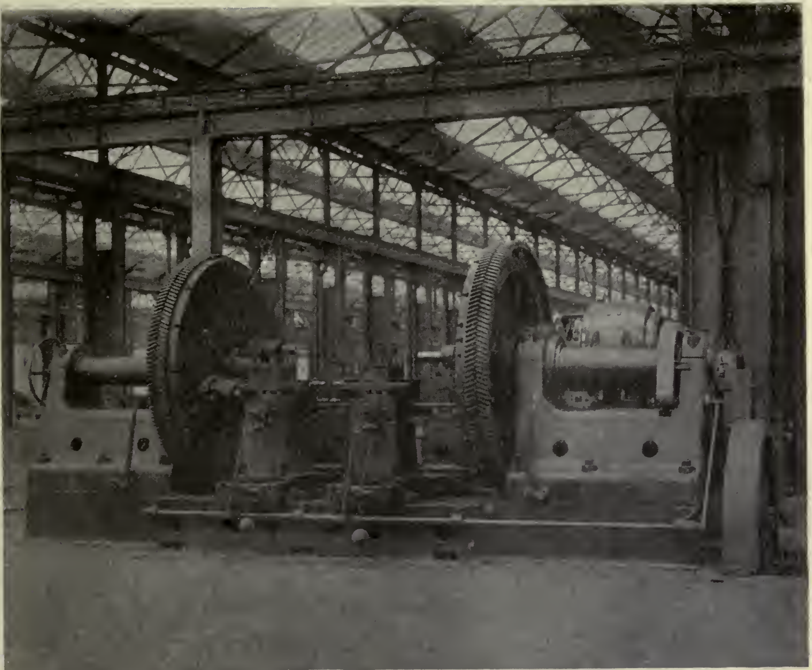
The latest design of wheel and tyre lathe turns the rims and bosses and bores the tyres. For use as a wheel lathe three tools are provided to each chuck, two being in front and one at the back; in tyre and bossing lathes two tools only are fitted, one in front and one at the back. The machine is of exceptionally massive construction in order to allow of heavy cuts being taken with high-speed steel tools. For this purpose it is heavily geared, the wheels being constructed with machine-cut teeth of double helical form, and very broad.

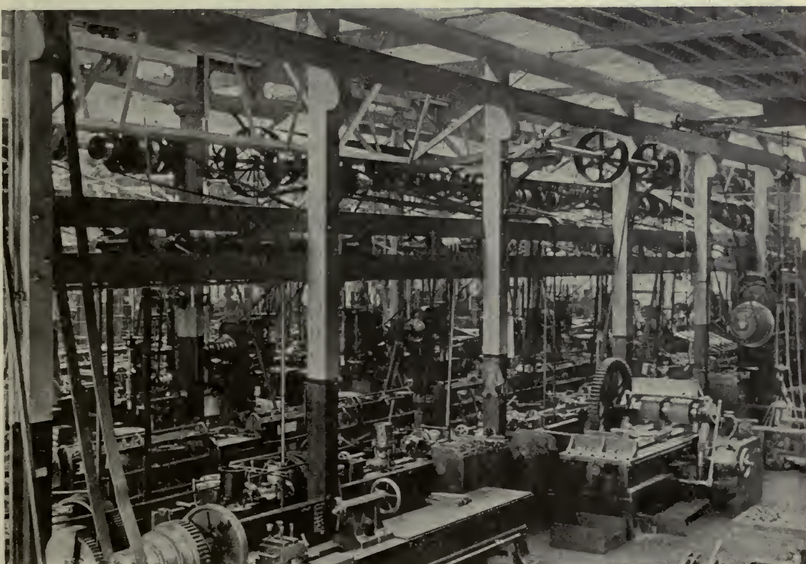
Crank axles, which are of forged or open-hearth steel, are first turned, and, if the webs are oval, are machined for hooping. After the hoops are shrunk on by being heated to a black heat and cooled down in water, the keyways are cut in a duplex milling machine, and the wheels, after being turned, bored, and the keyways slotted, are forced on to the axles by a hydraulic press. The holes for the crank pins are next bored by a wheel quartering machine, and the crank pins forced in by a smaller press and riveted over on the inside. The tyres, which have been bored out somewhat smaller than the diameter of the wheels, are heated in a gas furnace to a black heat, and then laid flat on a table and the wheels lowered into them by a travelling crane. The tyres are allowed to cool without coming into contact with water. Rivet holes are next drilled at the end of each spoke through the tyre, wheel, and retaining ring, by means of horizontal drilling machines, five in number, and the whole finally riveted up by a hydraulic machine. The wheels are then taken back to the lathe to have the tyres turned up to the standard gauge.

We depict a corner of the turning shop at Eastleigh Locomotive Works, where a pair of 7-ft. driving wheels can undergo the turning process. As the facing plates of the lathe revolve at slow speed, carrying the wheels with them, an attendant feeds up to its work a tool, which moves automatically and horizontally by cogs and worm-gear. As the wheel revolves the tool gradually decreases its diameter until the "tread" is rendered perfectly circular and smooth.

A visitor marvels at the size of the various shops at any of our great railway works. The boiler shop at Crewe, for example, is 673-ft. by 107-ft. 6-in.; shops 350-ft. long and about half as wide are quite common; but one of the erecting shops at Swindon is 489-ft. by 406-ft. The mere figures scarcely enable the size to be grasped. Under the roof of this one huge shop could be placed two parallel streets each 40-ft. wide with four rows of 30 middle-class houses, with their fore-courts and back gardens all complete.

A machine shop is a bewildering maze of thousands of feet of leather belting whirling round pulleys, and keeping in motion hun-





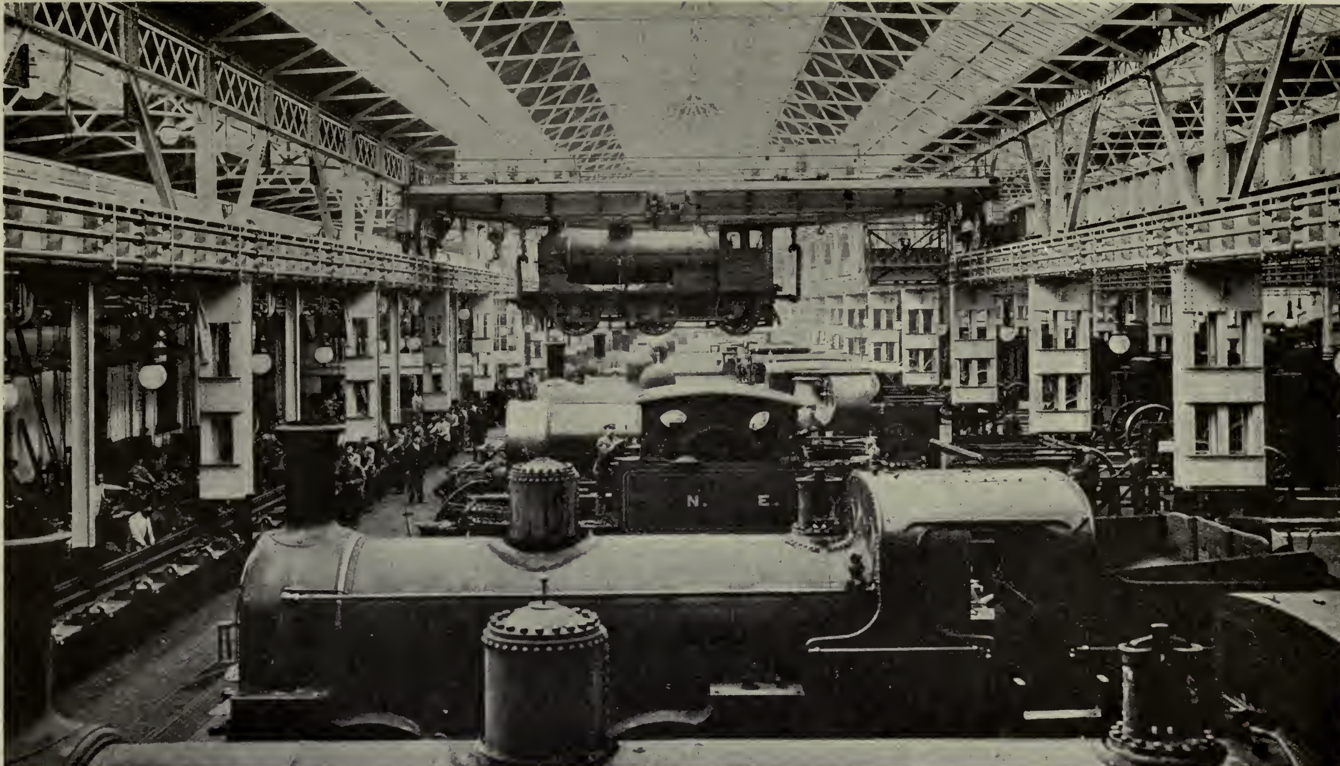
WHEEL LATHE, EASTLEIGH WORKS (L. & S.W.R.)
MACHINE SHOP, STRATFORD WORKS (G.E.R.)

dreds of machines that appear capable of accomplishing almost any conceivable feat in the way of cutting and shaping metals. Machines for boring, slotting, planing, drilling, shaping, screwing, and milling are in company with dozens of general lathes ; and there are grindstones, emery grinders, metal saws, vertical turning and boring machines, etc. Steel plates 25-ft. long, 3-ft. wide, and an inch thick lie six or seven deep on the tables of slotting and drilling machines, where various tools, operating together, shape them into engine frames and pierce hundreds of bolt holes. In addition to the usual overhead cranes, there are promenading cranes that move from one part of the shop to another, lifting rough castings and forgings on to the machines. As far as possible all drilling and other machinery is done to templates, thus reducing the cost of marking off, and ensuring the interchangeability of parts. By means of the milling machines many engine details leave this shop in a practically finished condition. The drilling for the most part is done by twist drills, and these with taps, dies, etc., are made in the tool shop, a stock of each being kept in the tool stores.

To the erecting shop are brought together the results of the efforts of the forgers, boiler-makers, turners, finishers, and numerous other classes of mechanics. Machinery and belting play no part here, but the gantry cranes are sufficiently powerful to lift an engine bodily and transport it from one part of the shop to another. In the chief erecting shop at the Midland Railway Works at Derby nine lines of rails run throughout its length of 450-ft., affording accommodation for over a hundred locomotives. Owing to the inspection and working pits, the metals are laid upon longitudinal sleepers.

Some of the details of erection naturally differ in various classes of locomotives, but the main features are the same, whatever the type. The first step is the setting up of the frames. These are in as complete a state as is practicable, having been slotted round the edges, straightened, all holes drilled where possible, and sharp corners taken off. All footplate brackets, cross stays, etc., are next fixed. They are first bolted together with a few bolts, and then set to their exact positions before being riveted up. The cylinders are next fixed in position between the frames, the accuracy of their adjustment being tested by careful measurements ; and other work is done to complete the skeleton before it is ready for the erecting pit, to which it is next transferred.

The boiler is lifted into position by an overhead crane. The expansion brackets already having been set, the boiler needs no adjustment ; the front tube plate is bolted to the cylinder casting, and the expansion bracket guides are attached to the frames at the firebox end. The boiler is lagged and cleaded, and connected to the numerous steam and water pipes. The smokebox, cab, and splashers are put up, this work being done by a gang of boiler-makers attached to the erecting shop.



ERECTING SHOP, DARLINGTON WORKS
(North Eastern Railway)

The engine is then ready for wheeling. To effect this it is lifted clear and the wheels are rolled underneath. When the engine is lowered on to them, a man is stationed at each axle-box to guide it into the horn blocks. Next the motion is put up and the valves set, this last operation being the most important piece of work in the erection of a locomotive. On completion of the motion, the springs are put up and fastened, the buffer beam is attached, and then the engine is lifted on to a "running road," if one is available. The coupling rods, brake gear, etc., are put on, and in the cab are fixed all its miscellaneous fittings.

When the boiler has been filled with water, the fire lighted, and the engine coupled to the tender, which is first coaled and watered, the whole is weighed. The weighing machine is so arranged that the wheels rest upon as many separate tables, and thus the weight upon each wheel is duly recorded by itself. When any inequalities in weight have been adjusted by altering the springs accordingly, the locomotive is ready for a trial trip.

Ordinarily a new locomotive has to run hundreds of miles to enable the officials of the locomotive department to note the development of any defects. To avoid this "light" running, which is a mere waste of power and interferes with ordinary traffic on the lines, means have been devised for testing locomotives in the shop while practically converted for the time being into stationary engines.

The Great Western and North British Railways have installed indoor testing plants at their respective works. The great principle of the test lies in the fact that the driving wheels of the engine being tested rest upon rollers, which the rotation of the wheels causes to revolve, instead of propelling the engine. The rollers, about 4-ft. in diameter, consist of ordinary wheels, but the tyres are turned to correspond, at the tread, with the section of an ordinary track rail at the same part. When the locomotive is mounted on the rollers and set in motion, the manner in which it differs from an engine running on the road is at once apparent; in the former case there is a propelling motion forward, whereas in the latter it propels the road backwards. The drawbar hook is hitched on to the dynometer, which registers the pull of the drawbar, the speed of the carrying wheels, and various other useful particulars. The tender is placed by the side of the testing plant, and feeds the engine with coal and water, the measurements of which are duly recorded. To witness a locomotive being tested at an enormous speed without moving an inch is a sight not easily forgotten, and all to the accompaniment of an appalling noise. At 70 miles an hour coupling rods make 300 revolutions per minute, causing 6-ft. wheels to revolve over 6000 times in the same brief space of time. Although an indoor test such as that just described affords engineers very valuable data, it cannot altogether supersede a road test, lacking the actual working conditions necessary to arrive at absolutely accurate conclusions. Especially is the machine engine-tester unsatisfactory as applied to tank locomotives, which generally go out for complete trial on the road.

Little need be said concerning the building of a locomotive tender. It is put together in a similar manner to the engine. The frames are set, riveted up and wheeled; and the tank is lowered into them, secured, and the various fittings attached.

At Crewe Works the usual time to build an engine is about four weeks, but as an experiment, and to test what could be done in case of emergency, the erection of an engine was begun at 6 a.m. on a Monday, and was finished, in steam, and ready to work a train, by 1 p.m. the following Wednesday, that is, in a space of 25½ working hours.

In December, 1893, at the Great Eastern Railway Works, a six-coupled goods engine, weighing with its tender over 67 tons, was erected, painted lead colour, and in steam in the space of ten working hours. Except that a greater number of hands was employed, the method of construction was the same as that employed for all engines built at Stratford. It may be mentioned that such a locomotive consists of between 9000 and 10,000 separate parts, while the parts in a tender exceed 7500.

In the majority of cases carriage and wagon building establishments are contiguous to the locomotive works, but in some instances they are widely apart; the London and North Western Railway Carriage Works, for example, are at Wolverton, and the Wagon Works at Earlestown.

There is no mistaking the products of the locomotive works: whether it be a monster engine, such as the "Great Bear," or a tiny locomotive employed on the Welsh "Toy" railway, they all bear an astonishingly family resemblance. Passenger coaches are more or less similar in external appearance, whatever differences their interiors may exhibit; but when we consider the vehicles provided for the transport of goods, minerals, cattle, etc., we are at once confronted with great varieties in size and still more in design.

If George Stephenson's first passenger vehicle, shown on page 27, be compared with a first-class coach on the Liverpool and Manchester Railway in 1838 (page 124), it will be seen that considerable progress had been made by the carriage builder. A rail was carried round the roof for luggage, and at one end a seat was provided for the guard. In a later chapter the evolution of modern passenger carriages will be dealt with in some detail, and at this stage we may content ourselves mainly with present-day construction.

A modern carriage works is practically divided into two main branches—the general engineering branch, which prepares the ironwork for the erection of the underframes, bogies, general fittings, brakes, and electric light and gas equipment, as well as general running gear; and the coach-building branch, which embraces the following trades: woodworking machinery, body-building, cabinet making, upholstering, French polishing, and painting.

The general engineering branch we propose to dismiss offhand, since the construction and fitting of underframes, etc., are somewhat the same as for locomotives. There is, however, a great difference between locomotive and carriage wheels. Usually the latter have no spokes, but are built up of solid teak-wood segments. To ensure that the wheel be properly balanced, it is necessary to place segments of equal weight opposite each other When the tyres and axles have been forced on, the wheels are tested on a

FIRST-CLASS COACH (1838)
(Liverpool and Manchester Railway)

balancing machine, adjustment being effected by bolting an iron strip on the opposite side. Any inequality in the balance of a wheel may do not a little to cause passengers to suffer from something approaching "sea-sickness" on land.

The principal woods used in carriage building are, for constructional building, English and American oak, Dantzic oak from Stettin and oak from the Polish forests, teak from East India and Burmah, and Hungarian and British ash; and, for decorative purposes, mahogany from Central America, Tobasco, and Cuba, walnut from South Europe, satinwood from the East and West Indies, sycamore from our own country, kauri-pine from New Zealand, and wainscot oak from Austria. These are known as hard woods. The soft woods include yellow pine from Canada, Dantzic fir or redwood from Prussian Poland and Russia, pitchpine from North America, and spruce or whitewood from Norway and Russia. The whole of the timber is seasoned by a natural process, and, as this takes from two to three years, a large stock must always be kept on hand.

In the woodworking departments there is a resinous, turpentiny smell that is quite refreshing after the oily atmosphere of locomotive workshops. For an example of a saw mill we cannot perhaps better the one at Wolverton, although at Swindon, Derby, Stratford, York, etc., we meet with little short of excellence. In the first named extensive and well-laid-out shop we find no less than eighty machines, saws predominating. They include frame saws, band saws, chain bench saws, jig saws, cross-cut saws, large and small rack saws, and circular saws. A thirty-bladed frame saw will cut an immense log into as many planks. Other machines compass such operations as mortising, boring, tenoning, rebating, moulding, planing, scraping, etc. Many of the metal-working machines are practically silent, but woodworking machines hum and buzz, and in some cases vent almost blood-curdling shrieks. On every hand wood is undergoing marvellous transformations, e.g. a matchboarding machine will not only plane both sides of

CARRIAGE-LIFTING, WOLVERTON WORKS

(London and North Western Railway)

a board at the rate of 35-ft. a minute, but at the same time will form a tongue and groove.

The body shop at Wolverton is built in four bays, each with three roads capable of holding four 50-ft. vehicles, so that forty-eight coach bodies of this length can be built at one and the same time. The workmen's benches are arranged between the roads and along the walls of the shop. Many visitors to the works find this shop one of the most interesting, for here coach bodies may be seen in all the different stages of erection. First comes the bottom framing, already planed, mortised, and tenoned by machinery in the saw mill, and on this the floor is built. The sides and ends are then erected, first the framing and then the panels, the partitions dividing the compartments being put in at the same time. The roof is put on, the seats fixed, and the doors fitted, and the body is then ready to be placed on its underframe, and taken to the paint shop for the inside finishing and trimming and for painting.

In the trimming shop are made all the cushions, seats and backs used in the upholstering of the coaches. The linings of these cushions are sewn by girls after being cut out in the cutting-out room. The cloth is cut out by a machine with an endless knife, working on the same principle as a band saw. After being dealt with by the girls, the linings are returned to the trimming shop, where the seats, arms, or whatever they may be are taken in hand by the trimmers, and stuffed and sewn up ready to be fixed in the coaches. The fixing is an important part of the work, great care being taken to see that the springs in the seats are arranged to the best advantage from the standpoint of the comfort of passengers.

The paint shop is a most important and expensive branch of the carriage works. Coaching vehicles receive a dozen or more coats of paint and five coats of varnish to enable the woodwork to resist the weather to which it is constantly exposed when in traffic. The work occupies not less than a month, and requires, for each coach, the surprising quantities of 6½ cwts. of paint and 11 gallons of varnish. The "coat of arms" and lettering are put on by "transfer."

At Wolverton there are twenty-one roads in the paint shop, on which about 120 vehicles can be painted at the same time. Special attention is given to the heating arrangements, the shop being kept warm, and, as far as possible, at an even temperature, in order to facilitate the drying of the paint. The shop is built so that a good light may be obtained, and, in the short days of winter, plenty of artificial light is provided, incandescent lamps being placed in between the roads in addition to arc-lamps hung from the roof. The work, therefore, does not suffer at any time for want of light.

The interior fittings of some of the passenger vehicles will be described in due course, for the moment we may confine ourselves to external and a few general features. Harking back to the early

1. DINING SALOON (G.N.R.) 2. SLEEPING CARRIAGE (E.C.J.S.)

3. SALOON (G.C.R.) 4. PULLMAN CAR (S.E. & C.R.)

carriages as exemplified in the old London and Manchester vehicle previously mentioned, we note that it was a four-wheeler. Nowadays passenger corridor carriages are commonly 50-ft. long, and dining and sleeping cars often have a length of quite 65-ft. If such lengthy vehicles were provided with only four, or more, rigid wheels, it would be very difficult for them to traverse sharp curves, but by means of four or six bogie wheels at each end of the car ease and safety of running are assured.

Passenger coaches are of various kinds. Some consist wholly of first, second, or third-class compartments; other are mixed, in which case they are called "composite" coaches. Guards' and

HOPPER WAGON
(North Eastern Railway)

parcel vans are sometimes separate vehicles, but generally they form part of a passenger coach. Travelling post-offices, mail vans, fruit and milk vans externally are usually of the passenger coach type in general construction, colour, etc.

We do not propose to describe the construction of goods vehicles, since in the main it would be but to repeat much of the foregoing matter; rather will we consider a few of the numerous types of wagons, vans, etc., for the different classes of traffic call for vehicles differing widely in size and shape. Illustrations of various types are shown herewith, and others will be found in the chapter devoted to goods traffic. In one respect, however, they possess a common feature, viz. great strength and solidity, not only to support heavy

PLATE IV.

THE "FLYING SCOTCHMAN" CROSSING THE FORTH BRIDGE.

(North British Railway.)

weights, but to endure the shocks to which they are subjected in shunting.

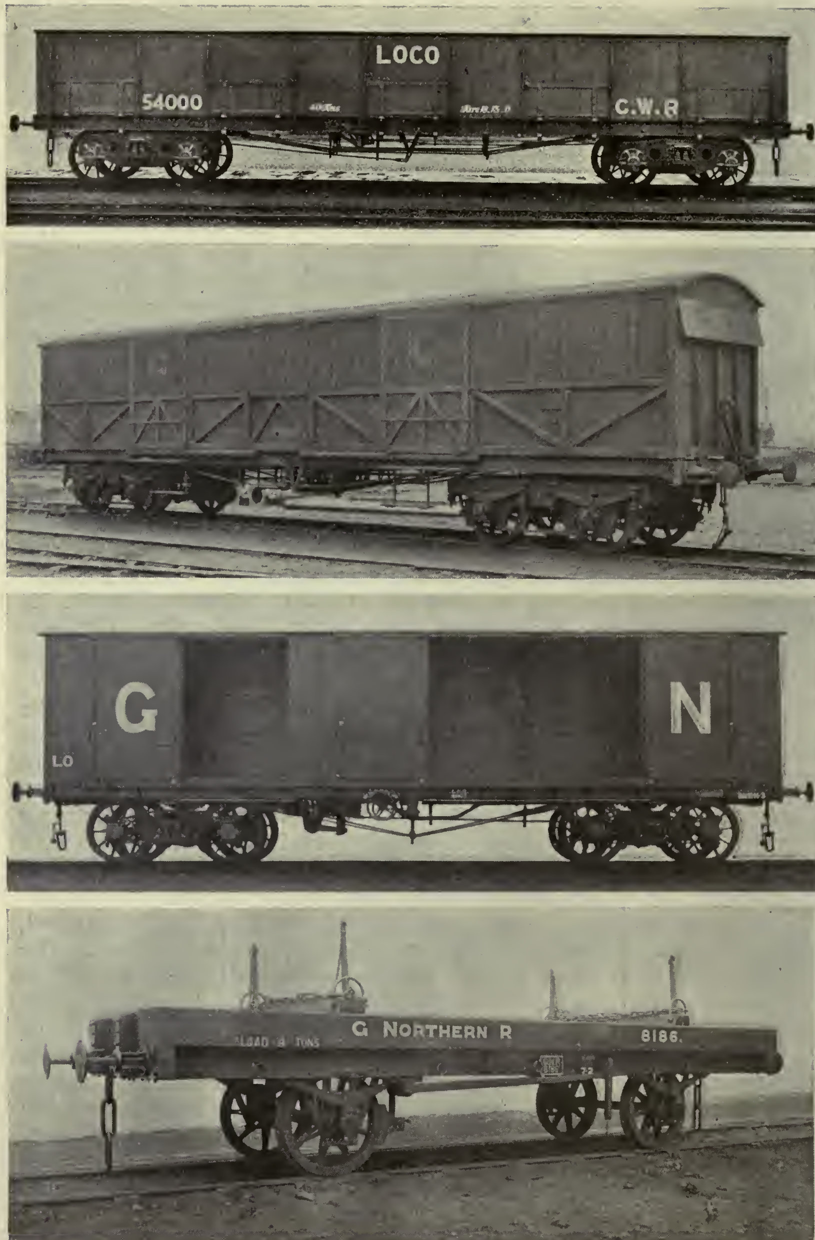
Not infrequently the painting of wagons is performed by mechanical means, decreasing the cost of labour and material, and getting a vehicle through the shops quicker, the coats of paint drying more rapidly than when applied by brushes in the ordinary way. The painting machines usually employed are operated by compressed air, which raises the paint from a reservoir and delivers it at the nozzle of the sprayer, where it is atomised by the air, and projected in the form of a fine spray upon the surface to be covered. The paint, being blown with considerable force, is driven into corners, joints, and similar places inaccessible by the brush, a consideration of great importance in painting metal work, etc. One nozzle will cover 3 sq. yds. of work per minute, leaving a fine matt surface which dries so rapidly that three coats can be applied per day.

Even the lightest goods or mineral wagon is built up of the stoutest timber, well bolted, and plated with metal at all vulnerable points. Many mineral wagons are constructed entirely of steel. Some coal wagons will carry 10 tons, but other gigantic vehicles will contain four times as much. Hopper wagons allow of the automatic discharge of loads of coal, ironstone, etc. The illustration shows the gearing and winches that operate horizontal doors. A wagon of this type discharges in about forty seconds without labour, whereas an ordinary flat door vehicle of the same capacity would cost 6*s*. for spade labour in emptying it.

Ordinary goods wagons are either open or closed, the former for carrying commodities not liable to deterioration from the effects of the weather, while the box vehicles are used for the transport of numerous classes of goods that require to be kept free from damp or extremes of heat and cold. Some open wagons are furnished with a metal tilt extending from end to end of the vehicle, so that when covered with a tarpaulin sheet the rain drains off and thus converts the wagon into a covered one.

For the conveyance of timber, not only are long trucks required, but there must be special provision to keep the load in place. The projection of a large timber balk would entail collision with a passing train. Rail wagons are very similar. In vehicles of both classes there are upright pillars and chains with which to secure the load as firmly as possible. In the conveyance of goods of all kinds the greatest care is taken to prevent any portion of a load falling off a wagon during transit, for the fouling of a line by quite a small object may bring disaster in its wake.

The transport of heavy ironwork, especially such as guns, boilers, girders, etc., calls for the provision of special vehicles. These trolley, or well, or crocodile wagons, as they are variously called, are always of low build, so as to minimise labour in loading, and to allow the passage of bridges and tunnels. A Great Northern vehicle



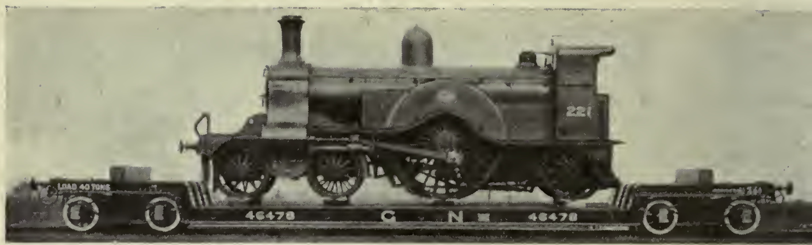
1. 40-TON COAL WAGON (G.W.R.)
2. FISH WAGON (G.C.R.)
3. BOX WAGON (G.N.R.)
4. TIMBER TRUCK (G.N.R.)

of this class is illustrated, carrying a 40-ton locomotive merely for testing purposes. There are wagons for the conveyance of furniture vans, horse-carriages, motor-cars, etc. Often twin wagons are employed for the transport of machinery. These wagons work in pairs, making practically one long vehicle, which will carry a specially long load. A flexible centre coupling is attached between the twin wagons, which are thus enabled to adjust themselves to sharp curves.

Cattle trucks are generally covered, but are provided with ample ventilation. Horse-box vans usually contain stalls for several horses, and often small compartments are attached for the accommodation of grooms, especially is this the case in the conveyance of racehorses. An animal is not allowed sufficient room

to fall down, even if the van receive a severe shock, and at various points the sides of the stall are padded to prevent injury to the equine passenger.

For the conveyance of meat and other perishable foodstuffs refrigerator vans are provided. In the best vehicles of this type the body of the vehicle is of double boards, with a 1-in. space between filled with silicate cotton ; the roof is also double, with arrangements for admitting a current of cold air. The van is also fitted with refrigerator tanks containing ice. Fish wagons are extensively ventilated by means of louvred sides, throughout their entire length, so as to keep the trawlers' catches fresh whilst being hurried to the markets. Special vans are used for the milk and dairy produce traffic. The ventilating louvres are best situated below the waist of the vehicle, so that when travelling the current



1. CROCODILE WAGON (G.N.R.)
2. BRAKE VAN (G.N. & N.E.R.)
3. HORSE-BOX (G.E.R.)
4. MILK VAN (L.S.W.R.)

of air is brought into direct contact with the cans. On the insides of the louvres is placed fine wire gauze, which is covered with perforated zinc, thus preventing dirt or grit entering the van during transit. The roof is also ventilated and insulated. The floor is constructed of granited asphalt laid on oak boards, so as to allow of frequent and easy cleaning.

No traffic calls for greater care in handling than explosives of any kind, which are conveyed in what are called gunpowder vans. The construction of such a vehicle is specified most closely. The body and roof are built of steel plates; the inside is cased with boards, secured with brass screws. The floor, sides, ends, and doors up to a height of several feet are lined with lead sheets, fastened to the wood casing by means of flat-headed copper nails. In opening or closing the doors there is no contact of iron or steel with the same metals, hinges, locks, bolts, etc., being of brass. All iron and steel work is well coated with white-lead oil paint, where it comes in contact with wood. The van is without ventilators, and is absolutely dustproof. It is painted vermilion, varnished, and thus is at once a danger signal to all who may have to deal with it.

CHAPTER VI

THE CONSTRUCTION OF THE LINE

THE first matter to be considered in the projection of a railway is its location, which may be decided by reference to a map. In a settled country the object of the line will be to connect certain towns and villages, but in many regions the new line should join up the inhabited districts with those areas that offer a promising field for settlement. In other words, the railway is constructed in populous areas to meet the needs and convenience of the inhabitants, but in thinly or unpopulated districts its purpose often is to induce population.

The surveying of a line is an operation that demands the greatest care, for mistakes will incur heavy and useless expenditure, afterwards calling for the reconstruction of track, or even its complete abandonment. The surveyors are the railway scouts, and in the laying of not a few lines in different parts of the world they have been called to take their lives in their hands, ever on the *qui vive* for the attacks of murderous natives or dangerous wild beasts.

We know with what positive hatred railways were received in some quarters of civilised Britain ; and, therefore, it is easy to imagine the hostility aroused in the breasts of savage peoples. In America the surveyors of the pioneer railways, after an arduous day's toil often could sleep at night only with the fear of the red man's tomahawk or scalping-knife to give rise to disturbing dreams —dreams that sadly too often crystallised into dread reality. When the French proposed to push a line into the Sahara, various tribes of pillaging Arabs nearly wiped out the railway scouts, and the fell desert did the rest ; and not a single man returned to Algeria to report on the object of the expedition.

In the van of the surveying party are the flag-men, for whom axe-men clear away bushes, and even trees, that would interfere with the work of the transit or compass man, who records the horizontal angles for the curves, and the leveller, whose duty it is to work out the gradients. The most important instrument used in common practice is the surveyor's level, which consists of a swivelled telescope with a spirit level attached, and mounted on a tripod. When the leveller focuses the telescope on a graduated rod, held at a measured distance by a helper, he can easily decide the rise or fall in gradient. In surveying mountainous country a theodolite, another telescopic, but much more complicated, apparatus is employed to calculate the trigonometrical measurements.

The final result of the survey is a profiled map of the track route, after which the engineer-in-chief sets to work upon his detailed ground plans, dividing the route into sections, which different contractors undertake to complete within an agreed time. Frequently a contract provides that a bonus shall be paid for every day gained upon the stipulated time, while the contractor is liable to a fine for every day beyond it. Nature sometimes defeats the

FORTH BRIDGE

most careful calculations of the difficulties to be overcome in making the iron road—for example, water burst into the workings of the Severn Tunnel and delayed its completion for years ; Kilsby tunnel broke one contractor's heart. At all times unforeseen natural causes call for the utmost versatility and resourcefulness on the part of the civil engineer, who must be ready to suggest some perhaps hitherto unthought-of method of coping with unexpected difficulty. The engineer is responsible not only for the spending of huge sums of money, but upon the quality of his work rests the safety of thousands of lives.

The excavation of a railway line, even where Mother Earth is most complaisant, calls for an army of workmen to fill hollows, cut through moderate elevations, and drive tunnels through hills. Railway travelling is now such an ordinary feature of our everyday life that we are apt to take the iron road very much as a matter of course. We give little heed to the enormous labour involved in the preparation of the track; no thought to the years of toil occupied in scooping out a burrow through which a train hurtles in a few minutes, or the embankment thrown across a valley, which may have absorbed money as a sponge does water, before it would permit the passage of a heavy train.

QUEEN ALEXANDRA BRIDGE, SUNDERLAND
Cantilever in course of erection

Then there are bridges and viaducts that would prove to be veritable death-traps but for the engineer's knowledge of strains and thrusts, the elasticity and tenacity of metals, the strength of stone and brickwork. The cost of various sections of a line differ enormously. Between Brentwood and Colchester, 34 miles, there are sixty-four bridges and viaducts, and about a like number in the 30 miles between Liverpool and Manchester. On the East Coast route to Scotland three bridges alone caused less than 3 miles of track to cost nearly half a million sterling per mile, excluding the Forth Bridge, which with its approaches cost nearly £20,000 per yard for about a mile and a half of track.

Originally, as has already been stated, our railway navvy was a man who had been engaged in the excavation of canals. Personally he is viewed very often as rather an undesirable person, whereas the real navvy has many good qualities. He is generally the embodiment of strength, whom it would be safe to pit against a similar worker of any other nationality. The black sheep of the fraternity is what is termed the "tramp navvy," who only works sufficiently long to obtain money for a carouse, and then moves on to find another job. For the moment, however, we are concerned with what brawny arms can do in conjunction with the pick, shovel, and barrow, in constructing a track as straight and as level as the natural conditions will permit.

Not infrequently the navvies work in separate groups, each under a ganger, who engages with the contractor to do a certain portion of work for an agreed sum, paying the men under him, and allowing a higher rate for himself.

As early as possible a temporary line is laid down, sometimes on the natural surface of the ground, just for the easy conveyance of plant and materials. Of course, a rough and ready line of this character allows plenty of scope for derailments, but, nevertheless, serves its purpose, until the temporary rails can be transferred to the track proper. The excavated material is drawn in tip-wagons and three-wheeled dobbins by horses, until the temporary line can be furnished with a better track that will support a "tipping engine," which displaces the "tip-horses."

Sir F. B. Head has stated that in the 112 miles between London and Birmingham on the London and North Western Railway, it had been calculated that the quantity of earth moved would be sufficient to make a footpath a foot high and a yard broad round the whole circumference of the earth, at a cost in penny pieces sufficient to form a copper kerb or edge to it. Supposing the same proportionate quantity of earth to have been moved in the construction of all our British railways, the excavated material would supply a wall round the globe 1-yd. thick and 9-yds. high.

The amount of excavation on any line at given points varies considerably, depending entirely upon Mother Earth's wrinkled face. In the case of a main line a cutting will be made through a hill of almost solid rock; while on unimportant branches, the line will be taken round an elevation of easy-working soil. The constructing engineer for the sake of economy endeavours to make cuttings and embankments balance each other to the greatest possible extent, the material removed from the hills being utilised in the construction of embankments across depressions, especially such as are not worth bridging.

Deep cuttings and long tunnels are avoided by engineers wherever possible because of their costliness in construction, and similarly, they avoid sharp curves and steep gradients, whose first cost may be cheap, but afterwards prove to be permanently expensive in running trains over them. Steep gradients call for increased tractive power, and sharp curves retard speed ; and under both circumstances there is extra wear and tear on the wheels of the rolling stock.

George Stephenson declared that a rise of 1-ft. in 133 should be the maximum ; but the great railway pioneer had not in view the powerful modern locomotives such as draw London and North Western Railway heavy trains from Tebay to Shap summit, where for 7 miles the gradient is 1 in 75. Near Glasgow, on the North British line, Cowlairs tunnel, 1¼ miles long, has a gradient of 1 in 45. Between Atherton and Chequerbent and Daubhill and Bolton passenger trains run over a gradient of 1 in 33, but the distance is only 1 mile. On the Midland Railway at Bromsgrove Lickey is a 2-mile incline, 1 in 37, which trains can only climb by double heading, or one engine in front and one behind. On the Cromford and Parsley Hay branch line (London and North Western Railway) the Middleton and Sheep Pasture inclines have a gradient of 1 in 8½ for 1100 yds. and 1320 yds. respectively. This line, however, is only for the carriage of minerals, and the inclines are worked by stationary engines.

In excavating operations " the steam navvy " is a wonderful labour-saving device, especially where large cuttings are required. From an arm working on a steam crane is suspended a pair of jaws, 4 or 5 yds. in length, which form a large scoop when they bite into the earth. One of these tearing " steam-devils," as the workmen call them, operated by only one man, will fill a wagon with two or three mouthfuls, and in the course of a day will do the work of seventy men ; for it will not only scoop up soft earth, but will remove the *débris* that succeeds blasting operations.

Even where no unexpected problems crop up for solution, tunnelling is a particularly difficult branch of railway construction. Specially selected men engage in this work and are known by the appropriate name of " miners." In the excavation of a tunnel work proceeds from the opposite ends, and usually the two headings meet in due course without any appreciable divergence. To the lay mind this exactitude in burrowing under the earth is remarkable, but it is commonly achieved by a rather simple method. The exact track is marked out on the surface of the ground over the hill through which the " miners " are to drive ; at certain points shafts are sunk to the required level below ; and in each of the shafts is suspended a steel wire carrying a plummet. Thus the workmen down below cannot go astray farther than from shaft to shaft.

The thickness of the brick lining of a tunnel depends upon the

character of the strata which it has to support. Four rings are sufficient ordinarily, but twice that thickness often is called for to resist material specially liable to swelling or falling-in, or where there is a superabundance of moisture.

As the heading is driven inwards, timber struts are used to support it. A visitor underground generally takes alarm at the manner in which the supporting timbers creak and groan, which is termed "talking" by the "navvies," whose nonchalance it takes a very ominous crack to disturb. Water is one of the commonest bugbears, for the excavations often break into springs and fissures, and sometimes into abandoned coal workings, whose location is unknown, until the stroke of a pick releases a volume of water, whose sudden inrush means death unless the heading be vacated forthwith. When the heading is very wet the workmen wear heavy flannel jackets, which are called "donkeys"; and if the income of water is very marked there is recourse to oilskins. Noxious gases usually give olfactory warning of their presence, or, failing that, will cause lighted candles to wane in a manner indicative of the desirability of quitting the spot and seeking fresh air.

Tunnelling through rock may be effected by two methods. Blasting is generally employed for removing large obstructions of this character; but the modern rock-drill has proved an immense saving of time and money.

Of specially arduous feats in railroad construction two British examples must suffice at this stage; many others will be mentioned in connection with the histories of separate companies, or in describing various foreign railways.

In the United Kingdom there are two tunnels exceeding $\frac{3}{4}$ mile in length, forty-two exceeding 1 mile, six exceeding 2 miles, five exceeding 3 miles; but the greatest of all is the Severn Tunnel, 4 miles 636 yds. long, which burrows under a wide estuary where the tide rises no less than 50-ft.

This great engineering feat was commenced by the Great Western Railway Company in 1873. Almost from the commencement there was continual trouble owing to the incursion of subterranean springs; but in 1879 the river itself burst in, and the workmen stampeded out just in time to avoid being drowned like rats in a trap. Mr. T. A. Walker, the contractor, who was set the task of ridding the workings of water, could make no effect on the flood with pumps, unless an iron door in the heading under the river was closed. Lambert, an experienced diver, went down into the drowned workings and groped his perilous way amid skips, barrows, tools, boulders, etc., for 300 yds.; but when only 100 ft. from the door he was forced to return, owing to the impossibility of dragging the air-hose any farther, and constantly it was in danger of being severed by the sharp edges of the numerous obstacles.

Next was called into requisition the Fleuss diving-dress, which has a knapsack reservoir of compressed oxygen connected with a mask worn over the face. Though the inventor himself attempted the task of closing the door, he did not succeed. After a little practice with the new apparatus, Lambert made a fresh attempt and shut the door, which was secured by two screw valves.

The pumps were once more set in motion; eventually the workings were freed from water and the tunnelling proceeded apace. In 1883 the river again broke in at the rate of almost 30,000 gallons of water per minute, necessitating a call for Lambert's services

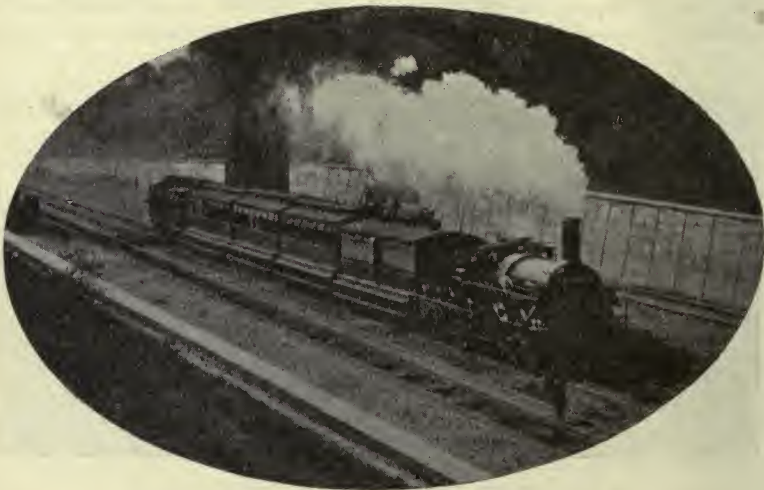
SEVERN TUNNEL, ENTRANCE ON WELSH SIDE

to close another door; and at a later stage the workings were flooded by an abnormal tidal wave.

Apart altogether from the strenuous fights with the river, the pumps were never idle, and even when the biggest spring had been conquered, 10,000 gallons of water required to be raised every minute. The pumping engines burnt 1000 tons of coal per month. About 77,000,000 bricks were used in the tunnel lining, which is 27 inches thick, and the cement employed weighed 37,000 tons. The total cost of the tunnel was nearly £2,000,000. The first train ran through in 1885, but it was not until 1888 that the great engineering wonder was opened to general traffic.

impervious to weather. In some parts of the world metal sleepers are used to defeat the ravages of ants and other timber-boring insects. Their durability is unquestionable, but they lack the elasticity of wooden sleepers, robbing the traveller of considerable comfort, while they entail additional wear and tear to the rolling stock generally.

Metal sleepers have been tried by several companies, notably the London and North Western Railway, only to be abandoned in every case. In 1911 300 reinforced concrete sleepers were put in at Pinner as an experiment to minimise noise, and at the time of writing were giving complete satisfaction.



MIXED GAUGE

The question of the gauge or distance between the two rails is of vital importance. Our British "standard gauge" is 4-ft. 8½-in., which was adopted for the Stockton and Darlington Railway, simply because the colliery tram lines allowed for that width between the wheels of the coal trucks. When later lines were proposed, it was suggested that other gauges might very well be adopted, but Stephenson maintained the advisability of making all the lines of the same width, as they would assuredly be joined together some day. When those prophetic words were spoken there were only three real railways in the kingdom, namely Stockton and Darlington, Liverpool and Manchester, and the Canterbury and Whitstable. The sceptics viewed Stephenson in many respects as the wildest visionary, and ridiculed the idea of joining together lines so far apart, but railway history justified the engineer's insistence upon a common gauge.

Brunel advocated a 7-ft. gauge, which was adopted in the construction of the Great Western Railway, destined to become one of the principal systems in the country. For engines with large driving wheels this famous engineer considered a greater width necessary in order to secure a low centre of gravity, and the wider gauge would permit more commodious carriages, which Brunel desired to sling between the wheels, much in the same fashion as a coaching vehicle, although, as a matter of fact, he never followed out the idea. But Stephenson had foretold the joining together of all our railways "some day." He proved to be correct, for the time speedily arrived when the Great Western Railway put down a third rail upon many miles of track so that narrow-gauge rolling stock could traverse its system in order to bring traffic from other lines. In 1869 the Great Western commenced to convert its lines wholly into the narrower gauge, but not until 1892 did the last broad-gauge section fall into line with the conquering standard gauge. In Great Britain there are 174 miles of railways with gauges ranging from 1-ft. 11½-in. to 4 ft. 6-in., departures from general practice that arise from purely local conditions, such as the Festiniog Railway, which originally was wholly a slate quarry tramline. In Ireland the standard gauge is 5-ft. 3-in., but there are also 505 miles of 3-ft. gauge.

The greatest care is devoted to the laying of the rails on British lines. Upon the sleepers are bolted cast iron blocks, or "chairs," into which the rails, usually in 60-ft. lengths, fit rather loosely, until they are packed tightly by means of wooden wedges called "keys." The rail-ends are held together on each side by "fishplates," narrow strips of metal bolted to the rails. The ends of the rails are not allowed quite to meet, a small space being left for expansion during the heat of summer. Where the rails form sharp curves the chairs are doubly bolted to the sleepers, so that the rails may withstand the extra grinding of the wheel flanges. The above brief description of rail-laying emphasises the trouble and expense taken to ensure a perfectly rigid road for the steam horse. The rails themselves generally vary in weight from 75 lbs. to 100 lbs. a yard, according to the nature of the traffic. A country branch line may find 75-lb. rails quite ample weight for its slow and light trains, but on a main line, which has to support an engine and tender of over 140 tons, hauling a train of nearly 400 tons at 60 miles an hour, or thereabouts, a heavier rail is necessary, and some companies are now using rails up to 120 lbs. a yard.

Up to this point the whole of the chapter has been devoted to the laying of the metals, but the construction of the line involves a very great deal more. The track must needs be drained, and in the case of the sides of deep cuttings and embankments many precautions must be taken in this respect to avoid landslips, involving danger to the trains and expense to the companies.

Signalling apparatus and the telegraph have to be installed from end to end of the line; together with gradient boards and $\frac{1}{4}$-mile posts; stations have to be built, for which, frequently, sidings must be provided; at various points there must be an efficient water supply for the engines, and in some cases water troughs are laid down between the rails, from which express locomotives can fill their water tanks while travelling at full speed. A trough is generally about 500 yds. long, $1\frac{1}{2}$-ft. wide, and 6-in. deep, containing water automatically kept at a depth of about 4-in. For successful long non-stop runs water troughs are an absolute necessity, for the weight of a large body of water on the tender is a drag on speed. The provision of good water for use in engine boilers is of prime importance. Generally railway engineers have to make the best of the supply which is found in the neighbourhood, irrespective of its quality. Water holds in suspension various kinds of matter, mineral or organic, which in the process of evaporation is deposited to form dirt or scale, which impairs the usefulness of the boiler. Consequently different systems of purifying the water before use have been adopted, the best results being obtained by chemical treatment. In the illustration is shown a water-softening plant in use on the Great Western Railway at Aldermaston, Berks. In this case the water is obtained from a neighbouring canal and is pumped into the water-softener, which has a maximum capacity of 10,000 gallons per hour. After passing through the apparatus, which reduces the hardness of the water from about 18 degrees per gallon to 4, the water flows to the storage tank by gravitation, and thence to the track troughs.

WATER-SOFTENER AT ALDERMASTON
(Great Western Railway)

The great majority of locomotives fill their tanks from water columns to which is affixed a flexible leather hose-pipe. This is rather a crude arrangement, dating back long before large engines used from 40 to 50 gallons of water per mile, with tenders up to a capacity of 5000 gallons. Modern water columns are now erected on the crane principle, the arm readily swinging round, with the water valve operated from the tender or tank, and calling for the service of only one man.

There comes a day when the contractor runs a train of trucks from end to end of the new line ; and the heads of the staff engaged in its construction are in constant consultation with the chief officials, who will be responsible for working the traffic, endeavouring to make sure that everything is in order for the Government inspection. Details of the works of the line have been sent to the Board of Trade, whose inspector, on a prearranged day, travels all over the line, testing the track, bridges, culverts, signalling apparatus, and, in fact, everything that concerns the safety of the passenger. After an inspection there are usually some minor alterations and improvements to be effected, before the line is declared ready for opening to the public, which is generally of a ceremonious nature.

The permanent way of British railways is constructed with greater care than anywhere else in the world ; but from the moment trains commence to run on the rails it needs constant supervision. Ballast sinks naturally, but particularly from having to support tremendous weights. The spikes in the chairs work loose, as do the bolts in fishplates, and in hot weather rails lift from expansion. On all of our great lines every yard of the permanent way is inspected daily, for there is a platelayer allotted to every mile. There is constant repacking of ballast and tightening of wedges and bolts, neglect of which might cause the derailment of an engine. Bridges, viaducts, and tunnels, too, call for constant inspection.

The repacking of ballast, on the face of it, appears a more simple matter than is really the case. At Manningtree, in 1879, some ballast which had been repacked during a frost, gave way during a thaw, under the weight of an engine, which with the brake van and a couple of carriages fell down an embankment. The fireman was killed and the driver injured.

Notwithstanding all the care that is taken to keep the permanent way in good order and clear of obstructions, bridges and viaducts occasionally collapse and landslips occur, sometimes only discovered when a train is involved in an accident. Local disturbances of the line are usually quickly remedied, but occasionally Nature revolts, shakes free from her harness, and takes the permanent way into her own hands. Floods are usually only more or less local, and fog will be dealt with in a succeeding chapter. Snow comes in a category all its own. We know the inconvenience and cost of removing a heavy downfall from the streets of even a small town, which is mere child's play compared to the task of a company whose metals have been buried by winter's feathery battalions.

Of our British railways the chief sufferers from snow are the Scottish lines, especially the Highland and Great North of Scotland, which count snow-ploughs as a very necessary part of their line equipment. When the snow-laden winds from Norway and the Arctic regions beyond descend upon Northumberland and Yorkshire, the North Eastern Railway, too, not infrequently finds some of its metals buried to a depth of from 9 to 12 feet; while

SNOW-PLOUGH
(North Eastern Railway)

in many spots drifts may be formed that obliterate all railway works except the highest signal-posts.

A snow-plough is built for utility and not for looks. The one illustrated is 26-ft. long, 9-ft. wide, and weighs 27 tons. The horizontal under-lip cuts through the obstruction at about 6-in. above the rails, and the wedge formation of the whole front turns the snow right and left and banks it up on each side of the track. With five engines pushing this steel nose ahead, one might imagine it capable of burrowing through solid earth, yet upon occasion such a snow-plough has embedded itself in a deep cutting and had to remain there for a day and a half.

Considering that it is mainly a southern line, it is rather surprising that the Great Western Railway should suffer much from snow; but a glance at its route map will show that some of its tracks are laid across very exposed districts. In January, 1881, the south and west of England suffered from a terrible snowstorm, and the Arctic experiences of the Great Western Railway were unparalleled in the history of the company, which suffered much more than the northern lines. There were blocks on 141 different sections of the system; 51 passenger trains and 13 goods trains were buried, and to put the line in working order entailed the excavation of 111 miles of snow, varying from 3 to 10 ft. in depth. The Great Western shareholders had been congratulating themselves upon a very satisfactory year's working, but the cost of removing the snow and incidental loss of traffic wiped £56,000 from the profit side of the account.

Violent gales are often responsible for much damage to the general equipment of railway tracks, although it is not always so marked as was the case on the Furness Railway, near Ulverston, in February, 1903. When on the viaduct, which crosses the mouth of the River Leven, the train was unable to proceed owing to the telegraph wires blocking the line. Scarcely had the train come to a standstill when the wind struck it broadside, overturning all the carriages, the engine alone remaining on the rails. If the train had fallen the opposite way all would have been precipitated into the sea.

CHAPTER VII

RUNNING THE TRAINS

In previous chapters we have followed the development of the locomotive from the time when it was a jumble of crude mechanisms until we arrived at the highly finished product of to-day. The present chapter very well may commence with some consideration of a passenger locomotive engaged in its daily round, and it can be considered efficient only if its work is performed with clockwork regularity according to time-table.

Every single item in the building of a locomotive is constructed, as we have seen, with the greatest care, and the whole machine is as perfect as brains and money can make it ; but from the moment it is placed upon the rails, it calls for constant watchfulness on the part of those whose duty it is to see that the engine shall not be subject to failures that will entail delay and incidental loss. In the loco shed, where an engine is housed, it receives the careful attention of the examiners and their staff, who, in addition to their own knowledge, are aided by the daily reports of the driver, who books any defects, so that they may be remedied before the locomotive again goes out on duty.

The driver and firemen take charge of an engine about half an hour before it is timed to leave the shed to take up its position at the head of the train it is deputed to work. The men book on at the time office, where they receive any special orders concerning the train from the timekeeper ; and then they study the notice-boards to glean any information respecting repairs, etc., over the line they are to traverse. They are then ready to step on to the engine, which has already been cleaned by the shed staff, the boiler filled, and the fire lighted two or three hours earlier.

All tools and materials for the trip are taken out of store. The tools comprise firing appliances, hammers, spanners, chisels, etc. ; the stores include oil for the cylinders, motion and lamps, discs, destination boards, packing for glands, etc. Flags, fog signals, and other appliances for warning other trains in cases of emergency are not forgotten, and it is also usual to carry spare parts, nuts, washers, and split pins that sometimes come in handy when far from the shed.

Before commencing to oil round the engine, the driver tests the hand brakes, cylinder, and gauge cocks, sight feed, lubricator, etc.; the motion is inspected as closely as possible, attention being paid to any lock-nut that may be loose, a pin that may be missing, a plate cracked or loose; in fact, no point is overlooked that will make for smooth running and the avoidance of accidents.

Meanwhile the fireman is attending to the fire, raking and levelling it so that steam rapidly rises. As soon as possible the feed injectors are tried, the ashpan and smokebox are examined,

ENGINE SHED, OLD OAK COMMON, ACTON
(Great Western Railway)

and the damper doors opened and closed. The fireman will also see that the water tank is full, and will prepare the coal by breaking it up to a convenient size for firing. When the brake gear has been examined, the engine is moved out of the shed to try the power. If the train is fitted with an air brake, the reservoir is pumped up and the brake applied; if vacuum brake, the correct exhaustion is secured by the ejector; and if steam, the steam valve is worked to try it. All being in order, the engine leaves the shed for the train, usually about half an hour before the booked time of departure.

Perhaps of all occupations engine driving is the one least likely to be learnt by the study of any treatises upon it. In any case there is not a great abundance of literature upon the subject, for the simple reason that it is difficult to convey by writing just what a driver wishes to know. In order to become a first-class driver a man must needs almost live on the engine until he feels as if he were a part of it. He must become so familiar with the line that at any moment he can tell at what speed he is running and his exact whereabouts, even if blindfolded. This is no exaggeration. There are London and

FULL-SPEED AHEAD
(London and North Western Railway)

North Western Railway drivers to-day who know every yard of the road, with signals, loops, junctions, and all the rest, between Carlisle and London, a distance of some 299 miles, and the same can be said of drivers on other lines concerning different lengthy sections of track.

During a journey the driver stands perhaps for hours looking through the window of the cab. Hundreds of signals pass across his vision, but without fail he must detect those which concern himself. Any failure on his part to distinguish a signal, and act upon it, may give rise to striking newspaper placards in the morning. Nor is signalling always as straightforward as one might suppose ;

it is carried out on certain general principles; but many junctions and crossings cause modifications, puzzling to the ordinary mind, but which must be read at a glance by the driver. The two men on the footplate seldom converse, unless something out of the ordinary occurs. Each has duties that claim his fullest attention, even if the noise in the cab does not make conversation a matter of difficulty.

The fire, water, and lubrication make heavy demands upon the fireman's attention, leaving him but little time to assist in looking out for signals. Firing a locomotive consists in very much more than just shovelling coal into the furnace. The fireman needs to be acquainted with the road, its gradients and its "bad spots," as well as with the weight and composition of the train that is being hauled. To tackle an incline, a full head of steam is desirable, and consequently before the rise is reached a little heavier firing is necessary, and a liberal coating of fuel will be called for when the driver increases the rate of expansion, or the increased blast speedily will play havoc with the fire.

To obtain good combustion a high temperature in the firebox is essential, and the admission of air to the furnace needs to be watched jealously, the fire door being open no longer than is necessary to introduce the fuel. However good the coal may be, there will be a disposition to clinker on a long run. Generally a few flints or pieces of chalk are thrown into the furnace with the first few shovelfuls of coal to prevent the clinker sticking to the firebars and to facilitate its removal. When clinker is forming in spite of all precautions, the fireman will resort to the "pricker," electing to use it while traversing down grades and level stretches, for the blast then being at a minimum, there will be less quantities of cold air drawn in through the open fire door. Any error of judgment in firing a heavy express leads to a shortness of steam supply. The driver's anxiety upon this score is seen by the frequency with which his eyes wander to the water and pressure gauges, in fact, he seldom turns his gaze from the window for any other purpose.

It is astonishing how quickly the driver detects anything unusual in the engine, especially in the case of one which he is working daily, for he learns any little peculiarity in its running or steaming. He can smell a hot bearing and can feel a breakage or displacement without it being one sufficiently serious to call for a stop. If anything untoward of this nature happen, the driver's anxiety is increased, for it will make against his reaching the destination up to time. He must be prepared to account for even the loss of a minute, knowing well that trivial excuses will not serve him.

Even taking into consideration the best protected cabs known on any of our railways, the men who work on the footplate in all kinds of weather are not to be envied. Enginemen, however, take little heed of weather, with one exception. Rain, hail, sleet, snow, and cutting winds are viewed almost with unconcern; it is fog that most tries a driver's nerve. As he drives through the reeking pall there is scarcely anything to guide him, save ghostly shadows of signals, which he must needs sometimes count as he goes along. If he loses his reckoning he is racked with anxiety until he can discern the outline of some familiar landmark, either a bridge, cutting, or station, or perhaps something which he can recognise by sound. The window is useless under such circumstances, and the driver has to stand with his face projecting beyond the side of the cab, his aching eyes straining to pierce the impenetrable murk. Little wonder that he utters a word of thankfulness when he draws up in safety at his journey's end.

The making of mistakes by a signalman has been reduced to a minimum by the interlocking of points and signals. Upon the other hand, the driver's reading of the signals is without help or check, and an error on his part is just as possible now as it was forty years ago. Attempts have been made to devise a reliable mechanical system to stop a train in the event of the driver over-running a signal at danger, but hitherto nothing has been found worthy of general adoption.

In the case of the driver, personality counts for everything. To perform his duties he needs a robust constitution, with sight and hearing unimpaired and other faculties to match; he must be steady of habit and possess abundance of patience and perseverance. These are the characteristics of hundreds of our splendid drivers, and all of them modest men withal, decked out in neither gold braid nor brass buttons. When passengers take their ease in a comfortable corner of a compartment, never doubting that they will reach their destination safely, all too seldom do they give a thought to the two pairs of eyes at the front end of the train upon which so much depends.

For a moment consider a train running at a fraction under 60 miles an hour, such as in the Great Western Railway non-stop run from Paddington to Bristol (118 miles), or Euston to Rhyl (209 miles), Marylebone to Sheffield (169¾ miles), and a score of others where the speed is almost equally good. It is obvious that there must be the most perfect understanding between the engine drivers and the signalmen. The driver does not hesitate to dash round a blind curve, rattle over points, or plunge into a dark tunnel; whether by day or night he has absolute faith in the lowered arm, or the green light of a semaphore, that gives him "road clear." Upon the other hand, the signalman, who has been called "the lighthouseman of the iron road," relies upon the driver acting in accordance with the directions he has given by means of rods and wires, omitting for the moment any reference to the means of working them.

There is no branch of railway work of greater importance than the operation of the signals, and it is interesting to inquire how a system, as perfect as inventive ingenuity can devise, has been evolved out of the primitive arrangements in use in the early days of railways.

When the "Locomotion" drew the first train on the Stockton and Darlington line a flagman on horseback went ahead to give warning of its approach, a method that the growing speed of engines soon proved to be an utterly futile proceeding. The next step was to station men at intervals along the line to regulate the traffic by means of flags; and a Stockton and Darlington station master adopted the method of placing a lighted candle in the station-house window to intimate that a passenger was waiting to be taken up by an incoming train. Soon after the opening of the Liverpool and Manchester line the candle had reached the dignity of a lamp, and flags and lamps were exhibited on posts several feet high. In signalling by hand or flag, the right arm extended horizontally signified "line clear"; raised vertically, it intimated "caution"; while both arms upraised was an imperative injunction to "stop."

OLD DISC SIGNAL
Recently standing at Spetisbury
(Somerset and Dorset Joint Railway)

When trains were few and far between these primitive contrivances served their purpose fairly well, but the growth of traffic necessitated something better. Flags on signal-posts gave way to discs worked from below by an attendant who operated a lever. These were of various patterns, but in the main their principle was the same; the disc turned at right angles to the line and facing the train meant "stop," while turned edgewise it intimated "all right." For night signalling the lamp was furnished with a red panel; the white light showed an "open road," and the red light was the "danger" signal.

Signalling devices of various kinds were practised by the ancients; in Asia and Spain towers were erected by Hannibal from which to transmit messages from post to post over wide tracts of country; and a Roman telegraphic station is depicted on Trajan's Column. Following out this system, the British Admiralty had erected a line of semaphore signals between London and Portsmouth and other ports. Each station consisted of a tower surmounted by a tall post, which was furnished with one or more movable arms, operated by an attendant who received the message and transmitted it to the next post.

In the year 1842 the railways adopted this primitive telegraph system. Posts, each provided with a movable arm, were erected by the side of the rails. The arm could take three definite positions, namely, (1) horizontal, (2) an angle of 45° with the post, and (3) vertical, respectively meaning "danger," "caution," and "safe." The semaphores were worked at the foot of the post by a man, who in some cases had charge of several posts a considerable distance apart. A lazy signalman at Meadowbank on the North British line was responsible for the next improvement. To save himself the trouble of walking or running from post to post, he utilised a wire pulley and lever to work the signal without leaving his hut. It is said that his initial time-saver consisted of a clothes'-line with a broken chair hanging on to the lever as a counterweight. In any case the idea worked well, and was generally adopted; and was the commencement of railway signalling as practised at the present time.

The signals, their arms pointing away from the rails, are generally placed on the left-hand side of the line, the "up" and "down" lines each having its own separate signals. The "home" signal is situated close to the spot where trains are called upon to stop, such as the approach end of a station; the "distant" signal is merely cautionary, sometimes 1000 yds. from the "home," and is used to inform the driver in what position the "home" signal is set; the "starting" signal is at the departure end of a platform. In many cases several hundred yards in front of the "starting" signal there is the "advanced starting" signal, for the use of trains that have to pick up carriages or wagons from sidings beyond the platform, and which can thus bring the train to a standstill before it enters the next section. Distant signal semaphores end in a fish-tail and show a white V-shaped stripe on a red background; the home and starting signals are cut square with a straight stripe. A semaphore in a horizontal position means "stop," and is said to be "on" or at "danger"; when dropped, making an acute angle with the post, it means "go ahead," and is then said to be "off."

Semaphore signals in themselves would be quite useless for signalling at night, and consequently at the end nearest the post the arm carries "spectacles," a frame containing panes of red and green glass, working in front of a lamp affixed to the post. When the arm is at "danger," the red pane is in line with the lamp; and when the arm is dropped the green pane rises in front of the light, so that the driver instantly can tell the position of the arm, although he cannot see it. Whenever possible the signal-box is situated so that the signalman can see the signals which he has to operate. In cases where curves, bridges, etc., obscure his view, a further mechanical device comes to his aid in the shape of little

SIGNAL GANTRY, ENTRANCE TO WATERLOO STATION
(London and South Western Railway)

signals within the box, which imitate the movements of the semaphores that are out of sight.

Formerly the semaphore arm was worked in three positions, like the old flag and hand signals, and three corresponding lights were exhibited, namely, red for "danger," green for "caution," and white for "road open." About 1876 the caution signal was abandoned, and green became the safety colour. A white light is not sufficiently distinctive to be used as a signal, engine drivers being liable to confuse non-railway lights by the side of the line with the white "line clear." In the United States the white light has been the cause of numerous accidents, and American railwaymen are abolishing it, as was done on British lines nearly forty years ago.

On British railways, and, in fact, almost throughout the British

Empire, the rule of the road is for trains to run on the left-hand track. The only example of right-handed running in this country was on the London and Greenwich Railway, which afterwards became part of the South Eastern ; and the system was maintained until 1901, when the running was altered to conform with the prevailing custom.

It was a practice on the early railways not to allow a train to pass through a station within ten minutes of a preceding train. This method worked with a fair amount of success provided a train did not break down between stations, leading to accidents through insufficiency of brake power to prevent a succeeding train running into the tail end of the cripple. It was quite clear that a distance limit should supersede a time limit, but to put any such plan into operation called for a ready means of communication between the signal-boxes. For this purpose a most useful ally was forthcoming in the electric telegraph with which Messrs. Cooke & Wheatstone had been experimenting for several years. In 1839 the Great Western Railway installed the first electric telegraph in England between Paddington and West Drayton, and four years later extended it to Slough. In the meantime several railway companies had adopted the " wonder-working wire," but it was not until 1845 that the fullest possibilities of the electric telegraph were recognised. In that year a man committed a murder at Slough and took train to Paddington, where he was arrested, thanks to information wired from 18 miles down the line.

The electric wire was at once installed on practically all our railways, linking the signal-boxes with the means of rapid communication, enabling the full introduction of the "block system," a potent reality in insuring the safety of trains, which only downright carelessness could counteract. The method possesses the quality of extreme simplicity, and can be explained in a few words. The line is divided by signal-boxes into a number of lengths or sections, and no two trains going in the same direction are permitted in any one section at the same time. The signalman receives a telegraphic warning that a train is coming, to which he replies " line clear." The next message informs him " train on line," which means that the train has entered his section, and he duly transmits the " be ready " signal to the box ahead ; and thus messages and replies in every box precede the train by the length of a section.

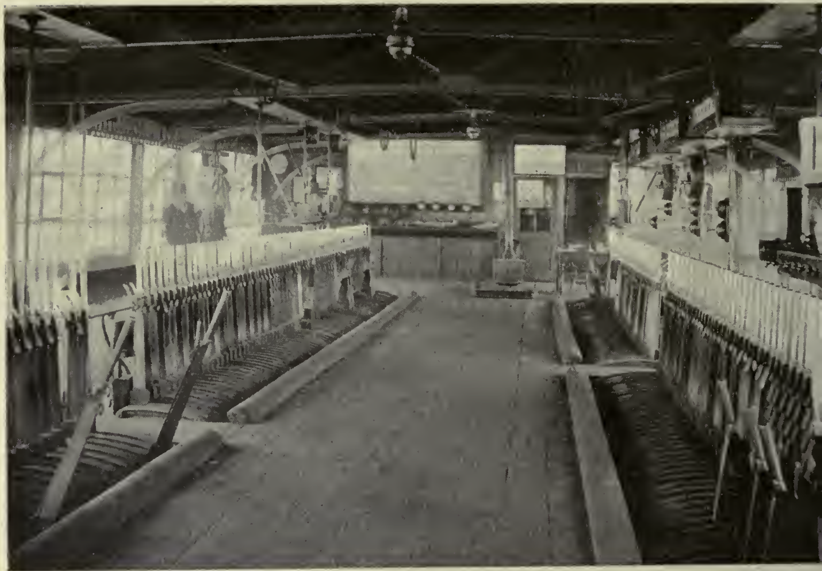
To regulate traffic in this manner would be comparatively easy if there were no branches or sidings to complicate matters. There would be no safety in merely signalling a train on from section to section, if there were a possibility of another train crossing the line between times ; and consequently it was necessary to institute a joint control of the signals and points, working in conjunction at the same time.

The points are movable rails placed within the main line by which trains can pass from one set of rails to another. The two inside rails are joined, and can be pulled to the right or left as desired. This arrangement is quite common even in children's toy railroads, and may be seen at tramway junctions in our streets. In the early railway days the signalman also acted as pointsman, and had to leave his box to move the guide rail and secure it in position by means of an iron pin. The invention of the switch caused rods to be led into the signal-box, and thus the signalman came to have the care of two sets of levers, governing the signals and switches respectively.

In 1846, at Bricklayers' Arms, a London junction, Charles Gregory concentrated a number of signal levers by means of chains and a stirrup frame, in such a manner that a main line signal "to proceed" could not conflict with a similar order on a branch line. This was but partial interlocking, for it only concerned the signals, and did not influence the points. It was not until 1856 that John Saxby contrived to lock eight semaphores and half a dozen points, in which the latter so dominated the signals that no two of them could possibly come into conflict with each other. It was Saxby who first put into a row the levers that work the points as well as control the signals.

The reader doubtless is familiar with the appearance of an ordinary signal-box with its rows of shining heavy levers, the pulling of which calls for much manual strength on the part of the signalman. In recent years, however, pneumatic, electric, or hydraulic signalling has made enormous progress. Instead of what was often a perspiring operation, the pressure of a button, or the working of a lever so small that one finger can move it, will complete an electric circuit or open a pneumatic valve; and interlocking apparatus is operated with as much ease as one switches on electric light. To witness the apotheosis of railway signalling one needs to visit a signal-box at an important terminus or junction. Levers are ranged side by side into the similitude of a gigantic keyboard, there are rows of telegraphic instruments, telephones, gongs, etc., and all of them a part of a whole load of tremendous responsibility resting upon the shoulders of the signalman. In such boxes work never ceases, ever levers are being pulled, and arms on the gantries over the apparently confusing tracks fall or rise in obedience to the will of the operator.

The general principle of interlocking has been aptly expressed by one writer thus: "Signals govern signals and points, points govern points and signals; each is a master, each a slave." The levers are painted in distinctive colours that vary according to their respective functions; they are also numbered to indicate which particular levers must be worked in conjunction, or in other words safety is secured by a lock which can only be opened by the application of the correct keys; for example, when the pulling down of a



SIGNAL-BOX ENTRANCE TO WATERLOO (L.S.W.R.)

PNEUMATIC SIGNALLING APPARATUS, LONDON ROAD, MANCHESTER (G.C.R.)

PLATE V.

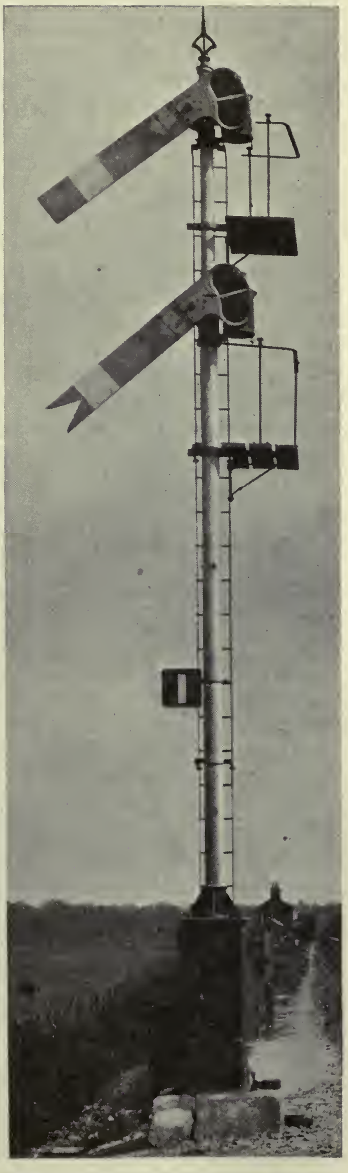
H.M. The Queen's Day Compartment—Royal Saloon.

(London & North Western Railway.)

lever opens a pair of points to allow a train to pass from a siding or branch on to the main line, the home and distant signals on the main line correspondingly set at danger, and vice versa.

There is no doubt that of late years there has arisen a distinct demand for some form of power-signalling to give greater ease and safety in handling heavy traffic, which necessitates a great number of tracks and stations and yards of considerable area. Mr. E. C. Irving, chief engineer of the British Pneumatic Railway Signal Company, claims that under their system one signalman can do the work of three with any manual plant, while from the mechanical point of view the advantages are also very great. It is now agreed on all hands that rods and wires should be abolished or at least laid underground in station yards, on account of the great risk to railway officials from exposed gear, backed up by a Board of Trade recommendation to that effect.

Mr. Irving thus briefly sums up the characteristic features of the company's apparatus for working railway switches and signals. (1) It requires no force but air. (2) The air pressure is always low, normally 15 lbs. per sq. in. (3) Every movement is accomplished by air pressure; nothing depends on gravity, or springs, or withdrawal or reduction of pressure. (4) Except when a switch or signal is being moved, or an indication is being given, all operating and indicating pipes are subject to atmospheric pressure and no more. (5) The final portion of the stroke of the "lever" is automatic, re-



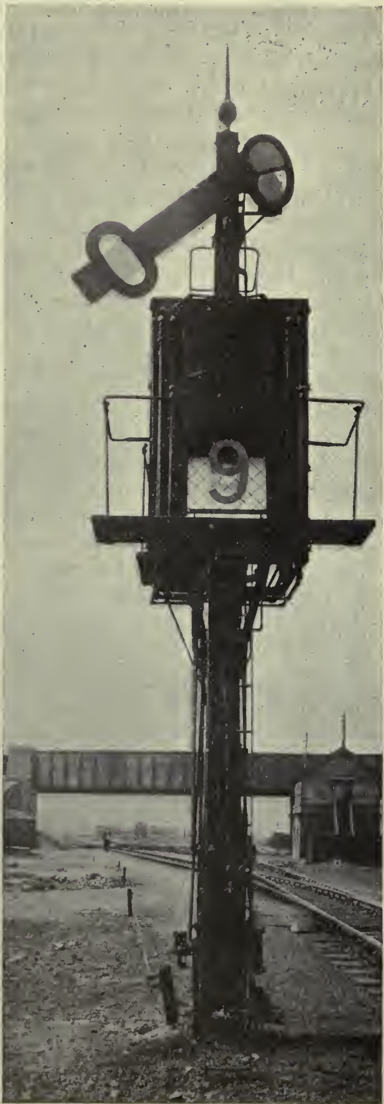
FIRST AUTOMATIC SIGNAL IN ENGLAND, GRATELEY (L.S.W.R.)

quiring no effort or care on the part of the operator. (6) Concentration in one cabin of the control of all the switches and signals within a given field. (7) Interlocking of the controlling parts of different switches and signals, so that it shall always be impossible to give conflicting signals. It may be added that all connections from the cabin to the switches and signals are buried in the ground, and the action is so quick that any necessary or desirable distance can be covered. The interlocking is based on the well-established mechanical types, but with all parts of much smaller size, but amply sufficient to afford all necessary strength.

With this low-pressure system there is no possibility of trouble from condensation of moisture in the pipes, and less liability to leaks, which are common with high-pressure apparatus. The action is also quicker than with high pressures. A switch 500-ft. from the cabin is moved, and the return indication is received back at the cabin all within a few seconds from the moment that the lever is pulled. The movement of a signal arm, at the same distance, is practically simultaneous with the movement of the lever.

Positive application of power is in every case necessary to accomplish any result; no movement or indication is possible without air pressure being applied; and absence or failure of power will always leave the signal in the stop or danger position, and thus be on the side of safety. The original theory of pneumatic switch and signal movement was to divide the stroke of the "lever" (the valve handle, called "lever" on account of its function, being the same as that of the lever in the older mechanical interlocking machines) into two parts, so as to provide for preliminary locking. The signalman moves the lever through the first part of its stroke; this sends air to the switch, and the switch must complete its stroke and thereby send air pressure back to a valve attached to the lever in the cabin, before the final part of the lever stroke can be effected. The lever must not complete its stroke until the switch stroke is surely finished. Having moved lever No. 1 for changing a switch, lever No. 2 must next be moved to give a signal for that switch. With this device the operator is relieved of all thought of the switch as soon as he has made the half-stroke with the lever; and he may then grasp No. 2 preparatory to moving it as soon as No. 1 automatically shall have completed its stroke. If, because of failure of any part, the completion of the stroke of lever No. 1 should not be effected, the operator would be warned of the fact by his inability to move No. 2, this being suitably interlocked with and controlled by lever No. 1.

Safety is the prime requisite in all interlocking. Not only does this system indicate the correct movement of the signal or switch, but the indication air actually completes the stroke of the lever, thus relieving the signalman of all further responsibility. This is entirely lacking in manual-power mechanical or any other form of power interlocking; the integrity of the rods, connections, and cranks being the sole dependence in such machines for this assurance. In large yards there is a third element which tends to increase safety — the smaller force of men required in the tower or cabin. Where from 50 to 150 manual-power levers are worked in a single cabin it is found necessary to employ from four to eight men. This is necessary on account of the number of movements, the long distance from one end of the machine to the other, and the considerable physical energy required to move the levers. With the pneumatic machine the levers are nearer together, and the physical effort required to move them is too small to notice. With this saving in labour and in steps, it is found practicable to work a 150-lever cabin with two men. And not only do we need fewer men, but the men have much easier work. They may be more deliberate in each movement, while at the same time they accomplish the desired result at the switch or the signal post with greater promptness. This moderation of the mental burden keeps a signalman's efficiency at a higher level.



GOODS AUTOMATIC SIGNAL
Controlling ten roads
(Wath Concentration Sidings, G.C.R.)

Durability of the low-pressure pneumatic, as compared with the ordinary mechanical interlocking machine, is a point which scarcely needs proof; the life of the plant will be at least double that of the ordinary mechanical apparatus under similar conditions. The wearing parts of the machine in the cabin have extremely light service. They are made interchangeable, are inexpensive, and of simple design, so that new parts can be quickly substituted. In the pneumatic plant all the connections from the cabin to the switches and signals are immovable, and buried in the ground. In a mechanical plant, on the other hand, the carriers for supporting rods, bell-cranks, and temperature compensators are among the most expensive parts of the machinery to maintain. There are various other systems of auto-signalling, all aiming at safety, but the foregoing will serve as an excellent example.

When a railway accident occurs the question is often debated to what degree trains are really safer on lines equipped with automatic signals than on lines worked by block. The following remarks by Mr. T. Preston (N.E.R.) on the relative methods of each system are particularly informative and interesting.

It is a well-known fact that with automatic signals, such as those between Alne and Thirsk, two trains cannot be in the same section at once, unless a driver runs past a signal at danger. A train, when in the section between two automatic signal posts, breaks the circuit for the signal behind it, making it absolutely impossible for that signal to come off again until the train is out of the section. That being so, it is obvious that an accident like that at Hawes Junction could not happen on a line signalled automatically. Any collision that took place on such a line would be the fault of a driver.

It is quite true that there are, occasionally, failures on the North Eastern Railway automatic area, but these failures are never such as to endanger trains—the worst that can happen is to delay them. Automatic signals are always balanced so that they fly to danger if anything goes wrong with the mechanism. As a matter of fact, with the North Eastern Railway automatic signals during a recent month there were only ten trifling failures in the whole of the forty automatic signal posts out of the many thousands of movements these signals make in the course of four weeks.

Practical railwaymen can find many reasons why automatic signals, as at present known, are unlikely to become general in this country. In the first place there is the installation cost. In America, where the block system was never extensively used and where new lines are constantly being opened, automatic signalling is certainly cheaper; but on English railways much money has already been spent in providing signal-boxes and manual signals, and this is all clear loss if automatic signals are put in afterwards. Then, again, the cost of automatic signals is greatly increased if points are connected to the running lines, as it means electric detectors, additional wiring, etc. In America there are long stretches of line without any point connections, whereas in this country it is quite exceptional to find as much as ten miles of railway without any points. Stations and junctions too are much closer together on English lines. Signal-boxes and signalmen cannot be dispensed with altogether, and men must be provided to work the points when these have to be used.

In some respects too the very best automatic signalling is not so good as the human agent. For instance, if a fire break out on a train, or a carriage door flies open, or goods fall off a wagon, a signalman may see these things and stop the train, but with automatic signalling only there is nothing to guard against such dangers. Or supposing a train gets divided whilst running, and the driver does not know it, a signalman, if he see it happen, can take steps to warn the driver, but if the train is on an entirely automatically signalled line, the train men must act entirely by themselves.

AUTOMATIC SIGNAL
With lower Distant Arms for Junction
Boards off for Main Line, Branch Distant at Danger (N. E. R.)

Another disadvantage of automatic signalling, at any rate so far as the N.E.R. is concerned, is that it does not give a sufficient margin of safety during fog. On a line worked under the block regulations, the signalmen are given instructions on certain short sections, that they are not to clear a train back until the next man ahead has cleared it back. The sections between automatic signals are short (usually about 1100 yards), but they naturally work just the same whatever the weather is, and so on our automatic area the signal-boxes have to be manned specially during foggy weather in order to work the line by block system.

It is true that various accidents would not have been possible on an automatically signalled line, but, on the other hand, most of the serious mishaps in recent years have happened from causes totally unconnected with mistakes in block working. The serious accidents at Grantham (G.N.), Shrewsbury (L. & N.W.), Tonbridge Junction (S.E. & C.), and Ulleskelf (N.E.) were caused by drivers disregarding signals. The Salisbury accident on the L. & S.W.R. was due to the driver not observing a speed limit. The derailments at Witham (G.E.) and at Felling on the North Eastern line a few years ago were due to causes connected with the permanent way. These cases simply show that however perfect signalling is, accidents will still happen on railways occasionally, no matter what steps are taken to guard against them.

In criticising the block system account must be taken of the many thousands of trains which are run safely under the block regulations. On the North Eastern there has been no serious accident that could be traced to a signalman's mistake for about 20 years, and many other railways have equally good records. It is also a significant fact that at the Board of Trade inquiries no suggestion of any sort of automatic signalling has been put forward as an alternative to the block system, and no open-minded man would condemn the latter system simply because of slips on the part of one or two particular signalmen, unless, of course, a better system were available.

The average signalman is one of the most alert and intelligent types of railwayman; there are thousands of signalmen in the country who have never endangered the life of a passenger during almost life-long service. Anyone who knows the block rules will agree that if they are properly carried out it is impossible for a signalman to cause a collision. In the Hawes Junction case the signalman allowed two engines to enter upon the main line, and then forgot all about them; if he had merely put a ring on his home signal lever, the accident would probably never have happened. In the Willesden collision on the L. & N.W.R. the signalman pulled a certain lever instead of the one next to it.

If the block system, as it stands at present, is ever to be superseded by some other system which is considered safer, it will probably be something on the lines of the "Lock-and-block" system, which is in use already on some lines, the Metropolitan, for instance. In this system the trains pass over treadles, which release the block instruments and enable the signalman to give "Train out of section," which he cannot do until the train is over the treadle. This is an expensive system to work on account of the amount of electrical locking it involves, and it also means that it is never possible to get two trains in a section even when the signalman wishes to do so, for instance, when he accepts a goods train under "Section clear but station or junction blocked." He may have one goods train shunting between his advance and his home signal, and want to accept another train up to his home signal, but with "Lock-and-block" he could not do this, and delays would arise.


STAFF POST · STAFF CATCHER

DRIVER PICKING UP STAFF WHILE TRAVELLING AT SPEED (G.W.R.)

In conclusion, Mr. Preston expresses the opinion that while automatic signalling possibly may be used to a limited extent on certain sections of line, it will be to reduce working expenses chiefly, or to relieve congestion of traffic, and not because the block system is considered unsafe.

So far we have been considering the signalling arrangements that apply to double lines of railways, but there are 10,000 miles of single-track lines in the United Kingdom, exclusive of railways that are only 100 miles in length and under. As the traffic works both ways upon the same metals, it is evident that the "block system" will call for marked modification, since there is the added danger of head-on collisions.

A single line is divided into "block sections," usually the length of line between the principal stations, where passing places are provided. No driver is allowed to pass from section to section unless he carries a staff, ticket, or tablet, according to the safety method employed. When a driver leaves A to proceed to B, he carries the staff with him, and yields it up on his arrival at B in exchange for the staff that gives him right-of-way to C. Meanwhile a train at B cannot proceed to A because the staff is not available. But there is an arrangement by which several trains in succession may leave A without fear of meeting a train coming in the opposite direction from B. Suppose the station master at A has possession of the staff and wishes to send three trains to B. The driver of the first train is shown the staff, and is given a ticket or tablet to carry to B; the second train takes a similar ticket; but the driver of the third train takes the staff itself to hand it to the station master at B, who will then have the right-of-way over the section.

The handing over of a staff at a stopping-place is a simple matter, but often in the case of single-line expresses staves are exchanged while a train is travelling perhaps 30 miles an hour. So adept do the men become that they can exchange staves by hand while going at that speed; but it is more common to utilise an "automatic staff-catcher," the looped staff being affixed to a post, loop uppermost for ready handling, while to return it the loop is dropped over an arm. There are various different methods of interlocking staves and tablets, but they are all means to the same end.

When fog takes a railway under its sway all the foregoing elaborate signalling arrangements in themselves are powerless to ensure safety. Semaphores by day and lights by night cannot be perceived by the engine driver, and hence he receives instructions by ear instead of by eye. Expressed simply, fog-signalling is a resort to the old hand-signalling, aided by the use of detonators. The fog-men are experienced plate-layers, who take their stand sufficiently close to the "distant" signals to perceive the arms or lights; where the semaphore is very high up there is a dwarf duplicate one lower down to render aid to the "fogger." His duty is to place detonators on the line while the signal is at danger, and to remove them when the semaphore gives "all clear"; and he also displays his red and green lamps or flags to the driver. The explosion of a detonator at once warns the engineman that the signal is against him, and he comes to a standstill pending further instructions.

In every case for each signal the fogman fastens a couple of detonators to each of the rails by means of a clip; the duplication is in case one detonator should fail to explode through the wheel pushing it off the rail. If the first detonator explode, the fogger removes the second one to save the useless expenditure of several pence, no inconsiderable item when it is remembered that an important company may use 12,000 detonators in half a day. In some cases the double detonators are so arranged that the explosion of the first one removes the second before the wheel reaches it. There are various ingenious appliances for fixing detonators on the rails in a manner that minimises the risk of the fogman being run down. In one case, by means of a machine charged with detonators, the explosive warnings are laid on the rails from the signal cabin; and by the use of another apparatus a fogman can control a number of parallel lines without the necessity of crossing the metals.

Fog is not only a dangerous nuisance, it is costly into the bargain. Detonators, fogmen's wages, more or less dislocation of traffic, and frequent accidents into the bargain, eat into railway profits very considerably; and inventors are ever seeking to evolve some safe and yet cheaper method of running the trains that shall partake less of blindman's buff, which necessarily can only be achieved by some mechanical method of direct communication between signalman and driver.

In all probability electricity eventually will come to the rescue, for on electric railways a train can be made to stop of itself by means of an electric current passing through the rail to the brake apparatus, when there is an obstruction ahead, this automatic mechanism performing the functions of both signalman and driver. In the meantime we may glance at several other methods, the adoption of which would abolish detonators altogether. Various engineers have sought to achieve the same ends by means of levers or triggers fixed alongside the rails and working in conjunction with the signal arms. Under the engine is placed a corresponding attachment, which, when it comes into contact with the lever or trigger, will ring a bell in the engine cab or cause a whistle to blow. This in itself would only inform the driver that he has reached a signal, whereas his precise desire is to learn whether the arm is "off" or "on." In one invention, instead of a bell or whistle warning, a miniature semaphore works across the window of the cab; while another patent arranges for the lever to apply the brakes instantly all along the train. Upon one point we may be certain: the mechanical ingenuity of our engineers will some day or other produce some practically infallible apparatus to replace the frailties of the human equation.

Closely connected with the signalling arrangements is the question of brakes. It is practically useless to be notified of danger ahead unless the engine driver is supplied with the means of diminishing speed quickly, or stopping altogether. Until comparatively recent years the engine was furnished with a brake worked by a worm gear, and the guard controlled a similar one in his van; but, however powerful they were, even when both were hard on, a fast and heavy express could not be brought to a standstill in a less distance than from half to three-quarters of a mile. Under modern conditions of traffic, while train weights have become heavier and speeds higher, the block sections have become shorter, causing the brake to occupy a position of the highest importance.

To meet the necessities of the case it was evident that each pair of wheels in the train should not only be braked, but that all the brakes should be capable of simultaneous operation. This need brought into use a continuous brake worked by chains, the guard winding up a main chain extending underneath all the carriages, and braking the wheels by means of short auxiliary chains. This apparatus often failed to be effective, for sometimes the main chain broke, and often a branch chain would take all the pull, owing to its being a trifle shorter than the rest.

The next step was to apply the brakes by the power of steam, which passed through a flexible pipe to cylinders placed under each vehicle. When the steam moved the pistons, levers were operated and the brakes applied. The chief defect in this contrivance lay in the fact that rapid condensation robbed the steam of much of its effectiveness, especially towards the end of a long string of vehicles. Water under high pressure was tried, but in winter the water froze in the pipes and rendered the apparatus ineffective.

The remedy was found in the adoption of the automatic brake, which has become the chief agency for the braking of passenger trains all over the world. As stated in earlier pages, the brake may be one of two kinds, one working by compressed air and the other by exhausted air.

When automatic brakes first came into use they served fairly well for short passenger trains, but acted indifferently for a long string of carriages or a train of forty or fifty goods wagons. In a train moving at 20 miles an hour, the brakes would bring the forward part of a train to rest in 15 seconds, by which time the brake had not commenced to act at the rear part, which practically had the effect of a collision between the braked and unbraked portions of the train. Mr. Westinghouse thereupon invented an improved triple valve which applied the brakes simultaneously throughout the length of a train nearly one-third of a mile in length in 2 seconds. The vacuum brake in due course was similarly improved.

It is difficult to say which is the better of the two brake systems, but the Vacuum Automatic is the one most in use in the United Kingdom. The Westinghouse Automatic Brake is employed on the Caledonian, Great Eastern, London, Brighton, and South Coast, North British, North Eastern, and about a score of other smaller lines; but the vacuum brake is in use on practically all the other lines to the number of fifty-six.

In most cases railways own numbers of passenger vehicles that are fitted with both systems of automatic brakes for convenience of working through services. More than a dozen companies possess

SLIPPING MAIL VANS AT BEDMINSTER (G.W.R.)

locomotives fitted with apparatus for working both automatic brake systems. Six companies whose engines are all fitted with the Vacuum Automatic have over eighty engines that are also fitted with the Westinghouse apparatus; but eight companies whose general system is the Westinghouse have among them about 760 engines also fitted with the vacuum automatic.

It is sometimes required to give a place a fast connection, and yet in the interests of speed it is not desirable to stop the whole train. This is accomplished by means of a "slip" coach, which forms the rear vehicle in charge of a guard of its own. When the "slip" coach nears its destination the speed of the train is checked only sufficiently to slacken the couplings a little, and then, usually by means of a pneumatic apparatus, the tail coach is detached from the train, which then gathers speed, leaving the detached unit to run to its stopping-place by its own impetus. The guard is able to bring the coach to a standstill by its own brake power.

It is easy to conceive that while a train is in rapid motion circumstances may arise making it highly desirable for a passenger to communicate with the guard, as in cases of sudden illness, assault, accident, etc. At one time this could only be effected by pulling a cord, fixed outside just over the carriage door, and running the whole length of the train ; but access to it could only be gained by means of an open window, and in cases of aggression it was not difficult to prevent attainment of the object. The outside cord has been abolished in favour of an interior chain running over the carriage doors from end to end of the train. The pulling of the chain not only attracts the attention of the guard, but also acts on the air brake, opening a valve to which the driver immediately responds. The guard then passes along the train to ascertain from which carriage the summons came, aided by an indicator at the end of each vehicle. In the case of corridor trains, the attention of the dining-car officials, or the guard, can be called by means of an electric bell without bringing the train to a standstill.

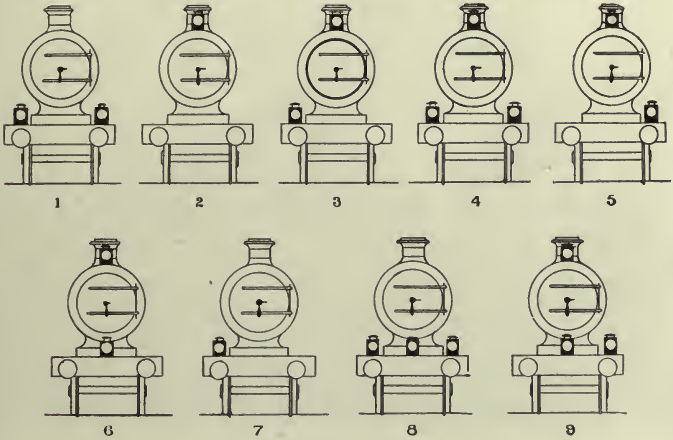
All engines now carry headlights according to a uniform Clearing House code, instead of, as formerly, each company exhibiting its own distinctive lights. All the lights are white, except in certain metropolitan areas, where green and blue are retained. The following is the list of lights which distinguish engines according to the work in which they are engaged, forming useful aids to signalmen, Clearing House officials, and others, who deal with the running of the trains :

(1) Express passenger trains : two lights, one over each buffer. (2) Ordinary passenger trains : one light under the chimney. (3) Express fish and fruit trains composed of passenger stock : two lights, one under the chimney and one over the left-hand buffer, facing. (4) Empty coach trains : three lights, one over each buffer and one under the chimney. (5) Fast express goods trains, and fish and meat trains, composed of goods stock : two lights, one under the chimney and one over right-hand buffer. (6) Express cattle and ordinary express goods trains : two lights, one under chimney and one at the centre of the buffer beam. (7) Light engines, or engine and brake : one light over left-hand buffer. (8) Through goods and mineral trains : three lights horizontally along the buffer beam. (9) Stopping goods trains : three lights, one under chimney, one in centre of buffer beam, and one over right-hand buffer.

Many railways have additional codes for working their own special traffic, lamps by night and discs or boards by day, on the whole the day discs corresponding to the night lights. The discs are of numerous shapes, squares, diamonds, circles, ovals, etc., sometimes striped or crossed, while in some cases a circle or diamond is inset in a square, etc.

British trains travel 423,000,000 miles during a year ; how many wheels revolve and the revolutions they make are incalculable. But the best-laid metals, the most satisfactory brakes, and the most perfect signalling arrangements count for little if the wheels of the vehicles are not sound. A fractured wheel is a menace to life and property, and consequently precautions are adopted to secure safety in this direction. All railway companies employ men called "train-examiners," whose ears are trained to detect any flaw in a wheel by the sound it gives, when struck by a long-handled, double-headed steel hammer. To the practised ear the "ring" of a faulty wheel is distinguished as easily as that of a counterfeit coin. All wheels are regularly tested in this manner, but express train wheels in particular are tapped at the commencement of a journey, as well as at the halts along the route.

The running of our trains over nearly 24,000 miles of railways



ENGINE HEAD-LIGHTS

is a tremendous business. When we say that the trains travel 423,000,000 miles in a year it conveys little, unless we reduce the statement to a determination that appeals more to the understanding. It means that nearly 19,000 trains traverse each lineal mile per annum, or about fifty trains a day. Of course, this average gives us no idea of the real density of traffic, which varies according to the nature of the line. Nearly half our lines (10,000 miles) are single-tracked, upon which the traffic is worked in both directions; on 250 miles of line the track is trebled; and on over a thousand miles, quadrupled and more. Where the London and South-Western Railway crosses Westminster Bridge Road there are eleven tracks that then spread out fan-wise into nineteen upon entering Waterloo Station, in and out of which 2500 trains, engines, etc., pass every day; and this, be it marked, does not include any goods traffic, which comes no nearer Waterloo than the Nine Elms goods yard. Much the same may be said concerning other London termini: take, for example, Liverpool Street, in and out of which an apparently endless procession of trains convey about 180,000 passengers a day. One morning 160 trains ran into this station within the space of three hours, and all on time with the exception of one train, which was two minutes late. Such a record speaks volumes for the smoothness of working, including the reliability of the staff, the quality of the engines, and the excellence of the signalling arrangements.

Tested from the standpoint of accidents, British railways, so far as the safety of the travelling public is concerned, afford wonderful testimony that the science of locomotion has reached a high degree

AN ACCIDENT

of perfection. In the early days accidents were frequent rather than serious. The breakdown of engines was the chief source of trouble. More than once it happened that when a locomotive came to grief three pilot engines, one after another, were sent to the rescue, only for each one to become disabled before reaching the scene where assistance was needed. Nowadays breakdowns and accidents of any kind are of less frequent occurrence, but when anything untoward on the line occurs, the increased weight and speed of trains tend to a corresponding addition of danger. In 1902 we find that only six passengers were killed and 732 were injured on the railways of the United Kingdom from causes beyond their own control; the proportion of killed to the number carried (exclusive of season ticket-holders) was 1 in 198,000,000; and of injured the proportion was 1 in 1,623,000. In 1906 there were

58 passengers killed and 631 injured. This was a black year, in which there were three notable accidents, at Salisbury, Grantham, and Elliott Junction; the proportion of passengers killed rose accordingly to 1 in 21,000,000. In the year 1908 not a single passenger was killed and only 283 injured, or 1 in 4,515,000, the best record in our railway history.

On all railways breakdown trains are kept at convenient running depots in readiness for instant use when an accident occurs. Such a train consists of a steam crane and several special brake vans stocked with tools and appliances to meet all contingencies, as

BREAKDOWN GANG AT WORK

well as providing accommodation for the men. On receipt of a call, a locomotive is attached and steam is raised in the crane boiler. The crew consists of men suitably trained for the work, and generally employed close to hand, so that in a very short space of time the breakdown gang is on its way.

A breakdown train is given a clear road as far as possible, and when it arrives at the scene of a mishap arrangements are made for "running on the wrong road," so as to enable it to get close to its work. The breakdown cranes are capable of dealing with loads up to 30 tons and upwards, and can run under their own steam when necessary. In some cases the power supplied by steam is controlled hydraulically. In travelling, the "jib," or arm, rests on trestles in the "guard truck" which always accompanies the crane, and thus bridges and wayside structures are not fouled ; in running trim a crane will pass under a loading gauge of 13-ft., although its working capabilities may extend to 24-ft. above the level of the rails. The total weight of the larger cranes may reach 75 tons, but usually smaller ones, with a lifting capacity of 10 to 15 tons, are quite sufficient for their work.

The contents of the tool vans always include a supply of hydraulic jacks, ramps, etc., particularly useful in rerailing operations. Other appliances comprise miscellaneous tools, such as spanners, wrenches, chisels, hammers, punches, files, bars, wedges, etc., together with a plentiful supply of spare gear, and in fact the whole outfit is that of a well-appointed temporary repairing shop. Truck runners or bogies, are always taken for running under vehicles whose wheels and axles have been wrenched off in the accident.

The engineer of the line is constantly travelling over the system in an inspection car, usually a coupé attached to an engine. Members of his working staff in much of their inspection work are conveyed from point to point on platelayers' trollies. The motor-car has been adapted to railway inspection work, flanged metal wheels being used instead of the ordinary rubber tyres. It has not yet been adopted on any great British line, but abroad, where there are long stretches of line with only an infrequent train service, such a vehicle proves exceedingly useful.

It is often of vital importance that road repairs be effected with the greatest despatch. For repairs to bridges and constructional ironwork generally, pneumatic plants are of great value, economical in time and cost as compared with manual labour, with the advantage of doing better work. There are many operations connected with repair work on a railway which can be performed expeditiously by pneumatic tools, such as drilling in metal, boring in wood, riveting, etc., and those driven by compressed air appear to have an advantage over steam or water, especially in their extreme portability. A complete travelling pneumatic installation can be contained in one van, and capable of operation immediately it is at a standstill. The plant comprises boiler, steam-driven air compressor, water tank and pipes, air receiver, flexible hose and connections, bench, vice, and various pneumatic tools.

CHAPTER VIII

PASSENGER TRAFFIC

ALTHOUGH the conveyance of passengers on British railways does not account for as much revenue as is derived from the carriage of goods, it is the department that most appeals to the popular mind. The passenger traffic is more visible and bulks larger ; there are infinitely more passenger trains than goods, and they travel many more million miles during the year. Passengers load themselves up at their starting point and unload and scatter at their destination ; whereas the greater proportion of the "goods" usually has to be collected before the commencement of the journey and delivered at its end, to say nothing of no inconsiderable amount that has to be warehoused until the customers call for delivery.

What is the number of passenger journeys made on the railways of the United Kingdom in the course of a year it is impossible to tell ; 1,265,000,000 (1909) is a reliable return as far as it goes, but it takes no heed of nearly 2,000,000 season-ticket holders, who must increase the number of passenger journeys enormously ; but we do know that the passenger railway fares amount to £42,000,000 per annum, or very nearly £1 per head for every man, woman, and child in the kingdom. In the present chapter we propose to note how this immense business has been developed out of its crude beginnings on Tyneside, when George Stephenson put the "Experiment," the very first steam railway passenger coach, on the rails of the Stockton and Darlington Railway less than ninety years ago. This was the pioneer vehicle of about 53,000 passenger carriages and 20,000 other miscellaneous passenger vehicles that are in use to-day on British railways.

Reference has been made in earlier pages to the Surrey Iron Railway of 1801, and there were a dozen or more lines in existence before the opening of the Stockton and Darlington. These lines were worked by horses, but, nevertheless, some of them possessed passenger coaches, and at least one railway engineer had foreshadowed the use of long carriages running upon eight wheels, and so fitted that passengers could take their meals whilst travelling—

but many years were to elapse before the latter shadow became substance.

The railway passenger carriage grew up out of the old stage coach, and, what is more, grew up very badly. In construction the railway carriages followed closely on the lines of the road vehicles which they were destined to displace, even going to the length of making provision outside for passengers and for the carriage of luggage. Contemporary prints showing trains on the Liverpool and Manchester Railway in 1837 give a vivid idea of the shortcomings of the vehicles, whether for passengers or goods.

On some of the lines that speedily came into existence four classes of passengers were recognised. First and foremost were those who elected to ride in their own road carriages, which were conveyed on railway trucks ; the fare was 2d. per passenger per mile, plus 6d. per mile for the carriage. First-class passengers paid 3d. per mile ; second-class passengers, 2d. ; and under the seats were lockers for luggage and dogs. Third-class passengers received no assistance from porters in the handling of their luggage, and they had to present themselves quite ten minutes before the departure of a train, or they were not allowed to book.

The first- and second-class carriages were bad enough, but those provided for the third-class passengers were the last word in comfortlessness. The sides of the carriages, if worthy of so dignified a name, were only 2 or 3 ft. high and without roofs. In only a few cases were they supplied with rough seats, so that they were no better than the vehicles now used for the conveyance of coal ; not so good, in fact, for there were holes in the floor to allow of the escape of rain water, but which admitted most inconvenient draughts from beneath. The buffers were commonly solid blocks of wood, and nobody in authority considered that such plebeian vehicles could expect to be furnished with springs.

Really the railway companies failed to see the utility of encouraging third-class traffic ; some did not cater for it at all ; and on an important line like the London and Birmingham only 24,000 third-class passengers were carried in six months. It was a wonder that so many took their courage in both hands to undergo the trials that awaited them by payment of about 1½d. per mile, which is more than the second-class passenger now pays on the same line. In long-distance travelling the luckless third-class wight was conveyed in company with horses, cattle, and empty wagons at most inconvenient times, and with abnormally long waits to make connections. To get from London to Taunton (168 miles) occupied 16 hours, and there was no choice of trains between 4 a.m. and 9 p.m. To reach Liverpool or Manchester was infinitely worse, for there was only one train a day, and there was a fifteen-hour wait at Birmingham.

TRAINS ON THE LIVERPOOL AND MANCHESTER RAILWAY (1837)

1. Train of first-class carriages. 2. Train of second-class carriages. 3. A goods train.

One reason advanced against rapid travelling for third-class passengers was that human endurance could not stand exposure to the weather if conveyed at speed, not even if the passengers warmed their hands on the engine chimney, of which advantage was sometimes taken in the carriage nearest to the locomotive, when it happened to be running tender foremost. Riding on the outside of a stage coach in wet weather, or in the depth of winter, was a far from enjoyable experience, but travelling in an open third-class railway carriage was a veritable purgatory, for in addition to the vagaries of the weather, there was often terrific jolting, and frequently streams of sparks and cinders from the engine stack.

In the running of the third-class mixed trains the passenger coaches were always placed next to the engine. Brunel advocated that practice, because passengers would be in considerable danger in the rear owing to luggage trains being liable to be run into by other quicker trains. Events proved that they were in far greater danger in front, for in case of any head-on obstruction, the carriages were crushed into the engine by the weight of the heavy wagons behind.

Several distressing accidents of this kind occurred, and probably it was about this time that one individual suggested the use of feather beds at the front and tail of the train, and also between the carriages, instead of buffers; another idea was that the engine should be attached to the carriages by a rope quite a mile in length; and it had long been proposed to carry on the engine a third man furnished with a small telescope, in order to perceive any danger well in advance. Needless to say neither of these brilliant notions was adopted, but it became the practice to make up mixed trains with a few empty trucks between the engine and passenger carriages. Upon some lines to-day, when there is no guard's van at the front of the carriages, the two compartments nearest the engine are not allowed to be occupied by passengers.

Many of the accidents on the early railways were of a preventable character, but the public needed educating to recognise the danger they ran by leaping from a train to chase a hat whisked off by the wind; and when there was no room in the compartments passengers were permitted to ride on the roofs and platforms of carriages. Trains usually carried two guards, both of whom sat on top of the train; one at the rear, looking forward, and the other at the front, looking back. This precaution was adopted chiefly to discover at the earliest possible moment when any portion of the train broke away. The luggage was strapped on to the roofs of the carriages, and almost needless to say it frequently took fire from the engine sparks, which did not make for the comfort of the guards lashed up aloft.

On the lines of some of the manufacturing districts in the north third-class passengers were not carried as a mere favour, or just as a concession to the poorer classes ; they were booked by all trains and covered carriages with seats came into service. In the early part of 1841 the Newcastle and North Shields Railway was carrying seven times as many third-class passengers as any two of the Midland and Southern lines. And as the third - class passengers ceased more and more to be viewed as undesirables, so their comfort received increased attention.

Some of the companies were much concerned to discover that not a few " persons in superior positions " did not hesitate to travel in third-class carriages for the sake of economy. In some cases rather drastic measures were resorted to in order to deter meanness that operated against the company's interests. Upon occasion sweeps were hired not only to ride with the superior persons, but to shake out their soot-bags. This may have taught the desired lesson to the offenders, but it would be interesting to have learnt the views of the normal third-class passengers, whose only offence was lightness of pocket.

But even if the railway companies as a rule were slow to learn that there were dividends in third-class traffic, Parliament came to the aid of the passengers in 1844 by passing the Cheap Trains Act. In this Magna Charta of the third-class passengers it was laid down, among other things, that on every railway there should be at least one train each way per day at a penny a mile, and that even at that low fare there was to be a roof for protection from the weather. In any case, however, by that time railway vehicles had made considerable advances in the shape of comfort. For the most part they were ugly boxes of four or five compartments, made wholly of hard wood except for the running parts ; seats were provided, but so hard and straight-backed that sleep was out of the question ; and they were lighted by oil lamps that were as often out as in, owing to the jolts, which were inseparable from early travelling. A little later the bodies of some carriages were made of iron, but extreme simplicity and lack of real comfort remained their hallmark.

There is still in existence the royal saloon built in 1843 by the London and Birmingham Railway for the use of Queen Adelaide, the consort of William IV (page 192). It appears to be closely related to the stage-coach, but the buffers, springs, and continuous footboard show marked advancement on the earlier attempts of the railway carriage builder, who could provide roomier and heavier carriages as the light four-wheeled engines gave place to six-wheelers with greater tractive power.

In the chapter on " Locomotives Past and Present " there are constant references to the growing weight of trains, and the absolute necessity for heavier and more powerful engines. The improvement in the carriages has gone hand in hand with an increasing weight in their construction. The earliest passenger coaches were four-wheelers, which in course of time developed into six-wheelers, weighing about 15 tons apiece, and affording room for 50 passengers ; and a train meant 120 tons behind the tender. By the end of the century the coaches were eight-wheelers, weighing 24 tons and holding 70 passengers ; and the weight of trains doubled. Nowadays a first-rate coach runs upon twelve wheels, weighs at least 35 tons, and yet holds only 72 passengers, or about two persons to the ton of carriage weight, whereas formerly it was nearer 4 to the ton. In the evolution of the passenger carriage, increasing weight has meant constant additional comforts and conveniences for the passengers, but with a marked decrease in the profit-earning capacity of the trains.

One has only to sit in a fairly ordinary carriage, running, for example, only upon a suburban line, to grasp the vast improvement

AN EARLY THIRD-CLASS CARRIAGE
(Great Western Railway)

over the vehicle that companies formerly placed at the disposal of their patrons. While the whole vehicle is built for strength, the compartments are well decorated, lighted, and ventilated ; the seats are cushioned, luggage racks are provided, and frequently framed and glazed photographs of interesting places on the line add to the ornamentation of the interior. In every respect even a third-class compartment is an object-lesson in the comfort it is possible to afford, while observing a rigid economy of space.

The heating of carriages during cold weather was formerly attempted solely by means of the "foot-warmer," a long oval tin of hot water placed in a compartment at the commencement of a journey. Acetate of soda was often employed. This substance when liquefied absorbs heat, and gives it off as it cools. These unsatisfactory contrivances have not yet disappeared, but in well-appointed trains the carriages are now heated by means of steam supplied in pipes from the engine, and regulated in each compartment. This system is by no means yet perfect ; over-heating, which is common, is very productive of colds, when passengers leave the train for the open air.

The lighting of trains has made enormous strides since George Stephenson's first passenger carriage on the Stockton and Darlington line was lighted with candles. For very many years the best means of lighting compartments was by oil lamps hanging from a hole in the roof, and placed in position by employés from the outside. But even when an oil lamp was at its best—and usually it was at its worst—the result was far from satisfactory. Gas lighting effected a notable advancement. Compressed oil gas is carried in reservoirs underneath the carriages, from whence it is conveyed by pipes to the lamp in the roof. This system, however, entailed lighting from the roof outside by a man armed with a flare, as in case of the old oil lamps, until incandescent lights with by-passes came into use.

For easy working, cleanliness, and freedom from smell, nothing can beat electric light for carriage illumination. Under the trains are one or more dynamos which are driven by the revolving axles during travelling. In order to keep on the light when the train is at a standstill, accumulators are employed for the storage of sufficient electricity for use until the train is again in motion.

Sleeping accommodation on trains was advocated by Lieutenant le Count of the London and Birmingham Railway about 1840. At that time postal employés working the mails were furnished with hammocks, a practice that suggested ordinary passengers might be supplied with accommodation for undressing and really going to bed, if they were willing to pay for it. Sleeping carriages for first-class passengers came into use in 1873, the Great Northern and North Eastern being the first to adopt them. Each sleeping apartment provided three berths, by pulling down the back of the seat. They were not particularly convenient, and some imaginative passengers could not sleep in them, owing to their suggestiveness of coffins. In a later form of sleeping carriage the four day seats were convertible into two beds, while two hammocks were slung from the roof. Further improvements followed in the shape of sleeping saloons in which each occupant was provided with a compartment to himself. The charge per berth is usually 7s. 6d. in addition to the first-class fare. On the Midland system at Glasgow and St. Pancras, if the train arrive at the station in the early morning, the sleeping cars are placed aside, and passengers can rest until 8 a.m.

In 1874 the Midland Railway Company introduced Pullman cars from America, in which the carriage is not divided into separate compartments, but is really a comfortable room furnished with easy chairs, with a passage running down the centre to the doors at either end of the vehicle. This introduced rather a startling novelty into the United Kingdom, for one of the Pullmans was fitted up as a buffet or travelling bar. The American cars in themselves did not revolutionise British travelling ; few companies even gave them a trial ; the London, Brighton and South Coast, London and South Western, South Eastern and Chatham, Metropolitan, and Highland are the only companies that still run Pullmans but their introduction led to marked developments.

SLEEPING BERTH
(Great Northern Railway)

British carriage designers were not long in evolving a vehicle that, while retaining the main advantages of the Pullman, should lend itself less liable to draughts, and should accord more with our national liking for some degree of privacy. This was effected by retaining the compartment system, but providing a passage along one side of the coach. This was known as a " corridor carriage," and a number of these vehicles joined together by folding-leather and canvas-covered gangways form the " corridor train " of to-day, that plays so important a part in long-distance travelling.

The North Eastern was the first of our companies to put corridor carriages on the metals in 1883. They were longer than had hitherto been the British practice, but the greater length was made capable of taking curves by the use of four-wheeled bogies, instead of the former rigid wheel-base. Carriages of this type were adopted by all the leading companies, and forthwith sprang into being various conveniences that for many years had been little more than a dream.

Refreshment rooms had long been provided at all important stations, but the catering as a rule left much to be desired, chiefly owing to the difficulty of gauging the varying requirements at given times; but notwithstanding the comic papers, passengers were not restricted to battening on antediluvian buns. The introduction of the luncheon basket in 1873 effected something towards ensuring the passengers' creature comforts; and then the corridor restaurant car put its seal upon the suggestion voiced in 1825 by William Chapman, at a meeting of the London and Northern Railway. He was the man who avowed that he saw no reason why passengers could not be conveyed in long eight-wheeled carriages, in which meals could be provided while the train was in motion.

The dining-car really was in use several years before the advent of the corridor train, for in 1879 the Great Northern put such a car on its London and Leeds service, being an improvement on the Midland Railway Pullman cars, in which only light refreshments were served; and the London and North Western and Midland railways shortly followed suit on their London-Manchester and London-Leeds services.

One naturally would have imagined that the employment of the corridor train would have led to the speedy introduction of restaurant cars on the main routes between London and Scotland, whereas our greatest long-distance trains were not favoured with such accommodation until 1893, and not a few important trains had to wait much longer. This arose from the custom of railway companies letting their catering work out to contractors, whose agreements usually stipulated upon the stoppage of certain trains to allow passengers an opportunity of dining in the refreshment rooms.

To overcome some of these vested interests entailed at least considerable delay; and in the case of the Great Western, £100,000 was paid in 1895 to the Swindon Junction Hotel Co., in order to put an end to a ten minutes' stop for refreshments, that was proving a bar to the speedy long-distance running at which the company was aiming.

The largest dining-cars on our railways are those in use on the East and West Coast joint services; and one of those running between Euston and Scotland may be noted somewhat in detail. The vehicle, which is 65½-ft. long, is divided into two saloon compart-

ments, first-class at one end, and third-class at the other, with one kitchen and pantry in the centre. The first saloon compartment seats 15 passengers, and the third compartment 21 passengers, so that 36 passengers are able to dine at one time. The kitchen and butler's pantry are 10-ft. 6-in. and 7-ft. 6-in. wide respectively, with a corridor 1-ft. 8-in. at the side, connecting the first- and third-class compartments.

The structural framing of these cars is in teak and oak, panelled outside with Honduras mahogany. The internal wood-framing of the first saloon compartment is polished walnut, with panels in mahogany, banded with green ebony and tulip wood. The cornices and blind hoods are deep Charrior carved mouldings, the dado panels are in Italian walnut, and the dining-tables in mahogany covered with red vulcan leather. The roofs are covered with Lincrusta, and the whole enamelled white with the floral design picked out in bright enamel. The third-class saloon compartment is fitted up with polished teak framing, and panels in light oak, with mouldings in mahogany; cornices and blind hood mouldings are plain; the dado panels are in light oak. The dining tables are in teak covered with brown vulcan leather, and the roof is covered with floral-designed Lincrusta enamelled white.

The seating in both saloons is arranged with movable-framed dining-room chairs with arms, the seats and backs being mahogany upholstered in maroon American leather for the first-class, and light oak upholstered in brown American leather for the third-class. The movable dining-tables are made long double to dine four persons, and short double for two persons. They have brackets at one end to fix on the side of the saloon, and a folding leg at the other end. The first-class compartment floors are covered with Wilton pile carpet laid on felt, with horse-hair matting down the centre. The third-class floors are covered with cork linoleum, with horse-hair mat down the centre.

The fittings in the kitchen are a gas-cooking range, with combined hot closet, grill and water heater, also Bunsen burner rings and hot plate, two wash-up sinks, folding table, cupboards, and refrigerator box. The butler's pantry contains two cabinet cupboards for dining service, cruets, cutlery, wine, etc., sink and ice-box, which latter serves as a table-top; racks for glasses are carried over the tops of the side lights. The water for the kitchen and pantry is carried in overhead tin-lined copper cylinders suspended from the roof.

The saloons are installed with electric light, with lamps suspended from the roof and bracket lights over the dining-tables. They have also electrical communication between the saloons and attendant. The dynamo and storage cells are fixed to the under-frame between the two six-wheeled bogie trucks. The saloons are steam-heated throughout. Ventilation is obtained by means of torpedo ventilators, which can be operated by either attendant or passengers; also electrical fans in each saloon compartment.

When a meal has to be served quickly after the departure of a train from any of the London termini, the food is often cooked in platform or railway hotel kitchens, if the latter are sufficiently handy, and the work of the chef on the car is limited to dishing-up; and in many cases soup, pastry, and sweets are prepared beforehand.

The chief interest connected with any dining-car kitchen is the fact that within it can be compassed the cooking of a five-course

DINING-CAR KITCHEN
(Great Eastern Railway)

dinner for a large number of hungry passengers. While a train is travelling a mile a minute, or thereabouts, joints and poultry are roasted or boiled, chops and steaks cut off and grilled, fish boiled or fried, to say nothing of the several vegetables. Even taking into account the smoothness of running, the train necessarily jolts and oscillates at crossings, and the chef needs to keep a wary look-out for boiling water or fat spilling on to his hands. Usually there are but one cook and an assistant in each kitchen, and the utmost method and alertness are called for on their part, not only in the actual cooking, but to meet the demands of the attendants, two, or at most three, to each car, who serve meals to the passengers.

Sometimes the dining arrangements are quite out of the ordinary. Upon such an occasion as the Grand National race the London and North Western will run five special trains from Euston to Aintree and back, carrying about a thousand passengers, all of whom require two meals whilst travelling. This necessitates a catering staff of 162—50 attendants, 42 cooks, and 70 pages. On these five trains alone over 1000 lbs. each of fish and lamb and six-score chickens will be cooked, with which to serve 2000 lunches and dinners.

On a long-distance non-stopping train the serving of meals may be as leisured as in an ordinary hotel; but sometimes the space

A COSY CORNER
(Great Eastern Railway)

between two important stopping stations may be only forty-five minutes, and during that short time not only must the meal be served, but the bills made out and collected; and altogether the restaurant-car staff experiences a very strenuous three-quarters of an hour. For celerity in catering for a large number of passengers the Great Eastern probably takes the palm on its Harwich Boat Express. The journey between Liverpool Street and Parkeston Quay only occupies eighty-five minutes, and there is not sufficient time to serve a meal in two relays. Extra table accommodation is provided to seat 47 first-class and 64 second-class passengers at the same time, and 111 diners are served from the one kitchen.

The introduction of restaurant-cars has naturally affected the demand for luncheon-baskets. A meal in a car is not only cheaper, but calls for less skill; as Mr. Acworth observes, "It is not given to everyone to balance a mutton chop and potatoes gracefully on his knee, while he pours himself out a glass of claret with his hands." Nevertheless the luncheon-basket is still an everyday feature of long-distance travelling, though to a less extent than formerly; for example, on the London and South Western line 60,000 baskets once marked the annual demand, whereas nowadays 20,000 is nearer the mark. Concerning the difference in price between a car and a basket meal, it must be borne in mind that in the latter case account has to be taken of the inevitable breakages of glass and crockery, and the wastage of cutlery through carelessness and, it may be added, sometimes dishonesty.

Very much more might be said of the commissariat departments of our railways, but considerations of space call for brevity. Platform catering has been smartened up wonderfully, and the refreshment-room is no longer an example of how not to do it; lady travellers, in particular, are grateful for the provision at many large stations of cosy tea-rooms, quite separate from the hurry and scurry of the public bars. Another comparatively modern innovation is the tea-wagon, which is now a regular attendant under the carriage windows of out-going trains, enabling passengers to partake of light refreshments without the hurried dash incidental to a visit to a refreshment-room, possibly situated on another platform.

The cloak-room accommodation for the use of passengers was initiated by the station master at Bath in 1840, and in its main features the system has undergone little change, although there are modern innovations that make for convenience. Many shopkeepers, by means of duplicate cloak-room tickets, undertake to send parcels direct to a station, so that after a busy day's shopping a passenger finds the purchases all in readiness for the journey home.

The railway bookstall is a feature inseparably connected with travelling. In the early days porters were allowed to supply newspapers and other literature to travellers, and it was astonishing what strange mental pabulum a possibly illiterate man would sometimes provide for his patrons. Messrs. W. H. Smith & Son commenced to put well-equipped bookstalls on the London and North Western Railway in 1851, and within a very few years they extended to every important station in the kingdom. This firm has found various competitors, but the old Strand organisation is still in the very forefront of the railway bookstall business. At most big stations there are to be found all kinds of conveniences for travellers, flower and fruit stalls, sweetmeat, tobacco and hosiery shops, hair-dressing saloons, baths, etc. The railway shoeblack has had a long innings, but his existence is now threatened by mechanical shoe-cleaners, worked on the penny-in-the-slot principle, like the automatic delivery boxes for the sale of sweetmeats, cigarettes, matches, etc.

The leading railway companies possess hotels of their own, and most of them compare favourably in size and organisation with any hostelries in the kingdom. Originally the majority of railway hotels, at any rate outside the metropolis, were chiefly for the convenience of passengers who had to break their journey for the night; but as might be expected, the advent of long non-stop runs, restaurants, and sleeping-cars has made them less necessary, and has robbed them of much of their former business. Upon the other hand, many modern hotels have been built at popular holiday resorts, and near to golf links; indeed, in a few cases railway companies have provided not only the hotel but the golf links, too.

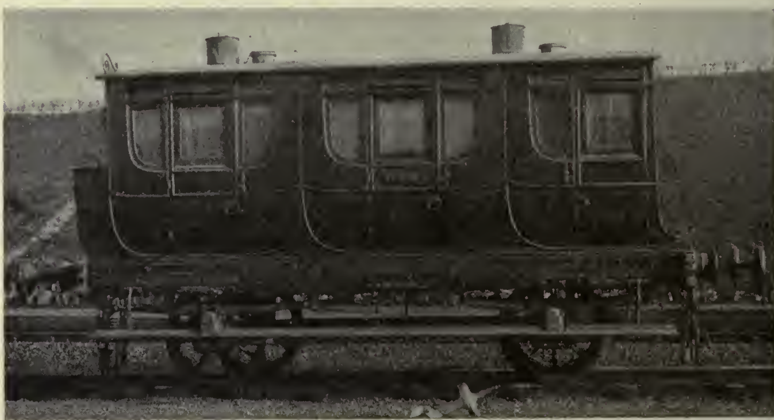
There are numerous branches of work arising directly out of the hotel, restaurant-car, and refreshment-room businesses, among which may be mentioned huge bakeries and laundries, and immense depôts for the storage of groceries, crockery, linen, and the hundred and one articles which any commissariat department has to despatch to all parts of its company's system.

Having now surveyed the rise of the modern train which in not a few respects may be compared to a hotel upon wheels, we may consider several of the more special features, such as royal trains, workmen's cheap trains, special trains, and the excursion system that has become such a marked feature of our everyday life.

When Queen Victoria came to the throne there were only three real railways in actual working, namely, Stockton and Darlington, Canterbury and Whitstable, and Liverpool and Manchester. By the time another year had elapsed the London and Birmingham Railway was opened, as were the first portions of the London and South Western and the Great Western. The Queen Dowager was an early patron of the first-named, and in 1842 went to the Isle of Wight by the London and South Western Railway. On the return journey the royal train accomplished the 78 miles between Southampton and Vauxhall in 1 hour 59 minutes. The Prince Consort frequently travelled on the Great Western between London and Windsor, but not until June 18th, 1842, did Queen Victoria give a trial to the new means of locomotion. The royal saloon, which was 21-ft. long and 9-ft. wide, was the handsomest carriage yet seen upon any line. In order to lessen the noise the wooden wheels were furnished with wooden tyres.

As a "royal" line the London and North Western has always ranked first, because of the long journeys frequently made by Queen Victoria and King Edward VII between London and Balmoral. A special saloon was provided for Queen Victoria in 1869, to which afterwards was added a companion coach, the two connected by a gangway. The floors were thickly carpeted, and to deaden the noise and vibration of the train, the sides and the roof were padded with quilted silk. One saloon was fitted as a bedroom and the other as a sitting-room. In 1899 the two saloons were united, and placed upon one frame running on two six-wheeled bogies. Railway-carriage construction having made marked progress, the London and North Western Railway had desired to build an entirely new vehicle, but Her Majesty preferred to retain the one endeared to her by many tender associations.

In 1902 Wolverton Works turned out two handsome bogie saloons for the use of King Edward and Queen Alexandra. Both the saloons are ventilated and in general dimensions are similar to the company's dining and sleeping cars. The length of the bogies is 65-ft. 6-in., greatest width 9-ft., and height from rail to top of the roof, 12-ft. 7½-in. Both saloons have a balcony or



QUEEN ADELAIDE'S SALOON (1843)
(London and Birmingham Railway)

" observation " platform at one end, which in the King's car leads intc the smoking compartment ; the latter is 10-ft. long, and is upholstered in green leather, the panelling and furniture being of mahogany with ebony bands. The day compartment, 14-ft. 7-in. long, is upholstered in a lighter shade of green, and is fitted with easy chairs, various tables, etc. Adjoining is the King's bedroom, 14-ft. long, in which are silver-plated bedstead, table, arm-chairs, and wardrobe ; this chamber is finished with white enamel, and the upholstery is a soft shade of dark green. Situated beyond is the dressing-room, 8-ft. long, similarly painted and upholstered ; while at the other end is an attendant's compartment, which contains electric heating apparatus for coffee, tea, etc.

The Queen's saloon contains the same number of rooms, but differently arranged. The day compartment is upholstered in blue,

PLATE VI.

FOG-SIGNALLING.

The duty of the fog-man is to place detonators on the line while the signal is at "danger," and to remove them when the semaphore gives "all clear." He also displays his red and green lamps, or flags, to the driver. The explosion of a detonator at once warns the engineman that the signal is against him, and he comes to a standstill pending further instructions.

with floral decorated patterns of rose, blue, and olive-green shades. The various laces and fringes are exceedingly handsome. The sleeping compartment is provided with a dressing-room. It is furnished with two beds, one for the accommodation of H.R.H. Princess Victoria. The bedsteads are silver-plated, the draperies being in soft pink. The dressing-table, wardrobe, and arm-chairs are of satinwood, inlaid with rosewood. All the rooms of the Queen's car are finished in white enamel. (Coloured Plate V.)

Both saloons are lighted by electricity; the compartments are warmed by electric heaters, while the balconies are fitted with a system of steam heating. "Torpedo" ventilators are fitted on the sides of the clerestory roof in all compartments. The window frames are of polished mahogany; the metal-work is silver-plated. The exteriors of the saloons are painted in the London and North Western Railway standard style, chocolate and white, to which a superfine finish has been given. The handles are gilded, and on the waist panels the royal arms are emblazoned.

H.M. THE KING'S SALOON
(London and North Western Railway)

All the more important companies number royal saloons among their rolling stock, other lines borrowing saloons when they are needed. The royal train on the East Coast Route is quite as palatial as the one just described. The smoke-room has walls of oak inlaid with boxwood and dark pollard oak; two arm-chairs and a settee are upholstered in reindeer leather, and the fittings are of oxidised silver. The day saloon has walls of sycamore wood, highly polished and inlaid with fine lines of pewter and light mahogany; the furniture consists of a settee, two arm-chairs, four smaller chairs, and a writing-table; the upholstering is in silk brocade. The bedroom, which, as in the case of the London and North Western royal saloon, is convertible into a dining-room by the removal of the bed, is panelled and enamelled white; the furniture is mahogany, inlaid with kingwood and covered with rose-coloured silk and damask, while the embroidered cushions are in green silk.

The Queen's saloon is fitted and furnished in exquisite taste. The furniture is chiefly satinwood. The windows are of bevelled plate-glass, fitted with blinds of green silk; the curtains are of white taffeta and are overhung with larger silk curtains. Underneath the thick carpets there is a layer of india-rubber, rendering the whole softer to the foot, while lessening noise and vibration. This desirable end is secured further by using felt packing and rubber cushions between the saloon body and the under-frame.

The lighting and heating are perfect. Electric blowers deliver warm air into the compartments to which is added warmth from electric radiators; and ventilation is secured by electric exhaustion. A steam coil gives extra warmth in cold weather. The King's

H.M. THE KING'S SALOON
(Great Eastern Railway)

saloon was constructed at Doncaster (G.N.R.), and the Queen's at York (N.E.R.), each of the partners thus having a hand in the provision of luxurious travelling for their royal patrons.

In 1864 Queen Victoria issued a letter to the railway companies, in which she expressed the hope that her subjects might be conveyed on the railways with the same care as was evinced in her own travelling. The desire reflected the greatest credit upon Her Majesty's kindness of heart, but any attempt to work ordinary trains with such superabundant caution would promptly put an end to half the passenger traffic.

When a railway company receives an intimation of a forthcoming royal journey, a special time-table is drawn up; and printed instructions are issued all along the route to station masters, drivers, guards, signalmen, platelayers, gatemen, etc., with numerous other officials whose work is less apparent to the eye. A pilot engine precedes the royal train by a quarter of an hour throughout the journey ; goods working in sidings adjoining the line is suspended ; facing-points are bolted and padlocked ; level crossings are closed and carefully guarded ; work at stations ceases some little time before the train is due ; extra platelayers patrol the line with flags by day and lamps by night ; no train is permitted to travel ahead or even to cross the line for a fixed time before the royal train passes, and no train may follow it within 15 minutes. Some of the higher officials of the line always accompany one of these special of specials ; a guard at the front of the train is so placed at a window that he can signal to another guard facing him at the other end ; and expert mechanics are always on the train. For cases of emergency the royal train carries a telegraph instrument, and by means of a portable cable for attachment to the wires by the side of the line communication may be made with any place along the railway.

The signalling arrangements are of the most elaborate character from end to end of a journey. Between London and Crewe, for example, there are over 130 signal-boxes. For the passage of an ordinary non-stop train the 100 signalmen lower 300 " line clear " signals, and exchange nearly 1500 messages by telegraph, telephone, etc. But for the working of a royal train the signalling precautions are increased very considerably. Royal persons pay railway fares ; in that respect there is no difference made between them and any private citizen who engages a special train.

Any person may have the luxury of a train to himself by application at any of the principal stations, providing he is willing to pay for it. The charges are 5s. per mile single journey, 7s. 6d. per mile double journey, plus first, second, or third class fares for each passenger. The minimum charge is £3. These trains are chiefly engaged by persons desirous of catching a vessel at a port ; by medical men visiting patients in cases of life and death ; and where huge business interests are at stake. Not infrequently their engagement is a matter of mere whim, sometimes pathetic, as, for instance, when a dying person wishes to close his eyes for the last time under his own roof-tree, instead of dying among strangers.

Passengers may obtain the exclusive use of a compartment by giving a few hours' notice at the departure station, or a day's notice at an intermediate station. In the case of a first-class compartment at least four full tickets must be taken, and for a third-class, six full tickets. For specially long journeys, as between England and Scotland, the minimum tickets are four for either class of compartment. A family carriage can be secured for four first-class and four third-class tickets, and an invalid carriage at the same rate ; for a first-class saloon, tickets must be taken equivalent to four first-class and four third-class tickets, while a third-class saloon necessitates a minimum of twelve full fares.

From special trains and special carriages we will proceed to others in sharp contrast. Roughly, the fares for the three classes of passengers normally are about 2d., 1¼d., and 1d. per mile; but when we take into account season tickets, special rates for tourists, excursionists, soldiers, sailors, etc., the actual average fares work out at considerably below these figures.

Parliament limits the fares which railway companies may charge passengers and, in the case of large working-class populations,

INVALID SALOON (G.N.R.)

who need to use a line to get to and from their work, specially low rates are imposed. This feature of railway business often amounts to a serious problem, especially in the London area, where the suburban traffic is enormous; but nowhere is it felt more acutely than by the Great Eastern in dealing with its passenger traffic between Liverpool Street and such places as Edmonton and Walthamstow. By its Act of 1864 the company is compelled to carry workmen between 5 and 7 a.m. from either of these places at 2d. for the return journey of 17½ miles and 14 miles respectively. In 1899 the Railway Commissioners fixed the fare at 3d. for journeys between 7 and 7.30 a.m., and half ordinary fares from that time until 8 o'clock.

These low fares have encouraged an immense population to settle not only in the two particular towns mentioned, but at other places served by the line, with the result that the officials have been at their wits' end to meet the demand for trains. By law there must be five trains a day, with a total mileage of less than 30 miles, whereas the Great Eastern Railway Company ran nearer thirty trains a day, with a mileage exceeding a hundred and sixty. Even then, in the rush hours, the trains were crowded intolerably, although they were as long as the platforms could accommodate and followed each other as closely as the block system would permit. In returning home, the hordes of workers cause less official anxiety, since they return by any train after 4 p.m., and on Saturdays any train after noon.

Mr. James Holden resolutely tackled the problem of the workmen's trains, which by that time were being run at a loss. He widened the bodies of the carriages so that each compartment would seat six a-side; put seventeen coaches on a train instead of fifteen; lengthened the platforms; and in his famous "Decapod" sought a type of tank engine to draw the heavier trains. In this manner seats were provided for conveying 13,000 persons over one track within 60 minutes.

Railways have entered into the social and intellectual aspects of life to an astonishing degree. Everything that is beautiful, whether in nature or art; everything that is interesting, whether old or new, the iron road makes us free of them all. By offering the cheapest of excursion facilities the companies have created traffic, fostering knowledge, inducing health, and instilling a deeper love of the Homeland that comes of better acquaintance with all her varied charms. Since the advent of railways holiday-making has become a stereotyped feature of the national life; of the making of excursions there is no end, their name is legion, their type infinitely varied. It will be of interest to note how the excursion train took its rise, together with a few outstanding features of modern special holiday traffic.

A remarkable feature of the early forties was the length of the trains upon special occasions. In July, 1840, the Nottingham Mechanics' Institute organised an excursion to an exhibition at Leicester at half fares, and in the same month the Leicester Mechanics' Institute ran a special train to Nottingham. These first excursion trains were sufficiently successful for the Midland Counties Railway Company to copy upon its own account; and in August we read of 2400 persons being conveyed from Nottingham to Leicester in one train of sixty-five carriages. The excursion idea evidently caught on, and huge trains not only brought grist to company's mills, but did much to popularise railway travelling. Numerous instances could be quoted of immense trains in different parts of the country. One in Scotland conveyed 1500 persons to see Queen Victoria when she visited Edinburgh in 1842; the train, nearly a third of a mile in length, consisted of 110 vehicles drawn by four engines in front and pushed by one behind. Possibly the largest train of this kind was a return excursion from Alderley to Manchester, made up of 112 carriages conveying quite 3000 persons.

Such an excursion nowadays would call for about 55 coaches, which would probably be made up into at least half a dozen trains. But on the early railways the length of the trains and the number of engines employed ensured all the passengers reaching their destination, which, owing to the poor signalling arrangements, and the frequency with which engines broke down, would not have been the case if the large party had been conveyed in several trains.

The handling of vast crowds of passengers with smoothness and despatch is the outcome of three-quarters of a century of experience, that has gone hand in hand with a never-ceasing improvement in rolling stock, signalling, etc. The London and South Western Railway had only opened its Nine Elms station (Waterloo was not then in existence) about a week, when the company announced the running on Derby Day of eight trains to Kingston, the nearest point on the line to Epsom. The officials were surprised to find 5000 persons assembled at Nine Elms early in the morning. The despatch of the passengers was commenced, but the out-going trains made practically no impression on the fast-growing mob, which at length broke down the doors, took possession of the station, and commandeered the compartments of a train without the preliminary of paying the fares. A force of police had to be brought to the scene, and the running of further trains was abandoned.

Nowadays the arrival of 5000 passengers at Waterloo, even if unexpected, would cause the officials no perturbation, and certainly would not call for police intervention. Even before the enlargement of the station nearly 12,000 "Boat Race" passengers have been entrained under the hour; and returning from Sandown or Kempton Park races, it is nothing unusual for a score of trains to work up the main line into the terminus within the same short time. On the Saturday afternoon of the Jubilee Review in July, 1887, no less than seventy-two specials ran to Aldershot practically without incommoding the usual heavy holiday and ordinary traffic. The despatching of train after train at intervals of every four minutes, travelling along a single line to a single station, is really one of the supreme tests of organization, with which we may compare the task of the Great Northern Railway in the "St. Leger" week, when the difficulties to be overcome partake of a very different nature.

To Doncaster excursion trains come from all parts of the country, sometimes as many as 170 on the most popular of the four days. The station itself is reserved chiefly for the trains conveying pas-

FRESH AIR FUND
Crowd of children departing from Liverpool Street Station
(Great Eastern Railway)

sengers at ordinary fares. The excursion trains are dealt with in the locomotive and goods sidings; for the workshops are closed for the week, and every goods and mineral truck is cleared out of the way. The sidings thus become huge excursion stations, where the trains draw up side by side, as many as thirty abreast in a single section. Where the incoming train comes to a stand, that is the point from which it will take its departure in the evening. Each passenger is handed a printed slip giving him the number of his train, time of its departure, how to reach it in the sidings, etc.; and on each train is a huge placard exhibiting its number. On their return journey many of the trains follow each other out at intervals of 75 seconds, but it must be remembered that they are not all travelling in the same direction, but scatter to all points of the compass.

There is no railway company in the kingdom that is not prepared to deal at any time with a great influx of passengers over and above the ordinary traffic. Bank holidays, in particular, provide rare tests of railway organisation. Upon such a day the London and South Western will despatch a thousand trains from Waterloo; but it must not be forgotten that many ordinary trains are discontinued upon special holidays. Many companies can point to notable feats in the rapid transport of what may be termed extraordinary traffic; for example, the Great Western Railway can boast that upon the same afternoon as Windsor Races no less than eleven special trains left Paddington for Windsor, carrying 4000 guests for the King's garden party.

Excursion trains at greatly reduced fares are now of such everyday occurrence and common knowledge, that for the most part they call for no details, leaving us free to consider only examples illustrative of the transport of specially large numbers of passengers, the cheapness of the fares, and the abnormal distances that are sometimes covered.

For numbers of excursionists making for one spot at one time the English Football Cup Final at the Crystal Palace is perhaps preeminent. For this popular sporting event a great number of return specials come into the London termini. In a recent year Euston headed the list with 43 excursion trains, King's Cross received 31, Paddington 25, St. Pancras 23, and Marylebone 15. The Great Eastern only ran three specials, since its particular territory contains no great football centre with the exception of Norwich. During the winter, too, an enormous number of trips are run in connection with the chief matches of the Football League, but not nearly to the same extent as for the ties in the concluding rounds of the cup competition, culminating in the great rush of football enthusiasts to the Metropolis to witness the struggle for the blue riband of the football season.

The question of long-distance excursion trains, which are, of course, "specials," leads one to inquire how far it is possible to travel in the course of a day, limiting oneself to ordinary booked trains. A gentleman recently contrived to cover 1008½ miles in 22½ hours. Leaving St. Pancras by the midnight Scotch express, he reached Leeds (195¾ miles) at 4.3 a.m., from whence he commenced his return to London seven minutes later. He arrived in the Metropolis at 8.15 a.m., and at 9.30 was on his way to Carlisle (308½ miles), which was reached at 3.50 p.m. In eight minutes he took train back by the 3.58, arriving in London at 10.25 p.m. It may be possible to improve upon this record, but it was a performance that shows how railways have annihilated space since the days of the stage-coach.

Many so-called "day" excursions considerably exceed the 24 hours, as, for example, the excursion to Killarney, which entails travelling 958 miles by rail and sea (page 64). A 36-hours' trip to France is much easier, for the geographical position of London affords particularly rapid communication with the Continent. A London and South Western excursion to Havre (sleep on board vessel both ways) for 24s. 6d. is a marvel of cheapness and rapidity. Leaving Waterloo at 10.50 p.m., the excursionist sails from Southampton at midnight, and at 8 o'clock next morning is in Havre. With fourteen hours at his disposal the visitor may proceed to Paris, and see not a few of the sights of the city before returning to the port to catch the return boat at 11 p.m. Avoiding the obvious course selected by the majority of travellers, we will select a special itinerary. A fussy little boat will convey us across the estuary of the Seine to Honfleur, where a pleasant hour may be spent before taking train to Pont l'Eveque to enjoy another brief rest. A rail journey of half an hour, and Trouville may be inspected at considerable leisure until the boat starts out for Havre, where the strenuous holiday-maker may dine comfortably and with ample time to catch the return boat to Southampton, which is reached in the early hours of the next morning, and then the train hurries Londonwards to conclude what has been aptly termed a "potted" holiday. This excursion entails travelling 158 miles between London and Southampton for the double journey, and 212 miles to Havre and back, working out at about ⅘d. per mile. From the point of cheapness alone this compares very unfavourably with some of the long-distance half-day excursions, such as London to Birmingham for 5s., or at the rate of about a farthing per mile.

No more remarkable reflection on the early attitude of railway companies towards the third-class passenger can be afforded than by the following round figures relating to the gross passenger fare receipts for 1909:

1st class	..	£3,272,800
2nd ,,	..	2,403,000
3rd ,,	..	31,658,500
Season tickets		4,616,700

In 1872 the Midland Railway announced that third-class would be carried on all trains, and, further, that third-class carriages would be furnished with cushioned seats. On January 1st, 1875, the same company abolished second-class. Since that date various companies have withdrawn the second-class, the North Western, Lancashire and Yorkshire, and North Staffordshire being the latest: and others are likely to follow suit in the near future.

Just as the early passenger carriage was modelled largely on the stage-coach, so the coach method of booking was retained. Each passenger was supplied with a ticket bearing his name, date, destination, and fare, the filling up of which, together with the counterfoil, occupied no little time. After a while the ticket did not require the passenger's name, but still called for considerable clerical work, as shown in the facsimile of an old ticket, printed on blue paper and perforated roughly at the edges. It was Thomas Edmonson who first thought of booking passengers anonymously by delivering to them cardboard tickets numbered consecutively;

OLD RAILWAY TICKET

and it was on the Manchester and Leeds Railway that the system was tried, with such success that speedily it was adopted generally.

The story of the modern railway ticket could be made a long and interesting one. Making allowance for "returns," it is safe to put down the tickets issued in a year at 1,000,000,000. Their total weight is about 1000 tons, and the cost of printing them amounts to quite £60,000. Any important company requires an enormous number of tickets, for from each of its stations one can not only book to any station on its own metals, but to a vast number of places on other systems; and the tickets of any two stations differ at least in respect of name of starting-point and the fare to destination. Some companies print their own tickets entirely; others obtain their supplies by contract with printers, who specialise in a class of work that calls for numbering with successive numerals, each series of tickets between any two places commencing at 000 and ending at 9999. The colours and patterns of tickets are of bewildering variety. Some series are called for in millions, while others are so little in demand that a new supply only calls for half a dozen, which may last a particular station for several years. To prevent fraud, on the part of the public or employés, great care is taken in the numbering and checking before being placed in stock.

The passenger's acquaintance with railway tickets is limited to a sight of the tubes within the booking office, wherein repose the tickets of each denomination, in strict consecutive order with the lowest number at the bottom. The lowest number is withdrawn by the booking clerk, pushed into a dating machine, and handed to the passenger. To check the sales at any given time and the corresponding cash for which the booking clerk is liable means a calculation, based upon the difference between the numbers at the bottom of the tubes when he went on duty. It may be remarked that the modern automatic delivery stands for sweetmeats, etc., were originally suggested by the ticket tube.

The running of one company's trains on another company's metals, or the transference of a passenger from line to line with his original ticket for a passport, is an intricate business, leading up to a vast amount of clerical work at the Railway Clearing House. Ticket nipping and punching is often viewed by passengers as a tiresome formality; much of it is done simply to show that the ticket has been used, and to prevent a dishonest passenger travelling with it a second time, if it happen to escape collection; but when more than one company is interested in the passenger, the nips and punches are for guidance in assessing each company's share of the fare which the ticket represents.

As early as 1842 it was found absolutely necessary to establish some means of checking and apportioning companies' shares in "through" traffic for both passengers and goods. The Railway Clearing House, therefore, was founded for that purpose, commencing business with a staff of half a dozen clerks. By 1861 the staff numbered 400; and now in a huge building in Seymour Street, Euston, about 3000 clerks are engaged in dealing with the complications of the enormous inter-traffic that takes place on our lines. The Coaching Department deals with the passenger traffic; the Merchandise Department concerns itself with the "through" goods, minerals, cattle, etc. A record is kept not only of the passengers who travel on more than one line with one ticket; but the particulars of the peregrinations of every vehicle on metals outside its own territory find their way to Seymour Street, as do many other items of railway work, such as lost luggage, etc.

The arranging of the details of a railway time-table is an intricate task that calls for much skill. Take, for example, the mail train presently described. It made its maiden trip on July 1st, 1885, and every night since that date it has left Euston at 8.30. The timing of long-distance trains in particular is not altered without some overwhelming reason. Making it a few minutes earlier or later would involve the alteration of numerous trains on all the branch lines along the route to Aberdeen, which in their turn would call for alterations in yet other trains.

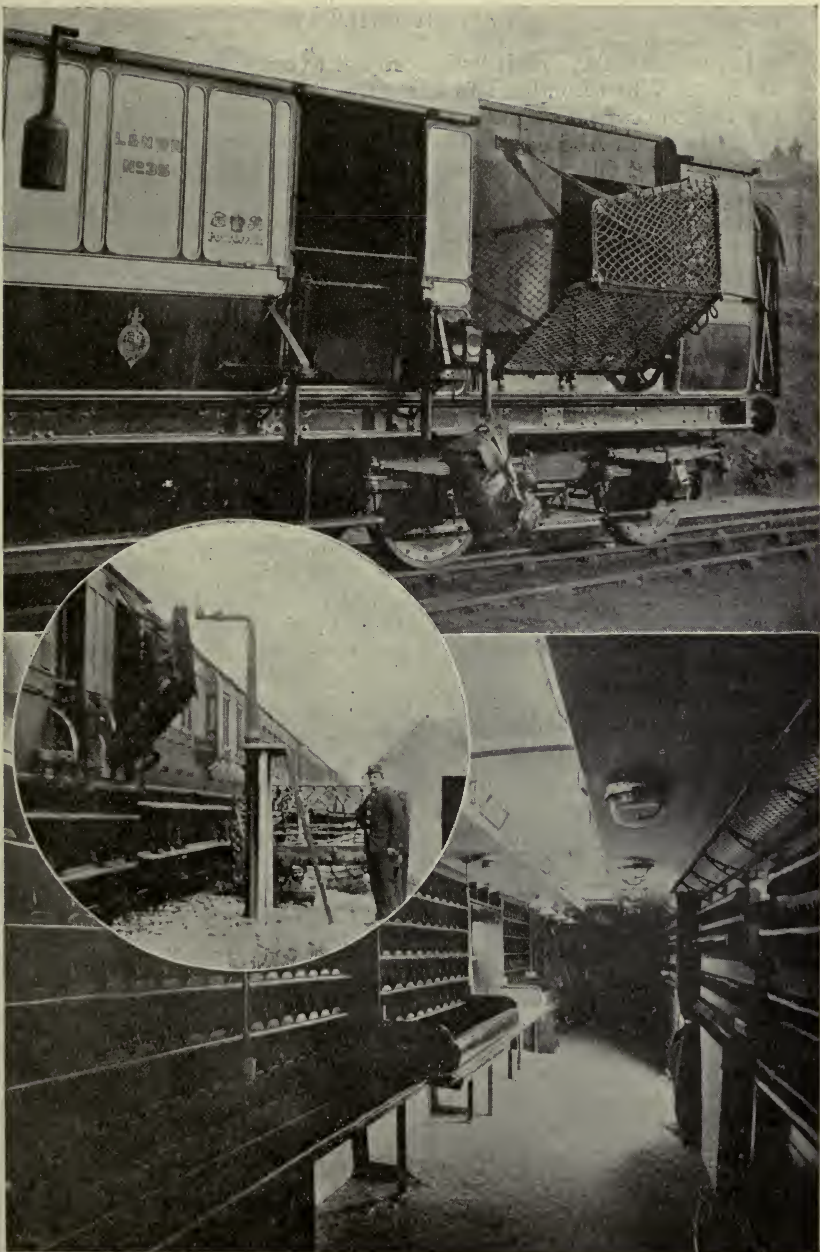
The time-table is first made out in diagrammatic form on what is called a "train board," which is divided into 1440 vertical spaces, one for each minute during the twenty-four hours. To this time scale is added a distance scale, formed by horizontal lines drawn from the stations and junctions, which are placed in the margin in strict order. The whole board thus forms a time-table in blank. The first train service of the day is then marked out, not by figures, but by sticking in pins at each stopping-place. The pins are then joined up by a piece of coloured thread. Train after train is marked out similarly until the services of the day are complete. By means of the pins are traced the courses of the trains, their situation at any given minute, and also where other trains can best be worked in. This visualised time-table is easily translated into the figured time-table which is provided for the use of passengers.

The well-known "Bradshaw's Guide" made its first appearance in December, 1841. It was then only a sixpenny pamphlet of thirty-two pages, which the time-tables proper by no means filled; it is now a bulky book of a thousand pages, but with the price unchanged.

The time-tables prepared for the use of the public are small and simple affairs compared to a time-table compiled for the use of the officials of one of our great railway lines. This forms a complex tome, in which is tabulated the running, not only of passenger trains, but also goods. Even trains of empty carriages and wagons that it is necessary to return to different parts of a system are duly entered, and not infrequently particulars are given of light engines passing to and from their work.

In 1838 an Act of Parliament was passed for the conveyance of mails by railway, and of all the trains that traverse our network of metals none exceed the postal trains in interest. Within the scope of only a few paragraphs, it will not be difficult to show that the Post Office could not perform its main functions with such marvellous regularity but for the railway facilities.

The first travelling post office was established on July 1st, 1837, on the Grand Junction Railway, between Liverpool and Birmingham, to which latter place the London bags were conveyed by road. Gradually the mail trains deposed the old stage-coaches, until on July 5th, 1847, the mail coach for Edinburgh left Newcastle-on-Tyne for the last time; but in the north of Scotland some of the road coaches survived until August 1st, 1874, upon which day the London night mails ceased to reach Thurso by road for the final portion of the journey.



EXTERIOR OF MAIL VAN

Showing catcher open and bag suspended for delivery

CATCHING THE MAIL BAG INTERIOR OF SORTING VAN

In the early days mail trains did not average more than 20 miles an hour. When London and Lancaster were first connected by rail, the mails occupied 11½ hours in transit, a little longer than is now taken to reach Aberdeen. Most of the railways are under contract with the Post Office to convey mails by any train, the guard taking charge of the bags; and an immense amount of postal business is compassed in that manner. But mail trains proper are timed, and their stopping-places fixed under statutory agreement with the Postmaster-General; even the length and weight of the trains are often specified, being important factors in the regularity and punctuality with which correspondence can be delivered. Most of the mail trains carry through passengers, but a few of the trains are for mails pure and simple.

The travelling post office *par excellence* in the kingdom, if not in the whole world, is the 8.30 p.m. from Euston on the West Coast Route to Aberdeen. The train consists solely of postal vehicles. For an hour before its departure the vans are being packed with bags, and the thirty postal officials perform their work exactly the same as if they were in an ordinary post office. The motion of the train is no bar to rapid progress, the district pigeon-holes being filled with astonishing celerity, and the letters tied up into bundles for transference to their proper mail bags which hang on pegs. On the English portion of the journey stops are made at Rugby, Tamworth, Crewe, Wigan, Preston, Carnforth, and Carlisle, where bags of letters and baskets of parcels are put out and fresh ones taken in.

But most wonderful of all, constantly along the line, while the train is at full speed, there is a shedding of bags of sorted correspondence, and a taking up of fresh bags in their place. For delivery to the sorting carriage while it is in motion, a mail bag is enclosed in a strongly strapped leather pouch, which is suspended from the arm of an iron post by the side of the track. The travelling van is fitted with an ingenious net arrangement, which is extended outside the carriage by a lever operated from within. The net sweeps the pouch into the sorting van, where it is at once opened and its contents distributed at lightning speed. Similarly, many sorted bags leave the train by a converse method. The bag hangs by a strap outside the sorting carriage about on a level with the footboard, from which it is detached by a net apparatus fixed at the side of the line. The sorters take particular care not to put letters or packets marked "fragile" into the bags, that have to endure the rough shocks incidental to delivery or discharge by means of the "catcher."

When the net is flung out in readiness to catch a pouch, an electric bell is set ringing to warn occupants of the sorting tender not to pass the opening until the pouch has been delivered, for it comes into the compartment with a crash and impact as though the train were being swept off the metals; and at some portions of the route these shocks occur with considerable frequency.

It may be wondered how the postal officials know when to put out a net or a bag while the train is travelling at high speed in pitch darkness. The man who works the net lever trusts to his knowledge of the line and his ears. As the train hurtles along there is a hollow reverberation as it passes over water-troughs, a boom in a cutting, a burr on a bank, a ring from one bridge, an echo from another. There is no portion of the route that has not a distinctive note of its own; the men on the footplate unfailingly recognise them, and so does the postal official who puts out the nets.

The travelling post offices run more than 3,000,000 miles per annum. In Great Britain there are about 300 apparatus stations, where more than 1000 pouches, containing 3000 mailbags, are exchanged every day.

The partners in the West Coast Route account for more than half the total mileage. The Down Postal 8.30 p.m. ex. Euston reaches Carlisle at 2.48 a.m.; six minutes later the Caledonian takes up the running to Aberdeen, which is reached at 7.35 a.m. The Up Limited Night Mail leaves Aberdeen at 1.10 p.m. and arrives at Euston at 3.50 a.m. Other postal trains between London and Aberdeen need not be specified, but there are various notable daily services, such as the London and Holyhead, London and Liverpool, and the American Mail on Saturdays only. On the Caledonian there are important mail trains between Glasgow and Carlisle, and Edinburgh and Carlisle. Second only to the West Coast Postal Express is the Great Western's Down Night Mail from Paddington to Penzance, which exchanges bags at Reading with the Midlands and South, connects with the London and South Western Railway travelling post office via Basingstoke, and despatches bags to South Wales via Swindon and Stroud. The Great Northern mail route is from King's Cross to York, throwing off a branch to Grimsby. York to Newcastle, and thence on to Edinburgh, is a continuation of the East Coast Route. The Great Eastern has two routes for sorting carriages to Norwich, via Ipswich or via Ely. The southern lines send sorting carriages to Southampton, Brighton, and Dover. Of cross-country postal services the two best examples are from York to Bristol, via Crewe and Shrewsbury, or via Derby, Birmingham, and Gloucester.

The cleaning of passenger vehicles is a very necessary work, for which the carriage superintendent is responsible. Exteriors are often cleaned by hand by means of brush and bucket, but there is another method employed that enables more carriages to be dealt with, while the amount of labour is greatly reduced. The carriages are drawn by a locomotive at slow speed between two rotary brushes of sufficient length, fixed perpendicularly by the side of the track at such a height as to come in contact with the body of the carriage. The brushes are rotated by a gas engine in the reverse direction to the motion of the coaches.

The interiors of compartments are regularly swept and dusted by hand, but more than that is necessary to rid the upholstery of dust. A modern vacuum-cleaning system is productive of very satisfactory results. There are various dust-extracting machines, all more or less alike in general principle. A vacuum pump is operated by an electrical or petrol-driven motor. By means of the pump a vacuum is established, and suction is directed to the broad-nozzled cleaner by way of flexible india-rubber pipes. As the nozzle is passed over the upholstery, it extracts every particle of dust, which is collected in a pan. Not only is the dust removed, but the material is renovated, and takes on quite an improved surface.

CARRIAGE CLEANING APPARATUS—REVOLVING BRUSHES
(Great Western Railway)

CHAPTER IX

GOODS TRAFFIC

THE goods departments of the railways are engaged in a work that at first glance appears terribly prosaic. Many thousands of persons take an interest in the passenger traffic, collect photographs of "crack" expresses, watch the advent of the new classes of engines, and carefully note record journeys; but usually the goods, minerals, etc., are left severely alone, although they are of vast importance, and in some directions present interesting features with which the passenger service cannot compete.

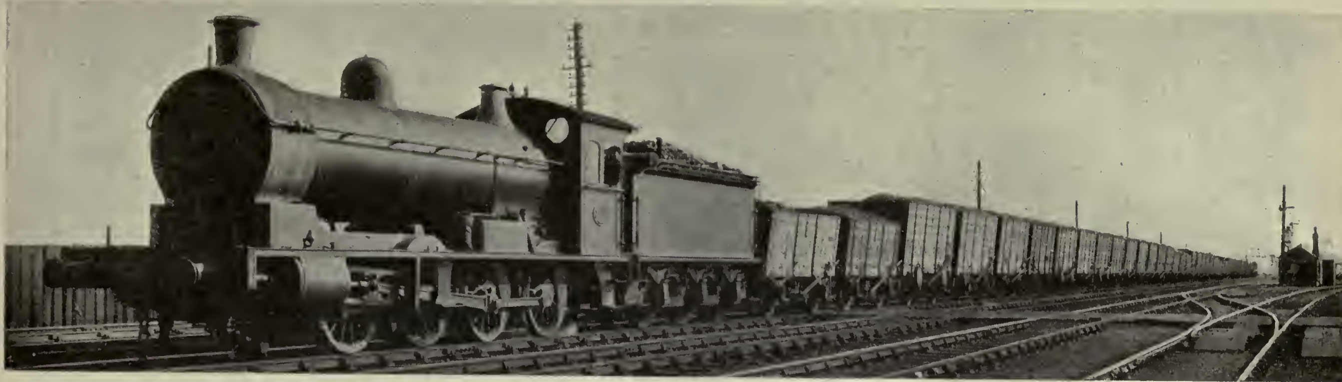
To the unthinking, "luggage" trains are unworthy of consideration only so far as they get in the way and delay passenger trains; and irate persons freely express their opinions of a management that allows such interference with the public convenience; but the consignees of the goods view prompt delivery as not second in importance to the punctuality of passenger trains; and the railway companies themselves know that a goods train is a dividend-earner, while not a few passenger trains are run at a loss. In passing, it may be remarked that it is a difficult matter for a railway company to decide accurately the actual cost of this or that operation. In the case of most commercial products profits are ascertained with comparative ease, the cost price being definitely known and the working expenses calculable almost to a nicety. A railway, on the other hand, has to be worked as a whole. The cost per train-mile of either passenger or goods traffic varies in different parts of the system, naturally being more in the metropolitan area than in the Midlands; and always to complicate matters there is the fact that much goods business is worked jointly with passenger traffic.

It was not until 1860 that the goods traffic on our railways was measured statistically in tons; until that time only the amount paid for conveyance was recorded. In that year the goods traffic amounted to over £14,000,000, or more than double the amount in 1850; but what was more, for the first time the income for goods exceeded that yielded by the passenger traffic. In succeeding decades the latter went up by leaps and bounds, but never again to catch up with the returns from the goods traffic. Upon our lines to-day there are over 766,000 railway wagons of all kinds used for the conveyance of live-stock, minerals, and general merchandise, together with about 650,000 similar vehicles owned by railway customers. Within the course of twelve months over 395 million tons of minerals and 104 million tons of general merchandise are carried, from which the receipts amount to more than £59,000,000. These figures assist one to understand why a railway man views a few minutes' delay, caused by a goods to a passenger train, with a lenient eye, whatever any particular passenger may think.

The running of a heavy goods or mineral train requires quite as much care as that of a fast express, although when it is lumbering along on a level stretch its management may appear an easy matter. With an enormous weight behind, perhaps 700 to 900 tons, steam must be given to the engine gradually, or coupling links and drawbars may be broken. Gradients require very careful consideration, or "snatching" at the commencement of an up-grade will cause couplings either to snap or to slip off the drawbar hook, and lead a portion of the train to break apart. The fireman, too, meets with his own particular difficulties. Usually the coal supplied to a goods engine is of inferior quality compared to that used for an express, while the slower speed affords him less draught for the fire. Altogether, slow and heavy pulling tests the steaming qualities of the engine, as well as the abilities of both men on the footplate.

Goods traffic comprises the conveyance of minerals, general merchandise, and live-stock. The first named, such as metal ores, coal, stone, chalk, salt, etc., present little difficulty in classification, but the term merchandise is as comprehensive and elastic as one might desire, and will cover articles as widely apart as raw cotton and ipecacuanha, palm-oil and spun silk, oxalic acid and eau-de-Cologne, steam engines and fish-hooks, shovels and jewellery. According to Parliament, consignments by rail fall under between two and three thousand headings, which the companies themselves extend into about double that number of items. The railway goods classifier is of an exceedingly ingenious turn of mind, and it is not difficult for him to place a coffin containing a human corpse, a live crocodile in a crate for the Zoo, or silkworms' eggs, of which the London and North Western Railway once conveyed 40 tons en route for Japan.

Nevertheless no inconsiderable portion of the goods traffic comes under the heading "Not classified." Where, for example, is to be placed a mummy consigned from Egypt to the British Museum. One such human antiquity once caused considerable trouble to the company to which it was entrusted for conveyance. The invoice having gone astray, the large box was opened at a London goods station, in order to learn its contents and to seek a clue as to its destination. Examination revealed what appeared to be human remains. The police were called in; the consignment was removed



LONG MINERAL TRAIN (N.E.R.)

to a mortuary to await a coroner's inquest. The evidence verified the suspicion that the " goods " was a corpse, but there was nothing to show how death had been caused, and if it were the result of crime, it certainly was not of recent date. Some time after the remains had been interred, the missing invoice was discovered, and in its wake came trouble for the railway company. The mysterious consignment turned out to be a Peruvian mummy, intended for exhibition in a Belgian museum. The " goods " had to be disinterred, and in due course the package arrived at its journey's end ; but by that time the ancient Inca was so much the worse for wear that the Belgians refused to accept delivery ; and eventually the company had to pay heavy damages for the error that had led to an inquest on a body, which had ceased to walk this sublunary sphere several thousands of years before the commencement of the Christian era.

Railway servants upon occasion, however, have discovered human bodies in goods packages, that have led to a very different penalty, namely death to the consignor, who was seeking to dispose of the gruesome proof of murder. More than once persons have elected to travel in a box or hamper for economical reasons, preferring to be assessed at a cheap rate of so much a hundredweight rather than paying ordinary third-class fare. In the pressure of business a label, " This side up," has been disregarded, with the result that the " goods " has found himself standing upon his head without any prospect of speedy relief, and has been glad to give audible evidence of his presence with corresponding proof of the attempt to defraud.

The goods traffic may be viewed as consisting of three departments, namely, parcels, goods proper, and minerals, and in this order we will consider a branch of railway work that would call for a volume, instead of a chapter, to do it the merest justice.

An immense amount of parcel traffic is worked in conjunction with the railway passenger service, goods, more or less light in weight, and that call for prompt delivery. An inspection of the guard's van on a passenger train will show the type of goods carried in addition to passengers' luggage. To see the parcels department *in excelsis* one requires to note the Christmas traffic. At that season, especially in the week immediately preceding Christmas day, the ordinary parcels are multiplied exceedingly, to which is added the exchange of gifts between vast numbers of the community, that calls for the running of many extra trains to convey the hundreds of thousands of parcels over and beyond the normal traffic. Generally, these special parcel trains carry the same headlights as passenger trains, and are given right of way by the signalmen in preference to ordinary " goods." At this same season of the year the parcels carried by the Post Office are increased enormously, calling for the duplication of parcel vans attached to the mail trains.

And all this extra parcels work has to take place amid a corresponding increase in the passenger traffic.

We may next pass to the special trains, not of a season but all the year round, particularly those concerned with our food supply, where the consignments, being perishable, call for prompt delivery.

In the course of a year the inhabitants of the United Kingdom consume over 20,000,000 cwt. of meat over and above the home supply. Beef comes mainly from America, and mutton from Australia and New Zealand. A vast amount of the American supply comes in the shape of live animals, which the mortality during transit across the ocean precludes in the case of Australia. American beef in its shorter passage across the Atlantic is "chilled" only, whereas Australasian mutton is absolutely frozen. Our present purpose will be served, if we devote attention to the American meat traffic between Birkenhead and various parts of the kingdom served by the London and North Western Railway, at the same time

MEAT TRAIN
(London and North Western Railway)

bearing in mind that other companies deal with similar traffic from the same port, while no inconsiderable portion of the American trade enters our country via Southampton.

When a cattle vessel comes alongside a landing-stage at Woodside, the beasts walk along gangways into pens ashore, from which they are conveyed to a "lairage," where they are kept from ten to fourteen days to recover their condition after the long voyage. There is no time wasted when animals are fit to kill; they pass to one of the abattoirs, which are under municipal management. At the Woodside abattoirs nearly 2000 cattle can be killed in a day, and about half as many at Wallasey. At these two places over 2500 beasts are sometimes killed daily for a period of a fortnight. At Wallasey alone there is lairage accommodation for 12,000 sheep, and often 3000 are killed in a day. The killing of a bullock is accomplished with merciful quickness. By means of hooks and chains upon wheels overhead, the carcase is hoisted up head downwards, and is skinned and dressed with astonishing celerity, after which it is divided down the middle into sides, and sometimes into quarters, which pass into the cooling chamber. In twelve hours the meat is set, when it is sewn up into canvas, marked, and transferred to the meat vans, where it is hung from the roof. It is nothing unusual for a score of "meat specials" to leave Birkenhead in a day, bound for London, Scotland, Lancashire, Yorkshire, and the Midland counties.

Refrigerator vans have an ice chamber at either end, through which a current of air passes through the van when it is in motion. Usually the vans employed do not need ice, ample ventilation being quite sufficient to keep the meat cool. Of the freshness of the meat when it reaches the market, there can be not the slightest doubt. The time occupied from when a live animal leaves the lairage for the slaughter-house, until the meat is delivered in Smithfield Market, approximately, is less than 22 hours, of which 12 are accounted for in the cooling chamber, and from $6\frac{1}{4}$ to $7\frac{1}{4}$ hours are occupied in the journey from Birkenhead to London.

In the matter of imported frozen meat, such as mutton from Australasia, there is naturally some difference in the manner it is handled by a railway company. From the icy cold holds of the steamers the meat is passed into adjacent cold storage, or packed into refrigerator railway meat vans for conveyance to cold stores, which are now found adjacent to all our great meat markets.

A very similar traffic is that which deals with our vast imports of poultry and game, especially at Christmastide. One Great Western Railway steamship alone will sometimes bring 100 tons of poultry from Waterford to Fishguard for distribution to different parts of Great Britain; Liverpool receives immense supplies from Canada, as do the eastern ports from the Continent; all of which call for the use of special vans and no delay in delivery to the hungry markets.

The fish traffic also requires special railway facilities, since the consignments are far more perishable than meat. For observation purposes we cannot do better than betake ourselves to Grimsby fish pontoon, a covered landing-stage, where the fishing-boats land their catches at 5 o'clock in the morning in readiness for sale at eight. Time was when the cod and halibut, skate and turbot, hake and plaice were caught in the North Sea within comparatively a short distance from land. Steam trawling has denuded some of the old fishing grounds, and vessels now regularly fish in the neighbourhood of the Faroe Islands and Iceland, and go even as far as the White Sea.

The modern steam trawler is practically a huge tank, in which the fish are kept alive during a voyage of perhaps a thousand miles, and thus the catches are dumped down on the Grimsby pontoon not only fresh, but absolutely alive, wriggling and quivering in heaps, or in baskets and boxes, which form the lots for the auctioneers, who effect their sales amid a perfect babel and deafening noise. The sale is over at midday, after which the boxes, baskets, and miscellaneous packages of fish are packed in the railway vans in the sidings on the opposite side of the pontoon. Between about 4.30 and 9 p.m. a dozen train-loads of fish will leave Grimsby for London, the North, the Midlands, and the West. All of the fish disposed of on the pontoon does not gravitate to the railway; some of it is purchased by Continental buyers, and is consigned abroad from Grimsby by boats, either home or foreign.

London obtains its fish chiefly from Yarmouth and Lowestoft, whose annual catch between them amounts to 80,000 tons. The Great Eastern Railway deals with the greater portion of the fish landed, and transports quite half of it to the metropolis.

The conveyance of milk to our large cities is everywhere a business of great proportions. Much of this traffic is run in connection with the ordinary passenger trains, but into London at least there are special milk trains, which in some cases discharge their

FISH TRAIN
(Great Central Railway)

loads at special milk stations, for the unloading of full or ofttimes slopping churns, and the noise of loading the empties, do not make for comfort on a passenger platform, however much one may be struck with the dexterity of the porters in twirling the churns from one point to another. At the Midland Railway milk station at St. Pancras it is nothing unusual for quite 800 churns to arrive by two trains about midday. In this case most of the milk comes from Derbyshire. On an average milk does not travel by rail more than a hundred miles, but there are many notable exceptions; for example, St. Erth, in Cornwall, is 300 miles from Paddington, yet it sends to London nearly 30,000 gallons of milk a year; but the London and North Western conveys Irish milk from Monaghan almost in the centre of the Emerald Isle. The milk traffic on the London and South Western Railway is particularly heavy. In a year quite a million 16-gallon churns are carried to London, about half the number being dealt with at Vauxhall. It has been calculated that a million churns placed four abreast would extend from Waterloo to Portsmouth. No inconsiderable portion of the milk comes from as far as Exeter, but there are also consignments from the north of France. Every day the company runs half a dozen special milk trains to London.

From the agricultural districts of the country there come to the thickly populated centres immense consignments of vegetables and fruit, varying according to the season. Early spring produce comes in vast quantities from France and the Channel Isles to the southern ports, to be made up into special trains for conveyance to London and elsewhere. In due course the Great Western trains

MILK PLATFORM, VAUXHALL
(London and South Western Railway)

are stuffed with consignments from the market gardens of the Vale of Evesham; the London and North Western picks up van loads of watercress from Berkhamsted, and by the end of July the Great Eastern may be carrying 500 tons of green peas in a single day chiefly from the district around Malden, in Essex. For special fruit traffic the Southampton strawberry districts such as Swanwick and Botley afford us capital examples. It is an ephemeral business at the best, and frequently spasmodic, to complicate matters. The weather conditions may ripen the berries with astonishing suddenness, and cause a heavy demand for fruit vans at short notice. The strawberries are packed in cross-handled chip, or wicker baskets, containing a few pounds each, and their shape and the necessity to avoid crushing demand care in packing in the vans, which have to be fitted with wirework shelves, so that the baskets may be loaded in tiers. From the strawberry districts many tons of fruit are despatched direct to jam factories; but in the height of the short season Covent Garden Market is often glutted with fruit.

During comparatively recent years the flower trade has extended enormously. The Scilly islanders in particular have built up a most prosperous industry, and from their fields of narcissus, tulips, and daffodils, etc., remarkably heavy consignments are sent by boat to Penzance. The flowers are gathered and packed in time to catch the evening mail train to London, where they arrive about 4 a.m. next morning; and an hour later at Covent Garden they are being

LOADING STRAWBERRIES AT SWANWICK
(London and South Western Railway)

distributed for sale in the metropolis, or for conveyance farther afield. The Spalding district of Lincolnshire is another important flower centre, where more than 500 acres of land are now under bulb cultivation, yielding about 1000 tons of bloom between February and June. Practically the whole of this traffic is conveyed by passenger train at low rates. For the London market about 2500 boxes arrive at King's Cross between 8.15 p.m. and 3 a.m., from whence pair-horse drays convey loads of 450 boxes in time to catch the first sale at Covent Garden at 4 a.m. Very heavy consignments of flowers, too, come from France to the southern ports.

In the early days of railways, before the electric telegraph was an overwhelming factor in the collection and dissemination of news, information of any great event was spread broadcast over the country by means of special trains travelling at the highest possible speed, and really it was from this practice that a fast train became known as an "express."

In 1848, a critical year in our history, Lord John Russell's Budget was awaited by the country with great anxiety. This memorable Parliamentary speech was delivered on the evening of February 18th, and if the provincial morning newspapers chartered expresses to bring them accounts of the speech, the trains would not reach their destinations in time to allow of publication until the morning of February 20th, and thus the news concerning the Budget was confined to the London newspapers, for which there would be an increased demand all over the country.

Our railways had yet to see their first bookstall, but the firm of Messrs. W. H. Smith & Son was in existence, and fully prepared to meet an emergency. The famous Strand newsagents undertook an early delivery of the *Times* and other London dailies, and to that end arranged with the different railway companies for a relay of trains from London to various parts. In those days the railway map of the country was very different from that of the present day. Communication between London and Scotland could only be effected by a circuitous route. As far as Rugby the train ran on the metals of the London and North Western Railway, 82½ miles in 121 minutes. Changing on to the Midland system, the train ran via Derby to Normanton, 113 miles in 126 minutes, or about 54 miles an hour. The succeeding 25 miles to York were run on the York and North Midland Railway in the very creditable space of 29 minutes. The next section of 150 miles on the York, Newcastle and Berwick Railway occupied 3 hours 26 minutes, an excellent performance considering that the railway bridges over the Tyne and the Tweed were only in course of construction. At Gateshead the newspapers were loaded into carts and taken across an ordinary bridge to Newcastle, where another train was in waiting to continue the journey; at Tweedmouth bulk was again broken, and boats requisitioned to convey the newspaper packages to another train at Berwick. At Newcastle the transference occupied 8 minutes, and at Tweedmouth 7 minutes. From Berwick to Edinburgh the train ran on the territory of the North British Railway, 58 miles in 80 minutes; and the final stretch to Glasgow on the Edinburgh and Glasgow Railway, 48 miles in 60 minutes.

The newspaper special left Euston at 5.30 a.m. and Glasgow was reached at 3.57 p.m. Deducting 50 minutes for stoppages *en route*, the 476½ miles were accomplished at the rate of 50 miles an hour. Considering the small engines then in use, the uncompleted state of some sections of the line, and the fact that the telegraph was only

TRAIN-LOAD OF STEEL LIFEBOATS FOR ALLAN LINER "VIRGINIAN" (L. & Y R.)

TRAIN OF SPECIE VANS FROM WATERLOO TO SOUTHAMPTON (L.S.W.R.)

just coming to the aid of signalling, the performance compares very favourably with the newspaper trains of to-day, which are a regular feature of early morning traffic.

There is scarcely a railway in the kingdom that does not run special goods trains at some time or other to meet the requirements of the district it serves ; and where particular need arises a company cheerfully meets it, for traffic is never refused. Rolling stock unemployed represents capital standing idle, whereas loads, whether of passengers or goods, spell profits. It would be easy to mention scores of special goods trains that one may meet up and down the kingdom—truck loads of kaolin or China clay from Cornwall on their way to the Potteries or to the coast for export to China ; trains of beer from Burton ; bicycles innumerable from Coventry ; a long string of ships' boats on their way from, say, the Seamless Steel Boat Co., at Wakefield, to a new liner at Liverpool or Glasgow ; a train of tripe and heels from the abattoirs at Birkenhead to the manufacturing towns of Lancashire ; a long procession of specie vans between Waterloo and Southampton containing silver money for shipment abroad, or gold in bars on its way from the Rand, on the metals of the London and South Western Railway.

The transport of live-stock is an important feature of everyday railway traffic. There is no little market town that does not possess its cattle siding, from which animals are conveyed from the local stock-sales to the butchers of the big towns. Sometimes one may consider that the animals are packed too tightly for comfort, and perilously approaching almost to cruelty. On the whole the traffic is carried out on thoroughly humane principles ; tight packing prevents the breaking of animals' legs from jolting, and generally the journeys are accomplished in too quick a time to entail any suffering. Where live-stock have to travel greater distances, or where delays occur, suitable arrangements are made for feeding and watering the four-footed passengers. The carriage of horses entails special care, since even a comparatively trifling injury may lead to a marked depreciation in value, and in the case of a racehorse, for example, nullify the whole journey. When dealing with the construction of the rolling stock, one of the latest types of horse-boxes was described, and calls for no further particulars. There is a heavy transportation of horses upon lines that are convenient to racecourses, of which there are five on the London and South Western system in rather close proximity to London alone. In addition to horse-boxes often attached to passenger trains, there are special horse-box trains conveying horses to the different courses, sales, etc.

It might seem that cinematographing a popular sporting event has little or no connection with the subject matter of this volume ; but railway companies will accept any traffic that comes within the scope of a reasonable business proposition. Within eight hours of Eremon passing the winning post in the Grand National race of 1907, pictorial representations of the event were being shown at three London theatres, thanks to the facilities provided by the London and North Western Railway.

In a composite car sent to Aintree overnight were tanks, trays, chemicals for developing film photographs, etc. Ample water was provided, and light excluded. Immediately the race was over the camera operators hurried to the developing car and commenced to prepare 650-ft. of films. At 4.45 the train started for London. Before Crewe was reached the films were developed, and were undergoing the fixing process. As the train rushed through Stafford, Rugby, and succeeding stations southwards, the films were revolving

TAKING CINEMATOGRAPH VIEWS OF RAILWAY SCENERY

around a big drum in order to dry them. At Willesden the drying was completed, and when at 8.58 p.m. the train reached Euston, the films were wound up into narrow rolls. The operators stepped into a waiting motor-car and raced to the film works to print pictures from the negatives, which were delivered at the theatres just 7½ hours after the race. Special trains for facilitating the exhibition of cinematograph pictures are now of common occurrence. Views of the Coronation Procession of King George and Queen Mary were shown in Paris at night, the films being developed, etc., in a special train to the coast.

Railway companies not infrequently cinematograph interesting features on a line from a moving train. The films are used for advertising and educational purposes. When thrown upon a screen the spectator is treated to a view of scenery as though he were seated in front of an engine. If the pictures are taken from the tail-end of a train it is easy to recognise the fact, for the moving scenes give the impression of the train passing all signals at danger.

In some parts of the kingdom pigeon-racing is a popular sport. Great races are organised that call for the employment of special trains to convey the birds for liberation at an agreed starting-point. Where the birds are fewer in number they are carried in the guard's van of a passenger train, and are set free at the place and time stated on the basket label. This traffic is particularly heavy on the North Eastern Railway, and Mr. W. H. Stephenson, of the Coaching Rolling Stock Department, York, has to provide for many such trains during the flying season (May to August), and few people, except those intimately acquainted with pigeon-flying, have any idea of the extent to which live pigeons are carried by the principal railway companies during those months.

On the North Eastern Railway twenty-five years ago a junior clerk or porter had occasionally to liberate pigeons from a small hand-basket, and place in the basket, before returning it, a piece of paper, showing, for the information of the owner, the time at which the birds had been liberated. A few years later the traffic had so increased that it was not an infrequent occurrence at a number of stations for a porter or other member of the staff to be engaged for half an hour on almost every Saturday or Sunday during the season in liberating pigeons conveyed in small hand-baskets, or in baskets more approximating to the present standard pigeon basket, and in inserting the necessary information on the slips. The traffic continued to increase, until it could not be regularly accommodated in the ordinary train vans, and to meet its requirements it became necessary to attach extra vans to certain trains. In 1905 the company found it advisable to run a special train practically every week-end from Newcastle to the south, solely for the conveyance of pigeons, one or more men (called convoyers) to accompany the trains, and to feed and water the pigeons *en route*. The size of these special trains has gradually increased until it is not unusual to have as many as twenty-eight vans on each train, and sometimes two special trains on one day in the height of the season.

Before the birds are sent south by the "specials" they are trained for short distances in their own particular neighbourhood, usually on the direct "south" line. As the birds get older the distance is increased until they are able to find their way home from places about 100 miles away; they are then considered fit to be despatched (along with other birds which have previously flown the longer distances) by the first "special." This usually runs from Newcastle to Selby. The following week the "special" is run to Doncaster, then on to Nottingham, the distance being increased each week until, ultimately, towns as far south as Southampton and Bournemouth are reached. At their destination the whole of the baskets are taken out of the vans by the company's servants and placed in a position selected by the convoyer; the birds are then liberated, as nearly as possible, all at the same time.

Pigeon vans are fitted with lattice shelves arranged in pairs and fixed to the sides of the vans, upon each of which a standard-sized pigeon basket can be carried. It will be seen that this arrangement increases the loading capacity of each van, and at the same time allows the free circulation of air around each basket, which is such

PIGEON VAN LOADED WITH BIRDS FOR FRANCE
(London and North Western Railway)

an essential factor in maintaining the birds in good condition throughout the journey. When not in use the shelves, which are fitted with spring arms, are turned to the sides of the vans, and project not more than 3-in., so that practically the full van space is then available for ordinary traffic.

The pigeon van illustrated is a London and North Western vehicle loaded with birds to be set free at Rennes, N.W. France.

The greater proportion of the goods traffic, however, is not concerned with specials, but with the ordinary merchandise trains, made up of all kinds of vehicles, which contain a medley assortment of commodities, raw and manufactured. The goods are collected by vans and lorries; the majority of these vehicles are the property of the railway companies, but a portion of the collection and delivery of goods is done by cartage contractors, such as Messrs. Pickford & Co.

To ascertain the work of a goods station one must go to any one of the huge establishments at the various London termini, or those that serve such cities as Manchester, Birmingham, Glasgow, and Liverpool. All through the day the collecting vans and lorries bring consignments of every description to the goods station proper, which consists of lines of rails and long platforms under cover. As fast as the packages are unloaded they are checked with the consignment notes, trundled off to weighing machines for their weight to be recorded, and are then conveyed to the decks or platforms convenient to the spot where they will be loaded later in the day.

By eight o'clock at night the platforms of a London goods station are congested with great stacks of goods, every imaginable commodity and every conceivable shape. When the work of loading the vans and trucks commences, one is persuaded that the chaotic array will never be reduced to order. Men, busy as ants, wheel the packages to the waiting vehicles; there is bustle and noise, but no confusion, since each man knows what to do—and does it. The loaders are skilled in fitting in packages of the most awkward shapes; and as each article is placed in a van it is entered upon a slip for later reference. As soon as a truck is loaded it is removed by a "traverser" on to a clear inner set of metals, and is then drawn out into the outer goods yard.

Upon a network of metals, lighted by great arc-lamps, the workers here deal not with packages but with trucks. They are shunted from one set of rails to another; turn-tables spin them round until they can be run upon any particular line; by means of capstans and ropes the loaded trucks are warped this way or that; and tank engines push them hither and thither. Most of the movements are directed by voice or a waving lantern. To the uninitiated it might seem that the shunters are engaged in a game of hide-and-seek with the trucks; they appear to scatter them all over the yard, as if their object were to separate many of them as completely as possible. But when a goods engine makes its appearance from the outer darkness, it is possible to realise that the shunters' apparent madness is nothing but the acme of method. The engine backs down upon a few trucks, perhaps a single one; there is a quick manipulation of a coupling stick, and the engine draws off with its insignificant load. Shortly it reappears upon another set of metals, and bears down upon more trucks. Backwards and forwards the engine passes, increasing its load at each operation, until behind its tender it may have a string of vehicles more than two hundred yards in length with a brake van in the rear. As far as possible the trucks are in the order in which they will be disconnected from the train at the various stopping-places. There is then a pause of perhaps only a few seconds, a semaphore drops, a gleaming red light

GOODS YARD, DEANSGATE, MANCHESTER
(Great Northern Railway)

changes to green, and the long goods train moves out on its journey.

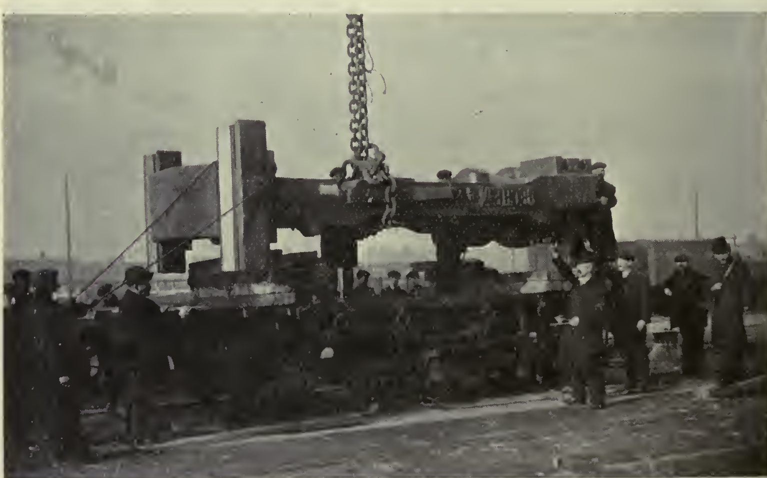
The morning scene at a goods station is just as animated. The trucks are unloaded with feverish, but methodical, speed. As each package is removed from a vehicle it is verified by means of the consignment notes, and is then wheeled off to a deck allocated to goods for a certain delivery area, or maybe it has to be consigned to the adjacent warehouse to await further orders. To the decks come the delivery vans and drays, into which the loaders stow the goods with an eye to expeditious removal when on the round. The loader knows the streets which any particular vehicle serves, and consequently takes care that the packages to be delivered first are placed in the van last; but method in this direction does not mean any slackening of speed in packing, and in a surprisingly short time after their arrival the goods are being distributed in every part of the metropolis.

At an important goods station it is usually not a difficult matter to make up full loads for through trucks; but in small and comparatively unimportant places a van has to be loaded almost regardless of the final destination of the contents. In the case of trucks containing goods for mixed destinations, it is customary to run them to a convenient centre to be "transhipped." Crewe being a London and North Western "half-way house to everywhere" is in a unique situation for such traffic. Within the tranship shed, which deals with about 25,000 packages a day, there are seven pairs of rails which accommodate eighty-two wagons for loading outwards and thirty-two incoming wagons for unloading. Upon four capacious decks the goods are sorted in practically the same manner as at a city goods station, and a glance round will show as heterogeneous a collection as one can desire. Barrels, packing-cases, bales, boxes, and baskets are there in bewildering variety; a grand piano jostles a crate of live pigs, or one containing a Shetland pony; enamelled baths and pots and pans are hedged in with chairs and overmantels; sacks of meal and oilcake are flanked by grates and ovens; cotton and woollen goods, bicycles, bundles of leather, sheets of tin, rolls of linoleum are mixed up with machinery, bags of nuts and bolts, coils of wire, perambulators, and whole heaps of articles whose coverings prevent more than a guess at their contents. A van-load of fresh meat comes for distribution among a score of towns, a load of Irish butter or Middlewich condensed milk for similar treatment. Transhipment of goods in this manner not only expedites delivery, but the better loading effects economy in the running of wagons, and reduces the mileage that they have to travel on the metals of other companies.

Not infrequently railway companies are called upon to transport consignments that are "out of gauge." If the consignment were too high to pass under bridges its conveyance would be out of the

CREWE TRANSHIP SHED
(London and North Western Railway)

question, but where width is the chief difficulty a company will undertake its transport. A short time ago the North Eastern removed a large rolling mill engine fly-wheel from the South Durham Steel and Iron Company's Works, Stockton, to West Hartlepool. As the wheel weighed approximately 35 tons, measured 20-ft. in diameter, and was in one piece, it will be at once seen that it could not be carried on one wagon either in a vertical, horizontal, or slanting position, owing to such obstructions as bridges, platforms, gate posts, etc., having to be negotiated on the way ; but would require special treatment. The difficulty was eventually overcome by loading it horizontally on two wagons running side by side on the down and up lines respectively. The load travelled without the



HEAVY "OUT-OF-GAUGE" LOAD
(North Eastern Railway)

slightest trouble or mishap to its destination, a distance of 11½ miles, passing over six junctions and round curves having 14½ chains radius and 4½-in. super-elevation of the outer rail. A speed of 15 miles per hour was attained on straight portions of the road. On arrival at West Hartlepool the operation of transhipping had to be gone through again in inverse order, and the wheel shunted into the works sidings on the 40-ton wagon.

Another bulky, heavy "out-of-gauge" casting—one of a pair weighing 38 tons—was worked by special train from Hull to Skinningrove Works on March 5th, 1911. The leading dimensions of the casting were: length 15-ft. 11-in.; width 11-ft. 6-in., this being 2-ft. 6-in. beyond the standard gauge. They were loaded to project 10-in. wide of gauge at the platform side, and 20-in. on the "six-foot" side, as shown in the photograph. The extensive overhang made it necessary for the articles to have the use of both main lines, and, consequently, they could only travel on a Sunday, when other traffic was suspended. Great care had to be exercised lest the castings should come in contact with standing work, particularly in the Yarm Tunnel, and the special train was accompanied throughout by traffic inspectors.

The advent of railways led many people to the assumption that the horse would become extinct as an important factor in traction. It is an astonishing commentary upon the opinions of the alarmists that some of our large railway companies own from five to six thousand horses, all of them carefully chosen animals. There are three types of horses employed in railway work. Parcel vans and omnibuses call for light horses; dray-horses are of a heavier class, the number to draw a vehicle depending upon the load; while for shunting operations the most powerful animals are requisitioned. Although hydraulic or electric capstans are now largely employed, the shunting horse is still a prominent feature in many shunting yards, especially in the lesser important depôts and stations. The horse is markedly intelligent, but a railway "shunt" horse becomes positively wary in the avoidance of danger from moving vehicles; but, nevertheless, there is always the liability to stumble between rails, or to trip over wires and bars, with a resulting equine casualty.

STATION OMNIBUS, KING'S CROSS
(Great Northern Railway)

A railway horse, on an average, costs £60, and, if for no other reason, his welfare receives special consideration. Railway stables are usually replete with every convenience for keeping the animals in the best of condition for work that is always of a particularly trying and arduous character. To stable a large number of horses in London close to the goods depôts, where their work lies, is no easy matter, owing to the prohibitive price of land; and thus we find many stables underground, or actually consisting of buildings several storeys high, the animals ascending or descending to and from their quarters by means of inclined ways, ridged at intervals so as to form steps, so that it is no exaggeration to say that the tired cart-horses go "upstairs to bed." The Great Northern employs 2000 horses in its metropolitan goods business alone.

The provender stores for a large number of horses calls for an immense building fitted with elaborate machinery for the cutting of hay, clover, and sainfoin, and the mixing of the chaff with oats, beans, etc. Different machines effect various processes of cutting, crushing, sifting and cleaning, as well as weighing and measuring; dust is extracted automatically, and a big magnet attracts any nails or metal substances that would form no desirable concomitants to a meal.

Even under the best of conditions horses are liable to numerous ailments, but railway horses are also very subject to sprains and strains, and other injuries incurred in their daily work; and hence a horse infirmary has to be provided for the sick members of a stud. A visit to an establishment of this kind is pathetically interesting. Here may be seen patients suffering from bronchitis or pneumonia, for which a mustard plaster is the standard cure. A liberal coating of the biting condiment is laid upon the sufferer's coat, to be washed off with warm water when it has taken effect. In cases of extremity oxygen is administered, and chloroform is often employed before the "vet" uses the lancet. Where it is necessary to sweat a horse, a steam or "Russian" bath is often an efficient aid. Railway horses are more prone to foot troubles than any ordinary complaint; the never-ceasing jar entailed by asphalted or granite-paved roads plays havoc with hoofs, which also are often perforated by French nails that fall out of packing-cases as they are loaded or unloaded. Foot troubles usually demand little more than absolute rest to remedy matters. When a horse is lame in two or more feet the patient is placed in a sling, consisting of broad leathern belts, and by means of a chain and pulley the animal is drawn up a little, to take its weight off its painful hoofs. Cold water comforts and

DRAY HORSES
(Great Central Railway)

strengthens weak legs and feet, and a batch of invalids may often be seen contentedly "paddling" in the big outdoor bath; and at a later stage they take gentle exercise in a yard that is well littered with straw, so that there is no jar to retard recovery.

A PATIENT IN A SLING IN THE HORSE INFIRMARY
(Great Eastern Railway)

Often, after detention in the infirmary, a horse is despatched to a convalescent home in the country before returning to his daily round of collecting and delivering. Generally the life of a railway horse does not exceed six or seven years, after which length of service he is still worth about £20 for engagement in less heavy work, often returning to the countryside from which he was originally drawn into railway service.

Railway companies were quick to seize upon the motor-car as an aid in transport work for both passengers and goods. Railway motor-buses are common in many parts of the country that are outside the ordinary rail services, and motor-cars are used in connection with many summer excursions. Motor-wagons are employed in the collection and delivery of goods in towns, and for the conveyance of traffic in rural districts, and thus villages and farms, seven or eight miles from a station, are brought into touch with the railway.

It is obvious that a railway company possessing an immense number of wagons and goods vehicles of various kinds must work upon some well-organized plan, or a part of the system would be short of vehicles, while another portion would have a useless surplus. Good management entails the regular employment of rolling stock to the fullest possible extent; the rapid make-up of trains of loaded vehicles; and the speedy return of an empty to the point where another load awaits it. Sidings are a necessity even where the traffic is light, their importance and extent increasing with the volume of business; but at some convenient point there must be facilities not only for the accommodation of waiting rolling stock, but also for its prompt sorting and marshalling into trains.

At Edge Hill, near Liverpool, there is a famous concentration yard to assist the working of the daily goods traffic out of Liverpool.

From the docks, quays, and neighbouring depôts there come perhaps as many as 2500 loaded wagons, no matter what trains they are to form, nor what portion of the kingdom to which they will run. All the wagons are hauled on to the reception lines at the top of a bank a mile and a half long. From thence the wagons pass by gravitation one at a time into the storage sidings, which consist of a couple of dozen of parallel lines, capable of holding as many different trains. Technically this operation is called "sorting." It ensures to each train its proper complement of trucks, but they are placed in haphazard order, which must be rectified before the commencement of the journey, or intricate shunting operations

MOTOR WAGON
(North Eastern Railway)

would be called for before any particular truck could be dropped at its destination.

The train next requires "marshalling"; that is, in a train for London, trucks for Crewe, Rugby, Northampton, Watford, and Willesden must be arranged in the order of the places named. This operation takes place in what are called the "gridirons," an arrangement of lines that will be easily understood by the following explanation.

Suppose the train to consist of forty-nine trucks. They pass into the first gridiron, which comprises seven lines, upon each of which it will be easy to run seven trucks in somewhat better order. Upon the first line will be run the trucks that are numbered 1 to 7, but still in haphazard order; the second line will receive numbers

8 to 14 and so on, until the seventh line, into which will pass numbers 43 to 49. In the next gridiron the first row of seven trucks is run on to as many different lines, and the trucks on the succeeding lines are distributed similarly as shown. It is then easy to run out the whole of the trucks in strict consecutive order, and the train will be ready for the engine to hitch on and proceed on the journey. The whole working arrangement is a masterly exhibition of organisation that effects a wonderful saving in time and labour.

Other companies have adopted more or less similar methods of concentration, sorting, and marshalling. One of the newest goods sorting yards is at Wath, between Wombwell and Doncaster on the Great Central Railway. The yard is designed on the "hump" system, the trains to be marshalled being shunted up the bank by means of powerful eight-coupled bogie tank locomotives, and then distributed by gravity to their respective sidings. The ground occupied extends over about 100 acres, and the sidings have a total length of 36 miles. In every twenty-four hours it is possible to deal with 5000 loaded and empty wagons, collected from about forty-five collieries in South Yorkshire and neighbourhood. In the illustration is shown a corner of the Great Northern marshalling sidings at New England, Peterborough, where over a dozen lines are converging to a single set of metals.

It has been said that our success as a manufacturing nation rests chiefly upon a solid foundation of coal; and certain it is that not a few of our railway companies would not know the meaning of dividends but for their share in the conveyance of nearly 250,000,000 tons of black diamonds, which our miners win every year from the bowels of the earth. Coal bulks comparatively largely in the traffic of most railway companies, if we consider only the fuel their own engines require, but when a system serves some of the great coalfields, the mineral traffic assumes huge importance. This is well exemplified in a comparison of the receipts of typical companies closely connected with important coalfields with those that have no direct connection with collieries and mines.

Railway	Passengers, Parcels, and Mails £	Goods, Minerals, and Live-stock £
London and North Western ..	6,503,000	8,621,000
Great Western	6,588,000	6,944,000
Midland	4,058,000	8,375,000
North Eastern	3,218,000	6,609,000
Hull and Barnsley	26,000	506,000
North Staffordshire	268,000	616,000
Taff Vale	235,000	656,000
Great Eastern	2,982,000	2,447,000
London, Brighton, and South Coast	2,368,000	884,000
London and South Western ..	3,343,000	1,514,000

The London and North Western and Great Western railways carry an immense amount of minerals, but no inconsiderable portion of their great line mileage is interested more in passenger traffic, which thus levels matters to a great extent. The figures of the five succeeding companies show that the mineral traffic is their very life's blood, particularly in the case of the Hull and Barnsley, where the goods and minerals receipts outweigh the passenger income by almost 20 to 1. The statistics of the Great Eastern at first cause wonder, seeing that this very self-contained system is outside the coalfield areas; but, by means of the Great Northern and Great Eastern Joint Railway, there is direct communication with Lincoln and Doncaster, giving access to the Yorks, Notts,

COAL-TIPS AT PENARTH DOCK
(Taff Vale Railway)

and Derbyshire collieries; and in any case the Great Eastern supplies the whole of East Anglia with coal practically without competition. The two purely southern lines are in excellent contrast with any of the foregoing railways; in the case of the London, Brighton, and South Coast Railway the passenger train receipts outvie the goods and minerals by nearly 3 to 1, and on the London and South Western Railway by more than 2 to 1.

The Taff Vale line affords us a capital example of the working of coal traffic in a concentrated and highly organised form. Nowhere in the world is better steam coal found than in South Wales; and the Taff Vale line serves the Rhondda, Ferndale, Aberdare, and Merthyr valleys, while at Penarth Curve it receives Great Western coal trains from Monmouthshire and other places. The railway coal trucks are loaded at the collieries. When the coal skips come up from the workings below, they are emptied on to an endless wire screen, which travels over rollers with a never-ceasing jerky motion. The slack naturally falls through the meshes which are about one inch in diameter, and boy workers, standing alongside the screen, pick out the dross and shale, leaving the good coal to travel on and fall into the wagons. Though much of the Taff Vale coal goes to different parts of the kingdom via Cardiff, a great deal more of it is exported, our best customers being foreign nations, who know the value of practically smokeless coal for naval purposes. Opinions differ concerning the wisdom of our supplying the best of fuel to foreign warships, that some day may operate against our own country, but the traffic is there, and all we have to do is to watch the facilities for handling it.

MARSHALLING SIDINGS, NEW ENGLAND, PETERBOROUGH
(Great Northern Railway)

At Penarth Dock is a network of sidings into which come the trucks loaded with coal for bunkering steam colliers. Nearly a score of hydraulic coal tips are in constant use, by means of which loading is accomplished with such astonishing expedition, that it is possible for a vessel to receive 1500 tons of coal and sail on the same tide as its arrival. By means of four tips that can work simultaneously into the holds of the vessel, no less than 2500 tons can be loaded in 2½ hours. Four of the largest of these tips are illustrated. The sidings are constructed so that full wagons gravitate towards the tips, while the empty vehicles take their way down a falling gradient in the opposite direction, thus limiting the necessity of locomotive power, except for hauling the full trains into the sidings and the empty trains out for transference to the collieries.

When a loaded truck reaches a tip it passes on to a cradle, which hydraulic rams force up at the rate of 180-ft. a minute to a height of 45-ft., and the contents are emptied into the shoot, 24 to 30 ft. long and capable of adjustment to any angle. From the time that the wagon is placed upon the cradle until it returns empty to the quay level is only 30 seconds. In sliding down and out of the shoot there is no undue breakage of coal ; but the tip is also provided with a crane and anti-breakage box, automatic in action and able to empty at any required height. All the wagons are weighed as they pass into the sidings and again weighed as they pass out, so that the exact weight of coal is easily ascertainable.

In earlier pages attention was drawn to the safety of British railway travelling, but unfortunately the railway employés are not in such good case as the passengers, and statistics show that the men engaged in some sections of the goods traffic are more liable to injury and death than any other class of servants. In a recent year 5 passenger guards were killed, or 1 in 1695, whereas 28 goods guards and brakesmen met with death on the line, or 1 in 599. Of porters 37 were killed out of over 56,000 employed, or 1 in 1524 ; but 34 shunters were killed out of about 13,000 employed, or 1 in 387, and 1 in 25 was injured sufficiently to keep them from duty longer than a fortnight, and 1 in 34 was injured less seriously. The total number of injured shunters was 908. While on the subject of accidents we may note how other classes fare. Permanent-way men are very liable to be cut down by passing trains, as shown by 76 deaths, or 1 in 804, while 150 were injured more or less seriously ; of labourers, 40 deaths give a proportion of 1 in 1495. The ranks of the drivers and firemen were each depleted by 18, 1 in 1563 and 1 in 1429 respectively ; and a large number of both classes met with injuries, 431 of the former and 676 of the latter.

Taking into fullest account that familiarity breeds contempt, it is plain that work on our railways is to be classed as a dangerous occupation, and especially so in the case of those men engaged in shunting operations. The coupling of carriages and trucks is most fruitful of accidents, and it is the goods traffic that calls for the greater proportion of the work, although as a matter of fact more deaths occur in the passenger department. At one time the shunters had to pass between the trucks to couple or uncouple them, and men were constantly killed or maimed between the buffers. The modern use of the coupling stick has rendered the work of the shunters far less dangerous, but still leaves much to be desired ; but in the case of passenger stock the use of screw couplings compel a man to go between the carriages to tighten up or release the screw.

There have been many attempts made to contrive a practicable system of automatic coupling. In America automatic couplings are in common use, but, nevertheless, there are more accidents there than in the British Isles. To make automatic coupling compulsory in the United Kingdom would mean not only a tremendous outlay, but for a very long period would interfere seriously with the general work of transportation. Our railway companies own some 766,000 wagons, to which must be added about 650,000 belonging to private owners; and to fit these vehicles with automatic couplings would cost about £14,000,000. It has been calculated that each wagon would take two days to alter it, which would entail taking out of traffic nearly a thousand wagons per day for ten years, which was the period suggested in which to allow of conversion. In a report to the Government by one of our most expert inspectors, it was laid down that the comparatively small number of accidents due to coupling and uncoupling goods wagons did not justify such a large expenditure and ensuing dislocation of traffic. Further it was insisted that if the change were desirable, it would have to be effected in less than ten years, since during a transition stage, the shunters would be more than ever liable to accidents.

LAYCOCK'S COMBINATION VERTICAL-PLANE AUTOMATIC CENTRE COUPLER

Laycock's Patent Combination Vertical-plane Automatic Centre Coupler is in use on the Great Northern, North Eastern and North British Railways as part of the equipment of the East Coast Joint Stock, and it has also been adopted by various colonial and Indian railways. The central portion of the accompanying illustration shows the actual coupling parts that are visible between the carriages or wagons, the other portions not being exposed. There is no need for a shunter to go between the carriages to perform the operation of uncoupling, although it is still necessary when coupling the brake pipes. This type of coupling combines both automatic and non-automatic features, so that during a transition period a train could be made up of converted and new vehicles as required. Tests carried out on the Great Northern Railway have proved that one man in less than a minute can convert the automatic coupling into a non-automatic one, or *vice versa.*

There are various other automatic couplers, each with more or less distinctive features, but none of them have been formally adopted in the United Kingdom.

CHAPTER X

RAILWAY MEN

The persons employed on British railways at the last return numbered 621,340. They are engaged in an immense variety of occupations, some of which at first glance might appear to have a very remote connection with railway work, if one did not realise that the ramifications of the iron-road, direct and indirect, are almost boundless. The following are the outstanding classes of employment, with the number of workers engaged:

Carmen (men 17,672, boys 6584); carriage cleaners (6880); checkers (8729); clerks (men and women 58,503, boys and girls 10,672); engine cleaners (men 16,350, boys 5098); engine drivers and motor-men (28,141); firemen (25,714); guards (goods) and brakesmen (16,786); passenger guards (8474); inspectors (9229); labourers (59,812); mechanics and artisans (men 83,593, boys 10,204); permanent-way men (67,184); policemen (2127); porters (men 51,707, boys 4695); shunters (13,158); signal fitters and telegraph wiremen (4198); signalmen (28,658); station masters (8688); ticket collectors and examiners (4163).

To these may be added capstan-men, gatekeepers, greasers, shunting-horse drivers, lampmen, messengers, number-takers, pointsmen, watchmen, yardsmen, all of whose duties are well indicated by their names; but there are others less known, such as chockers, chain-boys and slippers, loaders and sheeters, bullock-men and book-carriers in the traffic department; attached to the permanent-way are painters and glaziers, asphalters and saw-sharpeners; divers and lock attendants are only two classes of about a score attached to the canal staff; the electrical and signalling department provides over three-score different classes of employment. It must be remembered, too, that the chief railway companies have important shipping and dock interests, which will receive attention in a separate chapter. In fact, a railway touches human occupations at almost every vital point in everyday life, from the head of the estate department, who in addition to railway land and buildings has to supervise the workmen's dwellings that have had to be provided in place of those demolished to make room for railway improvements, to the rat-catcher employed at grain and food stores, etc.

The money invested in British railways up to the end of December, 1909, amounted to £1,314,406,000, yielding a gross revenue of £120,174,000, from which had to be deducted a working expenditure of £75,037,000, leaving the net receipts at £45,136,000. The earning of this sum involved conveyance of 1,265,000,000 passengers exclusive of season-ticket holders, 395,000,000 tons of minerals and 104,000,000 tons of general merchandise, in the working of which the trains travelled 419,246,000 miles, a distance sufficient to girdle the earth nearly seventeen times.

LIEUTENANT-COLONEL W. H. HYDE
(General Manager, Great Eastern Railway)

If we consider for a moment the share of any one of our great railway companies in the above figures, it is at once evident that such a huge business can only be carried on successfully by men possessed of organising abilities of the highest order; and we propose briefly to inquire into the constitution of a company and note some of the men, from the highest to the lowest, who are responsible for earning dividends for those who have invested their money in the concerns.

At the head of the administration of a railway are the Directors, usually selected on account of their business acumen, their financial interest in the company, or because the satisfactory working of the line is closely connected with the welfare of their own commercial undertakings. The full Board generally meets once a month, but there are frequent committee meetings to deal with separate branches of the work such as "Locomotive," "Ways and Works," "Docks and Steamships," "Traffic," "Finance," etc. A directorship is not a highly remunerative post, seldom exceeding £500 a year, to which is added a gold medal to hang on a watch-chain, which is a free passport over any railway in the country; but there is no other position in the commercial world so eagerly sought after, for in addition to the interest attached to any great financial undertaking, a railway directorship is one of the hallmarks of social importance.

The Locomotive Superintendent, or Chief Mechanical Engineer, as he is sometimes termed, controls all the engines of a company, and is answerable for their satisfactory working. Where a railway has locomotive works of its own he is responsible for their designing and construction; but in the case of smaller organisations, he superintends only repairs and rebuilding. Upon some railways the building of the carriages and wagons is also supervised by him; but in other cases there is an assistant superintendent for carriages and wagons.

In the locomotive department is kept a record of the performances of every engine, the mileage it has traversed being a good guide to the necessity for renewal. It is a fact that remarkably few accidents are caused by defects in engines, which testifies to the care with which they are watched. The locomotive superintendent has to supply the power for all trains, whether passenger, goods, or excursion; and in the summer season, when the traffic is increased enormously, his duties are exceedingly onerous. Where a railway possesses any considerable mileage it is impossible to supply the locomotive power from any one centre; for example, on the London and North Western, Crewe sheds, however central, could not satisfactorily supply engines for the Carlisle district, 141 miles in one direction, and Euston, 158 miles in the other. Thus district superintendents are appointed, having charge of a certain number of engines with which to supply the needs of a particular area, but, nevertheless, working under the control of the superintendent.

The Chief Engineer is responsible for the good order of the permanent-way, not only the railed track, but all bridges, tunnels, fences, and buildings of every description that border the iron road. The supervision of the signals and telegraphs is sometimes the duty of an assistant to the engineer, and not infrequently of a special official. General alterations and repairs, repainting, etc., fall within the scope of the engineer's duties; if the alterations are of an extensive character the work may be given to a contractor, but even then the company's engineer is finally responsible. British railways have been officered by many brilliant engineers, and innumerable splendid bridges, viaducts, tunnels, etc., are standing monuments to their ability. The break-down gangs, which are stationed at different centres convenient for instant call to any part of a system, are controlled by the engineer, as are the permanent-way men

PLATE VII.

The Irish Express ascending the bank between Euston and Chalk Farm.

(London & North Western Railway.)

or plate-layers, carpenters, bricklayers, blacksmiths, plumbers, painters, glaziers, signal-fitters, telegraph wiremen, and others who are attached to district workshops.

The traffic department is the concern of two principal officers, the Superintendent of the line and the Chief Goods Manager. The superintendent and his staff are responsible for the working of the passenger traffic in its entirety, and also for the goods trains while they are upon the running lines; but as soon as goods vehicles come to rest for loading or unloading, they are under the control of the goods manager and his staff. The signalmen and the guards, whether passenger or goods, belong to the line superintendent's department, but the men on the footplate are controlled by the locomotive superintendent.

The Superintendent of the line is one of the most important officers of the executive, and an enormous amount of infinitely varied business passes through his office. The periodical revisions of the time-table, the running of an extra train, and the arrangements for royalty travelling are dealt with by this official. The delay of a train for only five minutes will bring a batch of papers to the head office for consideration. Passengers' claims from the company, and conversely the company's claims against passengers, are adjusted by him. He has the appointing or dismissal of a great number of employés from station masters down to the youngest boy porter; and promotions demand the keeping of records of every employé's service. Being responsible for the prompt and orderly working of the trains, it is only natural that many suggestions for alterations at stations, or on the actual track, are first suggested by the superintendent of the line, who is constantly travelling here, there, and everywhere.

The Secretary is the official representative of a company. The law demands, for example, that the owner's name shall appear on all carts, drays, etc., and often the secretary's name will be found inscribed on railway cartage vehicles. His office does not concern itself with the working of the line, but occupies itself solely with what may be called the private side of the company's business, such as stock and dividends, etc.

Another very responsible office is that of Accountant, for not only do railway accounts involve enormous sums of money, but the necessary subdivision of receipts into passenger, goods, and minerals on the one side, and the expenditure on ways and works, locomotive power, carriage and wagons, traffic expenses, etc., on the other. Every station, passenger and goods, keeps its own accounts, which are rendered periodically to the head office, and account books at numerous points along the line are checked by travelling auditors. Elaborate returns of all kinds are called for by the directors to show the profits of any branch of the service at any given time. Rates and fares are decided in the accountancy department, which also arranges for the printing, checking, and distribution of the tickets to the various stations, to which it also supplies the stationery that is called for in enormous quantities. Finally, it is the accountant who prepares the annual balance sheet, upon the figures of which depends the declaration of the dividend.

The Stores Superintendent is at the head of an important spending department. He is not connected with the actual working of the line, but what he does not know about the requirements of a railway is not worth mentioning. The general stores comprise every imaginable article from pins, matches, and soap to office and waiting-room furniture, with hundreds of articles between that there is no space to enumerate. Every station, signal cabin, and most offices possess at least one clock; every guard, passenger or goods, carries a watch that is the property of the company. Flags, lamps, fire-buckets, tools; bedding in the sleeping saloons; cutlery, glass, and linen in the restaurant-cars; and, in fact, everything of a portable character in use on a railway comes under the heading of "stores," and a strict account is kept of where any article is in service.

Stores of materials used in the upkeep of the permanent-way are usually kept handy to the divisional workshops. Rails, chairs, fishplates, points, and crossings are all stacked according to pattern, etc.; bolts and nuts, spikes and screws are counted into bags. Locomotive and carriage and wagon works have their own special stores, as have the signalling and telegraph departments. No railway passenger can have failed to notice the old materials that lie alongside the line apparently uncared for, but, nevertheless, their whereabouts is known to the storekeeper.

The coal-bill of an important railway is a heavy item. On the Midland 34,000 tons of coal and coke are used every week. One company possesses coal-mines of its own; some contract to take the whole output of a colliery; but generally the fuel is obtained in the open market, and the stores' superintendent may be trusted to purchase to the best advantage. The coal is stacked in the open alongside the line, and records are kept of quantities added or taken away.

Stocktaking is going on somewhere or other on a line all the year round, and the outdoor work in all weathers renders the task of an official stocktaker not an enviable one. The work entails long walks alongside the line; sometimes a platelayers' trolly is employed. In the latter case it is necessary on a single line to keep a sharp look-out for trains; often the stockkeeper and his party suddenly have to dig their heels into the ballast to bring the trolly to a standstill and haul it off the rails while a train goes past, a doubly trying experience when it occurs in a tunnel.

The number of executive officers varies in different companies, for the greater the work the more subdivision among the chief officials; for example, where a railway serves important coal fields there will be a mineral manager; the working of one line may call for a signals' superintendent, whereas on another there will be no necessity for a special officer. But always an executive officer is aided by one or more capable assistants; and a railway system is almost invariably worked in separate divisions, each under a district superintendent.

The real head of the service staff is the General Manager, whose

A COAL STORAGE AT STRATFORD

(Great Eastern Railway)

salary is that of a cabinet minister or a judge. It is impossible to exaggerate the responsibility that rests upon the shoulders of this official. The engineer builds a station, lays down a siding or widens a bridge, but it is the general manager who agrees to the need of it, pledges his word to the directors that it will pay, and obtains sanction for the expenditure. The locomotive superintendent constructs engines, but the general manager decides how many are required and the type most desirable. The goods manager may fix a rate for the conveyance of a certain class of machinery, but the general manager will confirm it. The solicitor promotes or opposes Bills in Parliament, but the general manager decides the course of action to be taken. His knowledge must be encyclopædic. With it all he must be a resourceful man of the world, for he is the commander-in-chief of an army of men that may number from fifty to eighty thousand, and upon his tact depends the smooth working of the staff generally; he it is who receives deputations of the men to discuss grievances as they arise. Sir George Findlay, one of the most famous of managers, asserted that if every day possessed forty-eight hours, he would still have had insufficient time to meet the demands made upon him.

One of the chief duties of the general manager is to keep an eye on all Parliamentary railway business, not only Acts that sanction new developments, but the numerous private bills that deal with railway matters generally, the conditions of labour, and many matters affecting expenditure. Parliamentary business is so extensive and important that most of the larger companies have an office at Westminster, and here the general manager, while Parliament is in session, perhaps spends more of his time than at his recognised head-quarters at a terminus. At the Royal Courts of Justice sit the Railway Commissioners, before whom are settled disputes between rival companies as to their running powers over each other's metals, or between companies and their customers concerning rates, etc., and here the general manager's presence is often an absolute necessity.

Yet, notwithstanding these urgent calls upon his time, the general manager endeavours to pay visits of inspection to every important station and depôt on the line. Often he is accompanied by some of the directors. A Directors' Inspection Saloon, with engine attached, is used for these journeys; it has an "observation platform," and is provided with desks and writing-tables. Sometimes the general manager is accompanied only by divisional officers, in which case the engineer's inspection carriage is utilised; this is merely a coupé with engine attached.

The London and South Western chief mechanical engineer's inspection car is illustrated. The following are its chief dimensions: Cylinders 11½ in. × 18-in.; driving wheels 5-ft. 7-in. diameter; bogie wheels 2 ft. 6-in.; heating surface, 117 boiler tubes 500 sq. ft.; firebox 50 sq. ft.; grate area 11¼ sq. ft.; boiler pressure 175 lbs. per sq. in.; capacity of tanks, 1000 gallons; coal carried, 1 ton. Total weight in working order, 37 tons 8 cwts.

Notwithstanding the multitudinous calls upon his time and energy the general manager is a soldier of the King. In the event of our country being invaded by a foreign foe, the mobilisation of the home army would depend greatly upon the efficient working of trains upon our network of rails. A few years ago the Government organised the Engineer and Railway Volunteer Staff Corps, which consists chiefly of the general managers of our railways, together with various engineers and a few big railway contractors, who, in emergency, would act with the military commanders. Each member of the corps has the rank of Lieutenant-Colonel, and is entitled to wear the full uniform of his rank (see page 239).

Sometimes upon retirement from his exacting office a general manager is given a seat on the directorate, where his expert and intimate knowledge of the system is of the highest value. In a few cases men thus have risen from the lowest rungs of the service ladder to the highest position the railway world can offer.

From the executive officers of a line we now pass to some of the railway servants who come more in contact with the travelling public, and most of whom form what is known as the "uniform staff." The Station Master is a well-known official, whose duties are well denoted by his name. At a tiny country station he may be signalman, porter, and booking clerk in one; he has to attend to all trains as they come and go; he will advise a passenger concerning

INSPECTION CAR
(London and South Western Railway)

a journey or the despatch of a parcel; he will telegraph up and down the line for lost luggage; if there is an accident on the line adjacent to the station, he will take charge of affairs until the breakdown gang puts in an appearance. No matter how big the station, the station-master's duties are practically the same, except that he has a staff of officials of various grades to carry out his orders. He is the disciplinary officer of the whole station, from the booking offices to the cab stands; he has not the power of dismissal of a servant, but he can suspend for any dereliction of duty, which will entail a fine or dismissal by the superintendent of the line. In the case of large stations this official is seldom uniformed, since it would lay him open to the wasting of his time by passengers whose needs can be met by minor officials.

At a large station the deputy station master will be better known to the public, but even he is a comparative stranger compared to the station inspector. He sees that passengers are seated in order that a train may leave a platform to time ; and, acting under the instructions of the station master, he is responsible for practically the whole of the outdoor working of the station.

There are other inspectors whose duties are of the utmost importance. The rolling-stock inspector is expected to provide vehicles to meet the demands of varying traffic. In the excursion season a sudden spell of fine weather causes an extra demand for carriages ; a race meeting requires a large number of horse-boxes ; a glut of fruit calls for extra trucks—and it falls to the lot of the rolling-stock inspector to see that vehicles are in readiness, where they are required. The lamp and signal inspector's work will permit of no perfunctoriness, since a signal lamp that fails to burn, or a semaphore that works badly, requires immediate attention lest it lead to an accident.

Booking clerks and ticket examiners and collectors have been mentioned elsewhere. The former, having to deal with tickets ranging in price from a penny to £5, needs to be not only quick, but accurate in giving change. When there is a rush of excursion passengers, particularly where racing men are concerned, he has to look out for counterfeit coin, and be prepared for various dodges to confuse him into taking too little for the ticket, or giving change in excess. The ticket collector, too, has to be prepared to detect innumerable devices to defraud the company out of its proper fare.

There are various classes of railway porter, e.g. goods, parcel, lamp and carriage-washing, but the platform porter is the one whom the public best knows and appreciates. At a big station this servant practically knows no rest within his hours of duty ; his work is one continual round of moving luggage either to or from the brake vans, opening and closing carriage doors, ever at the beck and call of passengers generally, and upon the top of it all answering hosts of unnecessary questions to which, nevertheless, courteous replies are expected, and, be it said, generally received, for most porters are aware that civility costs nothing, and not infrequently is rewarded. The great majority of porters are drawn from the agricultural districts, for regular wages and fair prospects of promotion exceed the opportunities offered by farm labouring, or, in fact, any branch of employment of the unskilled labour class to which many railway porters otherwise would drift.

The guard has always been a figure rather attractive to the popular mind ; he and the driver are the only real survivors of past travelling. In the old days he was perched on the top of the fore or last carriage, garbed in a red coat which was quickly smutted and burnt by cinders from the engine. Nowadays his comfort receives far more consideration, but with a great increase in his responsibility. His duties are not confined to the blowing of a whistle or the waving of a flag in intimation to the driver that all is right behind. In addition to passengers' luggage, part of his van may be loaded to the roof with parcels, in connection with which he has a bundle of way-bills. He has to know the exact contents of the van, and see that every item is turned out at its proper station. He has also to keep a report sheet containing particulars of the vehicles forming the train, duly note any that are taken off or added, and keep a strict record of detentions. The whole of the passengers are in the care of the guard, whose attention can be called in cases of emergency by means of the communication chain. Sometimes this is used capriciously, which offence is liable to a considerable fine; occasionally a passenger breaks the rule in this respect quite innocently, as when an old woman caused a train to be brought to a standstill, only to inform the guard that she could not endure the shaking incidental to fast travelling, and requesting that the train should go at a lower speed. Human and parcel freight do not mark the limit of the guard's responsibilities, horses and dogs are often under his care; the former travelling in a box occasion little or no trouble, but a strange and possibly ferocious dog is not the most pleasant of travelling companions, even when chained up or confined in the dog-box, a cage-like corner of the van. Passenger guards rise to their position by way of experience in goods work, and from their ranks are recruited inspectors, foremen, and other better paid servants.

TRAIN EXAMINER—TESTING WHEELS
(London, Tilbury, and Southend Railway)

Something has been said of the engine-men and signalmen in the chapter dealing with the running of the trains. The former commence their career at the locomotive sheds. The latter usually commence work as porters, for when a knowledge of the telegraph is added to what they have learned of railway work in general, they are ready to proceed to a box to gain practical experience. All railway servants have to undergo a strict medical examination, but in the case of signalmen and engine-men good eyesight is a particularly necessary qualification, and anything approaching colour-blindness is an absolute bar to employment. Of all railway workers the latter are subject to the greatest strain. The passenger service calls for speed, which entails long non-stop runs making great demands on an engine-man's physical and mental powers; his engine and the signals for the time being are his whole world. Just as the captain of a ship observes an unwritten law that he must remain upon the bridge so long as the vessel can float, so the engine driver and his mate cling to the footplate even in view of a terrible accident that may entail maiming or death.

Railway annals teem with the records of devotion to duty in the face of rampant danger, not only by engine-men, but porters, guards, signalmen, and other classes in the service. Engine-men, burnt and scalded, have brought a train to a standstill to ensure the safety of the passengers behind; porters and guards have saved persons crossing the line by leaping upon the metals and holding them down while an express thundered over them. Quite recently the traffic on an important line was brought to a standstill for no apparent cause. Investigation discovered a signalman dead in his box, but his last conscious thought had been for the safety of the trains, and even in the throes of death he had set all his signals at danger.

Various incidental references have been made in previous pages to the work of the permanent-way men, a humble class of workers, who, in the course of their daily labours in all kinds of weather, are exceedingly liable to accidents. When a gang is at work it is imperative that a man be employed solely on the look-out for approaching trains, so as to give ample warning. It sometimes happens that the look-out is faulty, and no caution is given; at other times men step out of danger that threatens from one direction only to be cut down by a train coming in the opposite way. Of course there is safety in the "six-foot," but in the face of imminent rushing death the poor railway man is confused, and a false step leaves a gap in the working gang. Platelayers are not supplied with uniforms; but to the men employed as foggers are issued old overcoats, that have been returned to store from some other branch of the service.

Every great railway employs a police staff of its own, garbed more or less like the ordinary guardians of the law, but having no official connection with the police proper, and no jurisdiction outside railway premises. The department consists of a superintendent, with a staff of detectives and constables. The latter are employed at stations, goods yards, and docks, chiefly to keep order during the day, and to prevent theft by night. The work of the detectives principally consists in tracking and discovering the persons who are guilty of the constant petty pilfering from goods during transit, who, when captured, are handed over to the criminal law. On the North Eastern Railway experiments have been made with police dogs for night duty with the constables, especially when patrolling docks. Airedale terriers are the breed employed, for they are muscular and hardy, and their natural intelligence is wonderfully sharpened under training. They are taught to obey a whistle, to chase and guard any trespasser not in uniform; and these canine friends of the police are particularly adept in finding of their own accord persons hiding for the purposes of felony. While on duty the dogs are muzzled, or a prisoner might receive more punishment than his crime demands.

Although railway companies take every possible precaution for the safety of their employés, accidents are of frequent occurrence, and therefore it is not surprising to find that ambulance work finds a recognised place in the general organisation of the line. Classes are held at convenient centres, and the men attend in large numbers, and a large proportion of them gain certificates of proficiency. Upon many railways this beneficent work is stimulated

PLATELAYERS

by competitions between representative teams of ambulance men for a challenge trophy, while the St. John's Ambulance Association offers a trophy for competition among the champion teams of the various railways. It was first offered in 1897, in commemoration of Queen Victoria's Diamond Jubilee.

Thanks to the ambulance men, much pain and suffering have been saved to unfortunate persons, both employés and passengers, who have met with injuries, and not infrequently first aid has been instrumental in the saving of life. Apart altogether from work on the line, a well-qualified ambulance man is of value to the general community, for accidents happen in places other than on railways, and railway men, off or on duty, are always to the fore in the unostentatious performance of a good work.

Railway men engaged in working trains, especially long-distance ones, frequently cease their spell of duty at a long distance from home, necessitating arrangements for their suitable housing until they resume duty on the opposite journey. In most cases approved lodgings are available for the men away from home, and a company employs messengers for calling the employés in time to recommence work. In this direction no company has done better than the Great Eastern Railway has accomplished for its engine-men, who are called to take a spell of rest in London. The men on the footplate are exposed to all kinds of weather, and even when there is no rain

ENGINE-DRIVERS' MESS-ROOM AT KING'S CROSS
(Great Northern Railway)

or snow to make matters worse, in winter the upper parts of their bodies may be nearly frozen, while the lower parts are almost baked. Fully alive to the needs of a most deserving class of men Mr. James Holden, the then locomotive superintendent, established an Engine-men's Dormitory at Stratford. It was opened in November, 1890, with 20 beds; extended in July the following year by the addition of 18 beds; and in February, 1899, a further dozen beds was added. Up to the end of 1910 about 400,000 men had rested under the direct supervision of the company, sometimes 117 men in a day, and only a few yards removed from where they resume duty. The founder of this beneficent institution retired from office in December, 1907, and was succeeded by his son, Mr. S. D. Holden, who takes no less interest in the institution than did his father before him.

When a man arrives at the dormitory he can have a hot or cold bath, while the kitchen steward prepares a meal for him; the engine-man provides his own food, either bringing it with him or sending a messenger to one of the neighbouring shops. By means of hot-air gratings wet and soddened garments can be rapidly dried. By the time he has enjoyed a bath and has donned a pair of slippers, the engine-man can sit down to a meal, or betake himself to a reading and recreation room. The sleeping apartments are plain, but scrupulously clean, and clean sheets are provided for every visitor. For a rest period away from home the company allows a man 2s. 6d., for half of which amount he secures the privileges of this railwayman's hotel. If the institution required a testimonial beyond the number of men who make use of it, it would be found in the fact that, when working under great pressure, Mr. Holden dines and sleeps there as if he were a footplate man himself.

Where there are large numbers of employés mess-rooms are often provided, of which the engine drivers' mess-room at King's Cross is a capital example.

The attraction of the British railway service is its permanency, its regular wages and prospects of promotion. The baton of a field-marshal is said to be within the reach of every French soldier, and similarly there is no high post in the railway world that has not been occupied by men who started work in the humblest capacity. The employés of a railway are divided into the "salaried staff" and the "wages staff." For the latter there are provident societies, sick and dividend clubs, savings banks and insurance schemes, and various other institutions that encourage thrift and provision for old age. Various companies support an orphanage to provide for the children whose breadwinners have died in the service. Short holidays are allowed each year with wages in full, and free passes are granted to the workers and their families at these times. Upon most lines too, at any season of the year, railway workers and their relatives are permitted to travel at reduced rates, especially where the duties of the railwayman call for his residence at a distance from the nearest market town.

Apart from what the companies and their workers do for their own particular systems, there are other agencies in which all railway workers as a class are interested. Chief of these is the Railway Benevolent Institution, which is a charitable undertaking to assist the widows and orphans of all ranks on all railways. Temporary help is also given in numerous cases of distress that arise in the railway service. To become a member of this great society a railway officer has to subscribe 10s. 6d. per annum, a railway servant 8s. per annum, but the sum of 2s. per annum puts a worker in full membership of the Orphanage department. The institution attained its jubilee in 1908, by which time about £868,000 had been distributed in temporary assistance to the widows of 5614 men killed, 15,686 dying of sickness, 126,353 injured while on duty, 2833 men disabled by old age, etc., and 272 children and other dependents incapable of earning their own living; incapacitated women employés had been assisted, and annuities of from £5 to £30 each had been granted to 3305 necessitous widows and permanently disabled members; while 1923 orphan children had been maintained and educated in the orphanage at Derby and at other schools. The outside public subscribes generously to this institution, and to others of a like character, for railway travellers have a kindly feeling for the 600,000 servants of the public who, year in year out, are at their service, day and night, storm or shine.

Charitable institutions appeal to the public for funds in a variety of ways, but, in pressing dogs into service as collectors, railway orphanages adopt one method at least that appears to be their own. A railway dog, with his collecting-box strapped upon his back, is prepared to make friends with any number of passengers. He barks his thanks and rattles the contents of the box with gusto at every contribution, whether it be a tiny child's own penny or King George's sovereign, which coin His Majesty dropped into a dog's box at Euston, when leaving London for the Coronation ceremonies in Scotland.

LONDON JACK III
(London and South Western Railway)

London Jack III is one of the best-known of the London and South Western collecting dogs. In the three and a half years ending June, 1911, the canine staff collected no less than £1000 for the Railway Servants' Orphanage at Woking.

Many grades of railway employés are supplied with clothing by the companies they serve. Clerks, artisans, and mechanics at the locomotive and carriage works, labourers and platelayers are among those who do not form the uniform staff. In the case of the last-named, however, men engaged on fogging duty are supplied with thick coats. Only one company has a tailoring establishment of its own, the clothing usually being supplied by a contractor. As a rule light coats and vests are served out every other summer, heavier garments every other winter, and a pair of trousers every six months. The clothing of the higher grade officials is made of dark blue cloth, while those servants engaged in rougher duties are garbed accordingly in stouter material, corduroy, etc. The uniforms of station masters, inspectors, guards, porters, policemen, dining-car attendants, etc., though varied, are well known, and call for no particular notice, but the work of some employés necessitates special provision: men engaged in loading meat and fruit wear blue blouses; tunnel men, thick flannel suits; sailors, blue jerseys, etc.

On the London and South Western Railway the employés wear red neckties, for which each man is served with two yards of red Turkey twill per annum. This item alone calls for the use of 20,000 yards of material yearly. It is supposed that this striking neckwear was adopted because it would lend itself to use as a danger signal. An average-sized necktie, it is true, would not make a very noticeable display, but a muffler might prove of great utility in a case of sudden emergency.

For the salaried staff the larger companies have superannuation funds, to which the members generally contribute 2½ per cent on their salaries, the company subscribing an equal amount per member. Under some schemes compulsory retirement takes place at the age of 60, in other cases at 65. There are provisions for superannuation benefits to accrue at an earlier age in cases of breakdown of health. When a member dies before superannuation, his relatives receive half a year's salary, or a sum equal to twice the deceased's contributions to the fund.

In the case of a small railway company a superannuation fund is less practicable, and its officials usually join the Railway Clearing House Superannuation Fund, which allows membership to any servant in the employ of a railway company connected with the Clearing House.

Many railway companies provide capital educational facilities for their employés, usually through the Mechanics' Institutes, which are a recognised feature of many centres where there is a large population of railway workers. The Great Eastern Railway formed a Mechanics' Institute as early as 1851, the first of its kind in the East End of London. It has extensive social and recreative departments, but primarily its purpose is to supply technical instruction for young railway workers. Deserving and promising students are allowed to devote the whole of the winter months to study, enjoying full pay as though they were at work. Some of the employé-students have gained highly creditable successes, such as Whitworth Scholarships and Exhibitions, passes in the Final

Examination of the London University for the degree of Bachelor of Science (Faculty of Engineering), etc. At Stratford there are practical classes where young employés may attend without fees and without loss of pay. The Lancashire and Yorkshire Railway has a splendid institute and technical school at Horwich. The chemical and mechanical laboratories are exceptionally well equipped. The North Eastern Railway arranges for classes at various centres on its system. The subjects include all those bearing upon railway work, such as shorthand, block-signalling, magnetism and electricity, practical mathematics, mechanics, geometry, steam, and steam engine, etc. The Great Western Railway has an excellent Mechanics' Institute at Swindon, and reading and recreation rooms elsewhere. In practical education it makes rather a special feature of signalling, having schools for this subject at Paddington and other centres; most companies do something in this direction.

Reading and recreation rooms are provided in many places, but the Glasgow and South Western Railway has gone a step farther than other companies in the formation of a large model village convenient to the locomotive works at Kilmarnock. The institute possesses a hall, that also serves as a church, library, baths, recreation rooms, etc. Not a few railway companies at one time provided ordinary elementary schools for the children of their employés, but under a recent Education Act these schools have passed under the control of the local Education Authority.

Railway institutes not only usually make generous provisions for technical instruction, social intercourse and recreation for the local employés, but the buildings are generally open to the members of any of these institutions, whose service calls them away from their homes; and it is pleasant for a man to have a quiet read, or a game at draughts or bowls while exchanging notes with a fellow-worker on another part of the company's system. Rifle ranges are found at many railway centres; not infrequently a range is composed of three railway coaches placed together in a longitudinal direction, providing a length of 25 yards and room for two targets.

When railway carriages are withdrawn from service frequently they are purchased for use as huts in allotment gardens, or for dressing-rooms on cricket and football fields. At Hallatrow, on the North Somerset line of the Great Western Railway, an old carriage has been transformed into a mission church.

Up and down the country there are railway athletic clubs galore and there is no branch of sport in which some of the shining lights are not railway employés. But railway men find time to serve their King as well as attend to their duty on the iron road. One example will suffice. On April 23rd, 1903, Field-Marshal Lord Roberts, at Euston Station, unveiled a bronze memorial tablet to the memory of 91 men, members of the London and North Western Railway Company's staff who fell in battle, or died in the course of the South African War, 1899–1902.

There are many towns, such as York, Derby, Doncaster, Gateshead, Stratford, etc., that have a very distinctive railway quarter, especially in the neighbourhood of railway works, but there are also towns that owe their very existence to railways; they have grown up to meet railway needs, and have their life and being in the iron road. Of this latter class Crewe, Swindon, Wolverton, Horwich, and Eastleigh are among the best examples.

There is no more interesting industrial community in the land than Crewe, and an account of its uprising reads almost like a romance. About the year 1830 a lawyer purchased Oak Farm and 60 acres of land situate near the village of Coppenhall in Cheshire,

SIGNALLING INSTRUCTION MODEL
(London and North Western Railway)

and as opportunity offered the purchaser added another 140 acres. His friends rather doubted his sanity, until in the course of a few years the promoters of the Grand Junction Railway required a slice of Oak Farm; another line from Manchester bought a second portion of it, while a Chester line also required a share. The lawyer had proved his foresight, for upon his small estate no less than three railways joined, and his property swelled enormously in value. In 1843 the Grand Junction Railway removed its construction and repair works to this convenient junction to which the name Crewe had been given, for although it was in the parish of Coppenhall there was already a station of that title, and the fact that Crewe Hall was in the neighbourhood also had more than a little to do with the choice of name.

From a lonely district with a scattered population of about 140, the place at once assumed some little importance, for the railway company bought 50 acres of land on which to erect workmen's dwellings, in addition to 30 acres required for the works, although at the commencement only $3\frac{1}{2}$ acres were absolutely needed. In 1843 the employés numbered 160; in 1846 they had risen to 600, and the township had 2000 inhabitants. In that year came the amalgamation that was the foundation of the present-day London and North Western Railway Company, and in the succeeding three years the population doubled and had doubled again by 1859. To-day Crewe has a population of nearly 50,000, of whom one-sixth

RIFLE RANGE
(London and North Western Railway)

are men employed in the works, while many others work in various departments of the Company's service.

Thirty or more years ago a writer observed: "There is only one great town (Crewe) that has been conceived for the locomotive, wet-nursed for the locomotive, weaned for the locomotive, breeched for the locomotive, birched for the locomotive, apprenticed for the locomotive"; but the same may now be said of various railway towns. The rapid growth of Crewe necessitated the provision of schools and baths; arrangements were made with a doctor to give medical attendance at 3d. per family per week, plus a subsidy from the company, which also paid a clergyman to hold regular services for which, in due course, a church was erected. To meet the social and intellectual needs of the employés an institute was built that has risen to a high position in the matter of technical instruction, and can boast of having won more Whitworth scholarships than any other similar institution in the country. In 1860 Crewe rose to the dignity of being governed by a Local Board, and seventeen years later blossomed out as a corporate town with a mayor, aldermen, and councillors of its own.

Sir Cusack Roney, in 1868, wrote:

"At the head of the mighty establishments at Crewe . . . is one man who, if he had been in Egypt, with works not a quarter the size and not half so ably carried out, would have been at least a Bey, or more probably a Pacha; in Austria a Count of the Holy Empire; in any other country in the world, except England, with crosses and decorations, the ribbons of which would easily make a charming bonnet of existing dimensions. But, in England, the earnest, persevering, never-tiring JOHN RAMSBOTTOM is—John Ramsbottom."

Before Ramsbottom was Mr. F. Trevithick, the son of the man who had the first really practical notion of the possibilities of the locomotive engine, and at succeeding stages one has only to substitute the names of F. W. Webb, George Whale, and C. J. Bowen Cooke. No purely civic body can outvie in importance the man who, for the time being, rules such a mighty establishment as Crewe Works. In 1887 Mr. Webb was also mayor of the borough, which year synchronised with the jubilee of Queen Victoria, the jubilee of the Grand Junction Railway, and the completion of the three-thousandth engine at the works. There were prolonged rejoicings at Crewe to celebrate these events. Upon Sir Richard Moon, the Chairman of the Directors, a baronetcy was conferred among the Jubilee honours; he received the freedom of the borough from the Corporation; and the Directors of the Company presented the town with a new park. In June, 1900, the North Western completed its four-thousandth locomotive, "La France," which was sent to the Paris Exhibition. To celebrate the event the Directors granted a day's holiday, without loss of pay, to their 8000 employés at the Crewe works; and the Corporation conferred the freedom of the borough of Crewe upon Mr. F. W. Webb. The month of May, 1911, witnessed the completion of the five-thousandth engine, which was given the very appropriate name "Coronation" (page 274).

In output Crewe works overshadows any other locomotive-building establishment in the British Isles. During the year 1910 the London and North Western Railway turned out sixty eight-coupled mineral locomotives, ten 4-4-0 "Queen Mary" class, seven "George the Fifths," five 4-6-0 "Experiments," two 4-6-2 tanks, and a new type of rail motor-engine. Between

1871 and 1874 a hundred locomotives were built for the Lancashire and Yorkshire Railway at Crewe. An injunction was then obtained against the London and North Western Railway, preventing the building of locomotives for another company, it being laid down that a railway company existed for purposes of transportation, and not to act as manufacturer for other companies.

Created and dominated by the London and North Western Railway, Crewe possesses all the characteristic features of citizenship exhibited by any other borough, even if the company does supply the water and the gas, and man the fire-brigade, and until a few years ago practically managed the elementary schools. In all respects Crewe acts up to its motto, "Never behind," which was adopted when the town was incorporated; it had been suggested that "In the van" was a suitable motto, but was negatived because a railway man's conception of the van is not at the front, but in the rear.

Rapid as the development of Crewe has been, the town would have been much larger if the whole of its plant works had been concentrated there; at Wolverton carriage works in Buckinghamshire and Earleston wagon works in Lancashire, there are 4000 and 1500 employés respectively who, with their dependents, would make a very appreciable difference to Crewe's census returns.

The Great Western Railway has its chief locomotive, carriage, and wagon works at Swindon, where 13,000 hands are employed; but there are branch repairing shops at several other places. At Stafford Road works, Wolverhampton, a few engines are also built. From a mere village Swindon has developed into a corporate town of 50,000 inhabitants, very much on the same lines as Crewe. The Swindon Mechanics' Institution is a famous educational and social centre for membership of which employés pay from 4d. to 10d. per month, according to their grade, while outside town people are admitted on payments ranging from 5s. to 12s. 6d. per annum. Two social events in particular take place every year, namely, a Juvenile Fête in the park, which was the gift of the company, and the annual day excursion, the former generally in August and the latter in July. As all of the excursionists travel free, no wonder that some fourteen or fifteen thousand adults, and 10,000 children, take advantage of the trips by more than a score of special trains to various parts of the kingdom, as widely separated as London, Cornwall, South Wales, and the north. The running of the trains entails the preparation of a special time-table of sixteen pages.

Horwich, in Lancashire, in 1887, had a population of only 4000, mainly interested in cotton-spinning and brick-making. The decision of the Lancashire and Yorkshire Railway to establish its engineering works there has increased the population to 20,000, of whom about 4000 are employed in the railway works; thus making quite half of the people dependent upon the company for their livelihood. The particularly fine institute has already been mentioned, but in the township there are numerous other organisations that make for the happiness and welfare of the railway workers. One special feature at the works is a great mess-room which will seat 1200 men.

Eastleigh, in Hampshire, five miles from Southampton, is the latest addition to our purely railway towns, and already bids fair to rival some of the older railway centres. Less than twenty years ago it was a small village with little prospects of ever becoming anything else, until the London and South Western Railway settled upon it as a convenient site. In 1890 the company removed its wagon and carriage works from Nine Elms to Eastleigh, followed in due course by the transference of the locomotive works.

At Horwich the railway company did not build houses for their employés, as did the North Western at Crewe for 800 families, and the Great Western at Swindon for 300 families. Most railway companies provide houses in close proximity to the line for various employés whom it is advisable to have handy for fogging, break-down work, etc. At Eastleigh the London and South Western left the housing of their employés to local enterprise, which has by no means met the increasing demand, and consequently some of the men are not able to live nearer than five or six miles to their work. This led the company to erect a hundred houses of its own, and within a short time all the employés will be housed convenient to the works. At the institute technical instruction and other scientific classes are amply provided for, together with all those institutions dear to the railway man's heart. The dining-hall in the works provides for 600 men to take their meals, where an excellently cooked dinner of meat, two vegetables, bread, and sweets can be obtained for sixpence.

Work on our railways makes arduous demands on a large body of men, upon whose welfare depends the convenience and, to a great extent, the happiness of the public ; and it is satisfactory to learn that the railway men's own welfare receives every consideration that the exigencies of the service will permit.

Having now concluded a rapid survey of general railway practice, although numerous interesting points have had to be omitted, we proceed to consider our leading companies separately. The history and working of almost any British railway affords sufficiently good reading to form a volume in itself. The exigencies of space will permit mention of only some outstanding features in the development and practice of any particular line, and as far as possible these will be selected so as to form a fairly complete review of railway history, showing how from crude beginnings have arisen huge undertakings, that contribute in a marked degree to the comfort, wealth, and happiness of the country at large.

CHAPTER XI

LONDON AND NORTH WESTERN RAILWAY

The London and Birmingham Railway was first mooted by a body of capitalists in 1823, and in the following year Sir John Rennie conducted the surveying for such a line to run by way of Oxford. Other capitalists employed Mr. Francis Giles to survey a second route via Coventry. At one time it looked as if both schemes would be commenced, but in 1830 the rivals came to terms for one joint enterprise, and George Stephenson and his son Robert were appointed engineers. In January, in the succeeding year, the Company issued its first circular, in which were summarised the chief advantages that the new line would confer. In return for an estimated cost of a little less than two and a half million pounds sterling, there would be provided easy, cheap, and expeditious travelling; the metropolis would be able to draw provisions from new and distant sources of supply; internal and external trade would benefit; and through the port of Liverpool, London would be put into expeditious communication with Ireland. It was further estimated that the passenger traffic would ensure an income of about £330,000, while that from goods was calculated at a little more.

In July, 1832, the promoters' Bill was thrown out by Parliament, chiefly by the influence of various landowners, who desired to use the rebuff as a lever with which to enhance the value of property required in the construction of the line. A year later the Bill was passed, and Robert Stephenson became the engineer-in-chief, undertaking to complete the work in four years. It is said that the engineer had tramped over every yard of the route between London and Birmingham a score of times before the direction was definitely fixed. Upon some estates the surveyors were treated with the utmost contumely. The threats of magistrates from the Bench and denunciations of clergymen from pulpits probably caused the engineer and surveyors little perturbation, but to be warned off land at the point of pitchforks was a different matter, necessitating a survey by night and the taking of levels by the aid of dark lanterns. The opposition was not confined to the country people, for the good folk of Northampton were so strongly opposed to the railway passing through their town that Stephenson had to divert the line and take it through Kilsby tunnel, some 4 miles south of Rugby.

Railway travellers often regard tunnels as unmitigated nuisances, or at the least unavoidable evils, but in railway history they often stand as examples of grit, pluck, and the highest constructive skill of our railway engineers and contractors. Kilsby tunnel, 1 mile 666 yards long, and driven through shale at an average depth of 150-ft., appeared to present no abnormal difficulties, as

ENTRANCE TO EUSTON STATION
(London and North Western Railway)

shown in the estimate of £99,000. Work proceeded smoothly enough, until the excavators struck a quicksand, bringing in its wake an enormous quantity of water. The contractors had to be released from their engagement, the head of the firm dying from sheer worry and vexation. At one time it was doubtful whether the works would not be abandoned, but the Stephensons came to the rescue, providing powerful pumping engines that raised 1800 gallons of water per minute, night and day for eight months. Modern pumps are capable of much better work, but those employed at Kilsby were marvels for those days. At a later stage there was another great influx of water, that caused it to be advisable to complete the lining of brickwork without delay. In order to effect this, the workmen were floated into the tunnel on a large raft; but at one time the water rose steadily, threatening to crush the men against the roof, and they only escaped by a sub-assistant engineer swimming to their aid with a tow-rope between his teeth, after which the raft was drawn to the nearest working shaft. Finally the tunnel was completed at a cost of £300,000. From that day to this it has stood as firm as a rock. A few years ago the brick lining showed signs of deterioration, for the early tunnel builders had no experience to guide them concerning the most durable material to withstand the sulphurous fumes given off by steam locomotives. Relined with Staffordshire blue bricks, the structure is now in even better condition than when first completed. The tunnel is ventilated by two large shafts each 59-ft. in diameter, and ten smaller ones of 9-ft. diameter.

The 7½ miles of line between Boxmoor and Tring were opened for traffic as early as October, 1834, but not until September 17th, 1838, was the whole line available for service. The number of men employed in construction averaged 12,000. The estimate of cost was very wide of the mark, for the total outlay exceeded £5,000,000, or roughly £50,000 per mile. Similarly the estimated income proved to be equally wrong. The passenger receipts amounted to more than £500,000 in the first twelve months, while the goods traffic did not account for £100,000; indeed, it took twelve years to reach the £340,000 mentioned by the promoters. Robert Stephenson had not hesitated to say that there would be no profits if the line cost more than was estimated; yet, though the cost was doubled, the first dividend amounted to 10 per cent, and the Company's £100 shares were quoted at a premium of more than 100 per cent.

It was originally intended that Camden Town should be the London terminus, but eventually land was purchased to extend the line to Euston Square, and if Stephenson had not been overruled the rails would have been laid as far as the Strand. The grand Grecian entrance arch to Euston station, which cost £30,000, is one of the most famous railway station entrances in the whole world; but the station itself was a very insignificant structure compared to that of the present day, which is the outcome of various extensions from time to time. We learn from a contemporary writer that strict precautions were taken to prevent the first-class passengers being annoyed by contact with the second-class, who had to enter the station by a separate door. How the third-class obtained entrance to the station is not stated, but those objectionable persons in any case were few in number, and their trains were despatched at most unlikely hours, when respectable people were least likely to be incommoded by their presence.

Although from the commencement of the working of the line

Euston was the terminus, the trains neither ran into the station nor out of it under steam. Until July, 1844, they were worked for more than a mile, between Euston and Camden Town, by endless ropes, operated by stationary engines at the latter place, each with a tremendously high chimney stack. The gradients on this section varied from 1 in 62 to 1 in 306. When the train was ready to leave the platform, porters pushed it for some distance outside the station, where it was attached to the endless rope. One of the Company's earliest announcements stated that 200 men were

WAGON-BUILDING, EARLESTOWN WORKS
(London and North Western Railway)

sworn in to act as special constables for the due enforcement of order in the establishment; over 150 men acted as porters, while 30 accompanied the trains as guards or conductors. The various classes wore distinguishing costumes, and they were enjoined to display the greatest civility to passengers, while forbidden to receive gratuities. We are not told how many men were required to push a train out of the station, but we can very well imagine the staff endeavouring to move the Irish mail of to-day. The official announcement went on to say that "certain policemen are stationed at intervals along the line to act as signalmen, whose duty it is to remove obstructions, and to warn an approaching train of any obstacle to its progress. The signals made use of in the daytime are small white and red flags, and at night lanterns with lenses similarly coloured."

In 1846 the London and Birmingham, the Liverpool and Manchester, the Grand Junction, and the Manchester and Birmingham railways were amalgamated under the title of the London and North Western Railway, the Company at once taking the premier position as the largest in the kingdom, with 420 miles of line and about 250 locomotives. In due course a hundred other companies were absorbed, until at the present time the Company, with a paid-up capital of £124,874,615, claims to be the "biggest joint-stock corporation in the world."

Taking a bird's-eye view of the London and North Western Railway of to-day, we find that it is exceeded in mileage by only one other British company; but there is no system with such extensive ramifications by means of its own metals, while its running powers over other railways are positively bewildering. Roughly, its main stem extends from London in the south to Carlisle in the north, flinging out arms eastward to Cambridge, Peterborough, and Leeds, and westward to Holyhead and Swansea; and in Ireland it has a line alongside Carlingford Lough, and a small section at the mouth of the Liffey. The total length of line owned by the Company is 1737 miles, to which must be added lines partly owned, leased, or rented, or worked, making a total of 1966 miles. The rolling-stock comprises 3060 locomotives, nearly 9500 passenger vehicles, and 77,000 goods vehicles of various kinds. In the course of a year 83,000,000 passengers (exclusive of season-ticket holders) are conveyed in trains which travel about 30,000,000 miles; and 54,000,000 tons of minerals and merchandise entail goods trains running over 17,000,000 miles. These vast movements bring into the Company's coffers nearly £16,000,000 per annum, of which the goods traffic accounts for more than half. The outgoings are on the same great scale. The maintenance of ways and works absorbs 1½ million pounds, locomotive power 2½ millions, traffic expenses 3½ millions, while other charges bring the total expenditure to very nearly £10,000,000, leaving profits sufficient to pay a dividend of over 6½ per cent upon the ordinary stock. It will be seen that since the opening of the original London to Birmingham line the receipts have multiplied by twenty-five times, but the dividend has decreased by 50 per cent.

Now let us view some of the figures in a more fanciful and picturesque style. The engines and tenders placed end to end would extend a distance of about 30 miles. Including Sundays, and disregarding the enormous number of journeys made by season-ticket holders, nearly a quarter of a million passengers are carried daily. The total passengers conveyed during the year is bald in the extreme when expressed numerically, but place them four abreast, and we get a column of humanity that would extend round the coast-line of England and Wales. Assuming that the traffic was equal during all the hours of the day, weekday and Sunday, the passenger and goods receipts would amount to £25 per minute. The system is worked by 82,000 employés of all grades.

Upon different parts of the system there are various magnificent specimens of engineering. Kilsby tunnel has already been described. Under Primrose Hill, Camden Town, side by side, there are a couple of tunnels with a length of 1150 yards. The work of construction was difficult, for the London clay expanded on coming into contact with the air, and exerted tremendous pressure. At Standedge, in Yorkshire, there are three tunnels abreast, driven through the

RUNCORN BRIDGE
(London and North Western Railway)

millstone grit of the Pennine Chain; these tunnels are 3 miles 62 yards long, the longest in the kingdom except the Severn tunnel on the Great Western Railway, and the Totley tunnel on the Midland Railway. From Edge Hill there is a tunnel for two lines to Waterloo goods station 3558 yards long, and another to Wapping 2100 yards in length. In Wales, as might be expected, there are numerous tunnels, of which the longest is on the line between Bettws-y-Coed and Festiniog. It is a single-line tunnel, 2 miles 340 yards long. For the greater portion it was driven through solid slate, and though less than half a mile of its entire length required a brick lining, the work of construction, which occupied five years, was very expensive.

Of bridges, the one over the Mersey at Runcorn is a handsome structure of open lattice girders. It has three spans of 305-ft. each, with a clear height of 75-ft. above high-water mark. On each side the bridge is approached by a viaduct, about a quarter of a mile in length. The Britannia Bridge over the Menai Strait and connecting Wales with the island of Anglesey is one of the world's famous bridges. It consists of tubular girders, with two spans of 460-ft. each, and two spans of 230-ft. each, with a clear height of 104-ft. above high-water level of spring tides.

George Stephenson first surveyed the line from Chester to Holyhead in 1838, but the Act was not passed until 1844. Robert Stephenson, who was the engineer, found himself faced by the necessity of accomplishing the greatest engineering feat hitherto known. He had to take the rails across the strait, 365 yards in width, in which the tide rose 20-ft. Half a mile below, Telford had thrown a suspension bridge across the channel in 1825, but a

EXPRESS TRAIN EMERGING FROM BRITANNIA TUBULAR BRIDGE
(London and North Western Railway)

chain bridge is not sufficiently rigid for railway traffic. At the point where Stephenson desired to place the bridge there is a rock in the middle of the strait which is bare at low water, and the engineer considered that a couple of cast-iron arches of 350-ft. span would serve his purpose ; but an unexpected difficulty arose, for the Admiralty refused to allow the navigation of the strait to be blocked for a single day, and even insisted that no scaffold could be allowed while the bridge was in course of construction. As the spanning of the space by a single arch was out of the question, Robert Stephenson decided to employ iron tubes passing from pier to pier. For the Conway Bridge a similar method was to be employed, and the experience gained would serve well in the greater project.

The building of the Britannia piers proceeded without difficulty, but the fixing of the tubes was a tremendous task. These immense iron structures were built on wooden stages on the Carnarvonshire side, just clear of high-water mark. They were floated on the tide to the foot of the piers, and then lifted into position by hydraulic machinery; as the tubes rose in the grooves in the masonry they were built in underneath at every step. The maximum weight lifted exceeded 1100 tons, and upon one occasion one of the press cylinders burst, causing delay and some little damage. One of the tubes created enormous trouble, and very nearly entailed disaster. When it was being floated out to the piers, the 12-in. rope, which restrained it, fouled the capstan, so that it could not be paid out farther. Urged by the current, the floating mass tugged the capstan out of its platform bodily, knocking the workmen down and casting not a few of them into the water. The tube would have been carried out to sea had not a large number of spectators, men, women, and children, held on to the cable until the massive iron structure was brought safely against a buttress. On March 18th, 1850, a single line over the strait was opened for traffic; in the following October the bridge was completed, and the double line opened.

The permanent-way of the London and North Western Railway is second to none in the world. The general bull-head section rails are in lengths of 60-ft. and weigh 95 lbs. per yard, but some sections are laid with heavier metals up to 105 lbs. per yard; the standard chairs weigh 45 lbs. each. Water troughs are situated at no less than sixteen points scattered over the system. John Ramsbottom, who was the locomotive superintendent of the Manchester and Birmingham Railway before it was absorbed, was the inventor of water troughs, and the London and North Western was the first to adopt them, in 1860.

It is a natural transition from the permanent-way to the rolling-stock. When the London and Birmingham Railway first commenced business, it used Bury locomotives of the "Liverpool" type, but Crewe works shortly commenced to turn out its long tally of engines that topped the fifth-thousand in 1911.

An early London and North Western locomotive was the "Cornwall," which was built in November, 1847, by Mr. F. Trevithick. The battle of the gauges was at its height, and it was hoped that this engine would eclipse all others for speed. It was an eight-wheeler, with a single pair of driving wheels 8-ft. 6-in. in diameter; the two leading pairs were 3-ft. 6-in. in diameter, and the trailing pair 4-ft. It had outside cylinders, diameter 17½-in. and stroke 24-in. The engine weighed only 27 tons. The "Cornwall" was sent to the Great Exhibition in Hyde Park in 1851, and in the official catalogue it was claimed to show improved construction in the size of the wheels and the position of the boiler, which latter was slung under the driving axle. The speed capabilities of the engine were quite up to expectations, but the underhung boiler evidently was not a complete success, for in 1858 the engine was rebuilt, a new boiler being fixed in the usual position over the driving axle; and one of the front pair of wheels was dispensed with.

In 1871, and again in 1881, the "Cornwall" was rebuilt, but with no change in its main features, although modern improvements, such as the cab, sand-boxes, standard chimney, smokebox, and automatic brake, etc., were added at various times. Very few locomotives remain in active service long enough to celebrate a jubilee, and fewer still can boast of running expresses for half a century; but the historic occasion found the "Cornwall" left with the largest driving wheels in the world, and hauling the Manchester and Liverpool express trains, as it had done for a dozen years or more. No record was kept of the engine's mileage before it was rebuilt in 1858, but between that year and its withdrawal from service at the end of 1905 it ran nearly 929,000 miles, so that its total easily must have exceeded a million miles. The engine always held a good reputation for speed, and was reported to have raced down Madeley Bank at 113 miles an hour. The veteran engine now draws the chief mechanical engineer's inspection car.

In the first year of its service the "Cornwall," as the result of a collision with a coal train, was thrown across both lines, and its driver killed; and, later, it fell over an embankment, again with fatal results. The engine became viewed as an ill-fated piece of mechanism, and not a few drivers refused to mount the footplate, even for increased pay. Eventually a driver, Mr. Robert Bowden, took his courage in both hands and drove the engine for many years, becoming known as the "Grand-dad of the Nor'-West," and celebrating his own jubilee in the Company's service.

The London and North Western earned a splendid advertisement in January, 1862, during the time of the American Civil War. The British R.M.S. *Trent* had been stopped, boarded, and some of her passengers removed to the United States war sloop *Jacinto*, which led to a formal protest by the British Government. There was no telegraph cable in those days, and the arrival of steamers with despatches was awaited with frantic interest. The *Europa* arrived 5 miles off Queenstown pier at 9 p.m. on January 6th. The mails and Queen's Messenger were landed at Cork at 11.15, reached Dublin by rail at 3.30 next morning, and Kingstown at 4.5 a.m., where they were transferred to the steamer *Ulster* for transport to Holyhead, which was reached at 8.15 a.m. Here a special train had been waiting, for 48 hours. At the head of it was No. 229 "Watt," one of Ramsbottom's 7-ft. 6-in. singles, which drew out of the station at 8.28. Bangor was passed in 29 minutes; the next 59¾ miles to Chester occupied 68½ minutes, and would have been faster but for a strong wind. Crewe was reached at 10.28; the 25 miles to Stafford were wiped off in 24 minutes notwithstanding Whitmore summit. At Stafford the "Watt" was uncoupled to give place to No. 372, one of McConnell's "Big Bloomers," built at Wolverton in May, 1861. On the first section of the journey the "Watt" had

1. "CORNWALL." 2. "LADY OF THE LAKE." 3. "CHARLES DICKENS."

the advantage of water troughs, which were laid down in the winter of 1859–60. Between Stafford and Euston there were then no troughs, but the tender of No. 372 was fitted with a particularly large well between at least two of the axles, and thus the journey of 133½ miles was performed without a stop. The first 49½ miles, to where the train left the Trent Valley section, near Rugby, were run in 46 minutes. At Tring there remained 32 miles to complete the journey, and only 32 minutes, if the train were to be in to its scheduled time of 5 hours. The driver only took 6 minutes for the first 8 miles, and eventually drew into Euston with a couple of minutes to spare. The weight of the train was little more than 20 tons, and the engine in steam weighed 34¾ tons.

Mr. Ramsbottom, who succeeded Mr. F. Trevithick at Crewe, introduced the Problem Class of high-speed engines in 1860. One of the best known of these locomotives was the "Lady of the Lake." It was a six-wheeler (2 – 2 – 2); driving wheels 7-ft. 7½-in. diam.; heating surface 1000 sq. ft., and steam pressure 120 lbs. It weighed 27 tons. Mr. Ramsbottom was succeeded by Mr. F. W. Webb, who rebuilt the "Lady of the Lake" in 1876; he increased all the wheels by 1½-in., added 47 sq. ft. to the heating surface, and raised the weight of the engine by 2¼ tons.

Six years later Mr. Webb built the "Charles Dickens" (2 – 4 – 0), one of the Precedent class, an engine which was destined to make railway history. The coupled wheels were 6-ft. 9-in., steam pressure 150 lbs., and the total weight 32¾ tons. For twenty years this engine, a favourite for its name as well as its own excellence, ran the morning express from Manchester to London, returning with the 4 p.m. from Euston, thus covering 367 miles daily, in 12 hours out and home, for six days a week. The engine was worked by two sets of men, each crew taking charge on alternate days, while the other couple rested. The "Charles Dickens" was withdrawn from this express service on August 23rd, 1902, by which time it had traversed 2,000,000 miles, a feat never before performed by any locomotive. Nor was the engine withdrawn from active service, but only to be put to easier work, more suitable to its light weight.

Another well-known engine of the same class was the "Hardwicke," which sprang into world-fame in August, 1895, by making a record run from Crewe to Carlisle, accomplishing 141 miles at 67·2 miles an hour during the race to Aberdeen, as described on page 50.

When Mr. Webb decided to adopt 3-cylinder compounds largely in place of simples, he built thirty engines of the "Experiment" class (see page 43). These were followed in 1884 by the "Dreadnoughts," of which the "Marchioness of Stafford" was a capital example. After gaining a gold medal at the "Inventories" Exhibition in 1885, this engine showed its capabilities by hauling the "Limited Mail" with twenty-one coaches up Shap Fell; the feat had been performed earlier by one of the "Experiment" class, but with only thirteen coaches behind the tender. The "Teutonics" made their appearance in 1889, and for what they could do the reader is referred to the record performance of the "Ionic" (page 50). The three classes mentioned were all six-wheelers, the Experiments had driving wheels of 6-ft. 6-in., the Dreadnoughts 6-ft., and the Teutonics 6-ft. 9-in., and each class showed an increase in weight, the last-named being 45½ tons.

In 1891 appeared the "Greater Britain," a 7-ft. compound 2-4-2, with a heating surface of 1541 sq. ft. and a weight of 52 tons; in April, 1893, this engine ran 3612 miles in six consecutive days. There were ten engines in this class; one of them the "Queen Empress," which was exhibited at Chicago in 1893, where it gained a gold medal. During its stay on the other side of the Atlantic it ran 1500 miles under its own steam; and doubtless it was an object of great interest to American railroad men, who could compare it with a Webb compound (2-4-0) built by Messrs. Beyer, Peacock & Co., of Manchester, for the Pennsylvania Railroad in 1888. Whatever good qualities the "Queen Empress" possessed, the English driver could be relied upon to exhibit them. Ben Robinson enjoyed the distinction of having driven the royal train oftener than any other man; his hand was on the lever when the "Hardwicke" forged along in the famous race to the north, and he it was who nursed the "Ionic" on the record non-stop run from London to Carlisle.

In chapter III there are various references to the more notable locomotives constructed by Mr. Webb before he was succeeded by Mr. G. Whale, who promptly went in for simple bogie engines in preference to compounds. Without attempting to dogmatise on the debated systems, it may be said that the weights and speeds of trains increased until it became necessary to use a couple of compounds on many main-line expresses—a practice that certainly did not make for economy. The first locomotive of Mr. Whale's "Precursor" class ran its trial trip from Crewe to Rugby on March 27th, 1904, when it drew a train 893-ft. in length and 412 tons behind the tender. The average speed was 56·9 miles per hour, although 67 miles was the rate just south of Lichfield. On the return journey the average was 59·8 per hour, with the high speed of 75 miles when coming down Whitmore Bank, south of Betley.

Heavier trains at increased speeds soon demanded an improvement on the "Precursors," and a new "Experiment" class (4-6-0) came into being. In the trial trip between Crewe and Carlisle, including the rise to Shap summit, the average speed of No. 66 was 50 miles an hour, the highest rate reaching 78 miles.

For the suburban passenger traffic, Mr. Whale introduced the "Precursor" tanks $(\frac{4-4-2}{T})$ of which fifty were speedily in service. They had a total heating surface of 1939 sq. ft., carried

1700 gallons of water and 2½ tons of coal. The boiler pressure was 175 lbs. per sq. in. The total weight of one of these engines in working order was 74 tons 15 cwts.

On May 15th, 1911, the five-thousandth engine built at Crewe

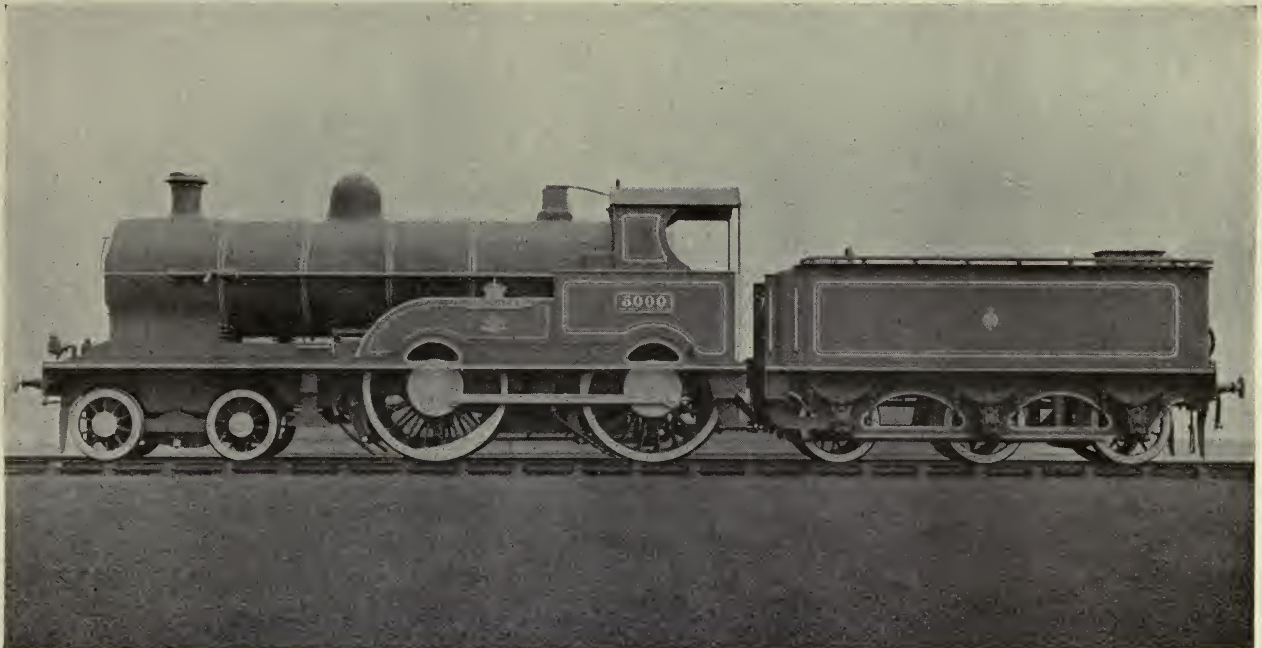
LONDON AND NORTH WESTERN LOCOMOTIVE "EMPRESS" BEING HOISTED ABOARD VESSEL FOR AMERICA

works left the shops to make its trial trips, one of which was to haul the 2 p.m. express ex-Euston to Carlisle. The photo-reproduction shows it to be generally of the "George the Fifth" type, but the coupled wheels are provided with large bosses and "half-moon" balance weights. In view of its employment on Royal trains, all working parts, including wheels and buffers, are polished bright, and it exhibits more brass-work than is usual on London and North Western Railway engines. Like all the locomotives of this railway, the new and notable addition to the stud is painted black with narrow linings of red and white. Although the official name of the new engine was "Prince of Wales" (engine No. 1676, which formerly bore that title, having been renamed "Shakespeare"), on the driving-wheel splashers was affixed a plate surmounted by a crown bearing the word "Coronation" in large raised letters, and below it the inscription, "The 5000th engine built at Crewe Locomotive Works, June, 1911." It is of interest to note that it was constructed almost entirely from material manufactured at the London and North Western Railway works under the superintendence of Mr. C. J. Bowen Cooke, the new chief mechanical engineer, the steel from which it was built being made in the railway company's own plant.

The leading dimensions are as follows: cylinders 20½-in. in diameter by 26-in. stroke; diameter of "truck" wheels 3-ft. 3-in., and of coupled driving wheels 6-ft. 9-in.; wheel-base: radial "truck" 6-ft. 3-in., centres of coupled wheels 10-ft., total 25-ft. 1½-in.; boiler: length of barrel 11-ft. 9¾in., diameter 5-ft. 2-in. outside; working pressure 175 lbs. per sq. in.; containing 168 flue tubes of 1⅞-in. external diameter, and 24 of 5-in. diameter containing the steam tubes of the Schmidt superheater; heating surface: firebox 161·75 sq. ft., tubes (1⅞-in.) 1004·96 sq. ft. (5-in.), 380·44 sq. ft., and superheated steam tubes 302·5 sq. ft., total 1849·65 sq. ft.; grate area 22·4 sq. ft.; total weight of engine in working order 59 tons 17 cwt., of which 38 tons rest on the coupled wheels. The tender is fitted with water pick-up apparatus, and, with 3000 gallons of water and 7 tons of coal, weighs 39 tons 5 cwt. The total wheel-base of engine and tender is 47-ft. 2¾-in., and the length over buffers is 56-ft. 7½-in.

For express goods traffic six-coupled engines with a leading bogie have been found to give excellent results. In appearance they much resemble the "Experiment" class, but the coupled wheels are only 5-ft. 2½-in. diameter, the heating surface 1984 sq. ft., water capacity 3000 gallons, coal capacity 5 tons. Total weight of engine and tender, in working order, 100 tons. Ponderous engines that are now so common cause one to remember that only as far back as the eighties permanent-way engineers on the London and North Western objected to engines of 45 tons weight, whereas main-line metals now support locomotives of more than double that weight.

To deal with the train services of the London and North Western Railway with the space at our disposal is an impossibility. The Royal Mail Route, as it is called, provides the shortest routes between London and many important towns in the kingdom. To Birmingham, 113 miles, in 2 hours; Liverpool (Edge Hill), 193½ miles, in 3 hours 28 minutes; Manchester, 184 miles, in 3 hours



CORONATION ENGINE

The 5000th locomotive built at Crewe Works (London and North Western Railway)

20 minutes; Carlisle, 299 miles, in 5 hours 50 minutes; Chester, 179 miles, 3 hours 40 minutes; Holyhead, 264 miles, in 5 hours 15 minutes; Dublin (North Wall), 334 miles, in 9 hours 15 minutes; Greenore, 343 miles, in 10 hours 30 minutes; and Belfast, via Fleetwood, 370 miles in 12 hours 15 minutes. In all cases the quickest trains are given.

Widespread and important as is the area marked by the above-mentioned towns, and hundreds of points between them, it by no means exhausts the Company's activities. Thanks to its extensive running powers, Glasgow can be reached from London, 401 miles in 8 hours 15 minutes; Edinburgh, 400 miles, in the same time; Perth, 450 miles, in 9 hours 30 minutes; Aberdeen, 540 miles, in 11 hours 28 minutes; and Inverness, 568 miles, in 13 hours 30 minutes. By means of its branches it is easy to get from the main line to places as far apart as Swansea and Leeds; Staffordshire and Lancashire are veritable London and North Western Railway strongholds; at Leeds it taps nearly the whole of Yorkshire; Cambridge is on the threshold of East Anglia; while the Lake District and North Wales are scarcely approachable without London and North Western Railway metals.

In 1904 the London and North Western and the London, Brighton, and South Coast railways inaugurated a new through service, that established direct communication between the former system and south coast watering-places. The south-bound train left Liverpool (Lime Street) at 11 a.m., arrived at Willesden at 3.13 p.m., Clapham Junction at 3.42 p.m., Brighton at 5.5 p.m., and Eastbourne 6 p.m. The corresponding north-bound train left Eastbourne at 11.35 a.m. and reached Liverpool at 6.30 p.m. There are scores of points where the North Western links up with other systems, not even excluding the Metropolitan District Railway, in which the London and North Western Railway invested £100,000 for the privilege of running into Mansion House station. Of long-distance trains to the north sufficient was said in an earlier chapter (pages 48–50), but a few words may be devoted to the more notable services elsewhere on the system. The boat specials to and from Euston and Holyhead now take 5 hours 15 minutes, or a quarter of an hour longer than the special trip described in 1862, but the weight of the Queen's Messenger special train was less than the weight of a present-day express engine alone, to say nothing of the tender and 300 tons behind it. The boat-trains are only specials in the sense that they cater for a particular set of passengers and mails: they carry other passengers; and they are run without disturbing the ordinary daily traffic of the line. All the London and North Western Railway passenger vehicles are painted chocolate and white.

With a clear line, modern engines are capable of a higher speed than the old ones, while drawing immensely heavier loads. Only

EXCHANGE OF ENGINES

(Great Northern, No. 1449, hauling London and North Western express, Crewe to Euston)

SCOTCH EXPRESS

(London and North Western Railway)

a few days before Mr. Whale left the Crewe works, two special trains, each weighing about 400 tons and carrying passengers and mails from the White Star Line s.s. *Cedric*, ran through from Holyhead to Euston, 264 miles, in 4 hours 56 minutes, without an intermediate stop, the speed averaging 53½ miles per hour. This run was 71½ miles longer than the one from Liverpool to London, which is the longest regular non-stop trip. More recent engines are speedier and more powerful, and when attached to a special train become real fliers. On July 24th, 1910, the "King George the Fifth" hauled a special from Euston to Crewe, 158 miles, in 158 minutes, the 133½ miles to Stafford being run in 126 minutes. This was the engine's best performance to date.

But modern excellence does not consist in the exceptional performance of any particular engine, but the good all-round work of the locomotive stud. Nothing can be better than the daily two hours' run from Euston to Birmingham, and the time could be shortened easily, but for the consideration of other traffic. The "City to City" express, between Birmingham and Broad Street (London), only occupies 2¼ hours on the journey of 124¾ miles. Coloured Plate VII shows the Irish express ascending Camden Bank.

One often regrets that the windows of a compartment of an ordinary railway carriage permit only a fleeting view of any interesting feature, charming scenery, etc., along the route. The bigger windows of a saloon carriage afford better facilities for observation purposes, but still leave much to be desired. Abroad, especially in America, observation cars have long been a feature of railway travelling, but not until August, 1911, was the idea introduced to the British travelling public by the London and North Western Railway. An observation car has not only its sides but its ends filled in with glass, thus being designed to furnish a splendid view of the route traversed by the 64 passengers, which the car accommodates. We illustrate this novelty, so far as British railways are concerned, climbing a steep cutting in North Wales.

With the speed and regularity of the trains there are a dozen and one conveniences that were formerly unknown to travellers. At Euston station there are even ladies' and gentlemen's bathrooms, and there has long been a writing-room for the use of passengers—a real boon to business men, who could have their letters typewritten by an experienced typist. The up "City to City" express has a breakfast saloon, the down train has a dining-car attached; but a typewriting bureau is a speciality on the train, enabling business men to deal with their correspondence *en route*, a decided advance upon doing it at the station.

Although Euston station is the oldest, it remains one of the mammoth termini of the metropolis. It has fifteen platforms, some of which are a thousand feet in length. Altogether it covers an area of 16 acres. The No. 1 signal-box contains 282 levers.

OBSERVATION CAR
(London and North Western Railway)

New Street Station, Birmingham, deserves second mention, if only because it was the terminus at the other end of the London and Birmingham Railway, although originally the end of the line was at Curzon Street, which is now the goods depôt. Since 1846 the Midland Railway has run into New Street for a nominal rent and payment of a share of the working expenses ; and it was the increase in the joint traffic that necessitated the extension of the station from an area of 7¼ acres to 14½ acres in 1882–5. To say

TYPEWRITING COMPARTMENT ON EXPRESS TRAIN
(London and North Western Railway)

that there are six platforms, three for each company, conveys very little, unless we add that they have a length of a mile and a half—being on the island principle ; and as some of them are capable of being worked in both directions, there may be as many as four trains at a single platform. Under the glass roof of 8½ acres, 700 trains pass in and out daily ; at holiday times the number amounts to 900 trains. A remarkable feature of the station is the footbridge which crosses the station from north to south. This not only gives access to the various platforms, but is a city thoroughfare constantly thronged with humanity, apart altogether from passengers. When the station was extended, it was foreseen that such a huge enclosure in the very heart of the city would involve a considerable detour for vast numbers of the inhabitants, and thus, in the Act permitting the enlargement, it was compulsory upon the Company to maintain an open thoroughfare across the station. What a boon the footbridge is to the general public is realised upon the periodical occasions when the Company closes the bridge to public traffic in order to assert its legal rights. Probably nothing ever occurs in the city to cause more exasperation to busy, bustling people, who are thus warned off their usual course.

The London and North Western Railway owns hotels at Euston, Bletchley, Crewe, Birmingham, Liverpool, Holyhead, Dublin, and Greenore; while at Preston it is interested in the Park Hotel with the Lancashire and Yorkshire Railway. The hotels are among the best of their kind, and are a boon to great numbers of passengers on the system. It scarcely need be remarked that the hotels, added to the dining services on the trains, cause the commissariat department of the line to be of immense importance, with innumerable details down to the keeping of pigs to eat the waste food, and the rearing of hens to provide new-laid eggs for the Company's dining patrons.

CHAPTER XII

GREAT WESTERN RAILWAY

THE Great Western Railway possesses a longer mileage than any other British company, which alone gives it a position of importance, but from its very commencement the Company attracted popular interest on account of its adoption of the broad gauge, which will always figure prominently in our railway history.

When locomotives and railways were in the air, the merchants of Bristol bestowed their fervent blessings upon the pioneers, for Bristol trade called urgently for better means of communication with London than river and canal afforded. Navigation between Bath and Reading was fairly satisfactory, but on the Avon at one end of the route, and the Thames at the other, there were often irritating delays; in times of drought there was too little water, in wet seasons there was too much. Water traffic at the best of times was slow, but when goods occupied from three to six weeks on a journey of about 120 miles mercantile patience was torn to shreds.

In 1824 a railway between Bristol and Bath, and another between Reading and London, were being discussed as a solution of the difficulty, but such a half-hearted scheme would mean breaking bulk twice during the transport of goods between Bristol and London; and then came a proposal for a railroad to cover the whole distance. Both schemes found their supporters, and the division of opinion caused matters to be left as they were; but after the lapse of seven years, the opening of the Liverpool and Manchester line woke up Bristol people to decide upon a railway of their own all the way to London. A company was formed, and an engineer appointed in the person of Isambard Kingdom Brunel. Young Brunel's design for the Clifton Suspension Bridge was accepted when he was only twenty-three years of age, and he had done some dock engineering when he was attracted to railway work.

The new line was surveyed. From Bristol to Bath the course was obvious; between Bath and Reading the direction was debatable, but it was decided to go via Swindon and Didcot; and from Reading the valley of the Thames was selected. Originally it was intended to call the line the Bristol and London Railway, but the title was dropped in favour of "Great Western." The first Bill, in 1834, provided for a gauge of 4-ft. 8½-in., and the London terminus was to be at Vauxhall or South Kensington, but it failed to pass the Lords. The next year an amended Bill met with a better fate; the line was to end at Kensal Green, but the gauge was not mentioned, this being a strategical move on the part of Brunel. Had the omission been noticed as the Bill passed through Parliament, doubtless the new company would have been forced to fall in line with other railways; but as it was, Brunel was left with a free hand in the matter. He was bent upon a

MAIN DEPARTURE PLATFORM, PADDINGTON STATION
(Great Western Railway)

7-ft. gauge, for several reasons; he desired to build roomier passenger carriages; the additional width would allow of a bigger firebox under the boiler, with extra power for the locomotive; and the broad gauge would do a great deal towards making the west and south-west of England a special preserve of the Great Western Railway. George Stephenson had declared that some day all the lines in England would be joined together; and if Brunel had subscribed to that view some portions of our railway history would be very different reading, albeit in some respects a little less exciting.

As with the London and Birmingham, so there was opposition to the Great Western Railway; the authorities of Eton School, in particular, objected to a station at Slough, and insisted that the line in the neighbourhood should be specially patrolled by railway policemen in order to safeguard the scholars. These reservations were inserted in the Bill; but it was found quite as easy to drive a train through an Act of Parliament as the proverbial coach-and-four. The letter of the law was observed so far as that no station was built, but the trains stopped at Slough to take up or set down passengers all the same. The construction of the Great Western Railway has called for various notable engineering achievements; upon the original line the Box Tunnel (1 mile 1452 yards) and the bridging of the Thames at Maidenhead presented special difficulties; in later times came the Chepstow and Saltash bridges; but all of them to be surpassed by the Severn Tunnel (page 140).

Some of the opponents of railways believed the locomotive to emit a breath as poisonous as the fabled dragon of old, and asserted that a bird crossing its path would drop down dead. In a tunnel it was said that "the sudden immersion in gloom, the deafening peal of thunder, and the clash of reverberated sounds in a confined space" would give to a passenger an "idea of destruction, a thrill of annihilation," while the effluvia from the engines would be a positive danger to health.

There was an outcry in various quarters against the construction of the Box Tunnel, which necessitated boring for a distance of 1 mile 1452 yards through a hill, at a depth of 270-ft. below its crest, while from London it was approached by a deep cutting more than 2 miles in length. The work occupied two and a half years, during which always more than 1000 men and 250 horses were employed; the excavations entailed expensive blasting that required a ton of gunpowder weekly; 30,000,000 bricks were put into the lining; while 125 tons of candles were used in lighting the men at their work. To span the Brent Valley at Hanwell demanded another great work in the Wharncliffe Viaduct, 300 yards in length and 70-ft. in height, comprising eight elliptical arches, each of 70-ft. span.

The line from London to Maidenhead was completed and opened to the public on June 4th, 1838. The locomotive engineer was Daniel Gooch. He selected the "Æolus" to make the trial trip, but one of its tubes sprang a leak and put out the boiler fire; incidentally it put Gooch out far worse, for there was an inglorious delay of an hour while a fresh engine was obtained. A few months later the "Æolus" showed that it had but suffered temporary indisposition, by hauling three coaches at 48 miles an hour; but the best engines in the Company's small stud were the "Vulcan," "Morning Star," and "North Star," which Gooch himself had helped to build during the short time he was employed at Stephensons' engine works at Newcastle.

The line from London to Bristol was opened in 1841, and a spacious road it was that Brunel had provided for the engines, which five years later Gooch commenced to build at Swindon. The young locomotive superintendent had a trying time with many of the locomotives with which he commenced working the earlier sections of the line, and often his nights were spent in superintending repairs necessary before the poor machines could work next day. He knew no peace of mind until he got a number

SALTASH BRIDGE
(Great Western Railway)

of engines built to his own specifications, of which the "Firefly" was the first to commence active service in March, 1840.

Brunel, too, had his troubles with the earlier portion of the track. He desired to provide a rigid road, but overdid it. He used longitudinal sleepers stoutly braced with cross-ties, and the joints of the sleepers rested upon deeply driven piles. After the rails were laid a very heavy roller was passed over them, and wherever they gave a little the screws and bolts were tightened. Other people had learnt lessons concerning rigidity. On one line, in a rock cutting, no sleepers were employed, but the chairs were spiked down to the bare rock; and in another case the rails were bolted on granite specially laid down to receive them. The results were disastrous, for the unyielding rigidity produced a steady crop of broken rails, tyres, and springs that would have spelt early ruin to any company. The very solidity of Brunel's track proved its weakness; it lacked the necessary spring between sleeper and sleeper which affords the wheels a better grip of the rails that particularly is necessary when a train is climbing a gradient. Often experience has to be bought—and in this case it cost roughly £100,000, for all the piles along the 23 miles of line between London and Maidenhead eventually had to be removed, and cross sleepers adopted in accordance with what was becoming the recognised custom; but upon some of the old branch lines longitudinal sleepers remained until the gauge conversion.

The new line, even before its completion, was justifying the hopes of the promoters. The business was singularly free from accidents, and by the time three million passengers had been carried, only one broken leg appeared on the casualty side of the ledger. On the Christmas Eve following the opening of the whole line a train, consisting of sixteen goods wagons, a luggage van, and a couple of third-class passenger coaches, ran into a landslip between Twyford and Reading. As the engine fell over, the men on the foot-plate leapt off uninjured, but the passenger coaches were smashed by the impact of the goods wagons behind, and eight persons were killed and twice as many injured. The coroner's jury recorded a verdict of accidental death, but under an old law, that has since become obsolete, they placed a deodand of £1000 on the offending rolling-stock. The law declared that whatever object caused a man's death was, *Deo dandum*, at once forfeit to the Crown, or, in some cases, to the lord of the manor, to be redeemed at a price fixed by the jury, and the proceeds devoted to pious purposes, or for the benefit of the relatives of the deceased. A similar accident to-day would involve a railway company in a much heavier bill for compensation.

Another accident, in 1845, deserves mention for quite opposite reasons. Fifteen miles out of Paddington the wheels of a luggage van, attached to an express, left the metals, but the longitudinal sleepers, which at that time had not been removed, kept the wheels fairly in line with the remainder of the train, which ran for a mile and a half without the driver or guard becoming aware that anything was amiss. They discovered it too late, when they reached a bridge, where the rails were laid differently. The whole train, from engine to van, was hurled down an embankment, but, strange to say, of the one hundred and thirty passengers not one experienced anything worse than a few bruises. Brunel himself was a passenger, and might have quoted the incident as a proof that longitudinal sleepers were not without redeeming features.

The outstanding element in the history of the Great Western Railway is centred in the question of gauge. George Stephenson's opinion concerning the linking together of all the lines in the kingdom has been quoted twice, and Brunel himself was forced to admit the wisdom of the old pioneer, whose earthly travels terminated on August 14th, 1848. Even before the death of Stephenson the Battle of the Gauges had commenced. Wherever the broad and narrow gauge systems came into contact, there was trouble with both the passenger and goods traffic. The narrow-gauge rolling-

ELECTRIC SIGNAL CABIN, SNOW HILL STATION, BIRMINGHAM
(Great Western Railway)

stock could not run on the broad gauge metals, and vice versa; and for the continuance of a journey passengers had to change trains, and in the case of goods and minerals their transhipment entailed delay, damage, and additional working expenses.

A Parliamentary Committee inquired into the matter in 1845, and a year later it was enacted that the uniform gauge for railways in Great Britain was 4-ft. 8½-in., the Great Western Railway excepted; in Ireland the standard gauge was fixed at 5-ft. 3-in. To understand the exact situation, one cannot do better than peruse what was written in the *Illustrated London News* of June 6th, 1846:

"At Gloucester two different railways unite—one running southwards from Birmingham, the other northwards from Bristol. The former has a width of 4-ft. 8½-in. between its rails; the latter, 7-ft. The gauge, or width of the rail, is *broken* or interrupted; hence the term we now hear so much of—'*Break* of gauge.' The gauge being thus broken, your journey is brought to a dead halt. With all your baggage and rattle-traps, whatever they be in number and size, you are obliged to shift from one carriage to another. You will hear the railway policeman bawling into the deaf passenger's ear that he must dismount; you will see the anxious mamma hastening her family in its transit from carriage to carriage, dreading the penalty of being too late; your dog will chance to have his foot crushed between wheelbarrows and porters' baskets—howling more terrifically than the engine itself; the best glass decanters, to be presented to your host, fall and are cracked to atoms; your wife's medicine-chest is broken, and rhubarb, grey powder, and castor-oil unnaturally mixed before their times; the orphans going to school at Cheltenham lose their way in the crowd; and the old maid and her parrot are screeching at honest John for his passive inactivity amidst the turmoil. If your carriage-horses accompany you, they too must be shifted by dint of whip and cajolery—perchance 'Highflyer,' over-restive and impatient at the prospect of another railway trip, protests so vehemently against a second caging, that he must needs be left behind; you resolve that no consideration will ever tempt you to bring your horses again by railway where there is 'break of gauge.'

"The removal of goods, owing to the 'break of gauge,' is even more irksome than that of passengers. Where it does not absolutely prohibit the traffic, the transhipment involves loss, pilferage, detention, besides a money tax of from 1s. 6d. to 2s. 6d. per ton.

"Now, let us contemplate the loss by damage done to the goods on one ordinary train of wagons laden with promiscuous goods, by reason of the break gauge causing the removal of every article. In the hurry the bricks are miscounted, the slates chipped at the edges, the cheeses cracked, the ripe fruit and vegetables crushed and spoiled; the chairs, furniture, and oil cakes, cast-iron pots, grates, and ovens, all more or less broken; the coals turned into slack, the salt short of weight, sundry bottles of wine deficient, and the fish too late for market. Whereas, if there had not been any interruption of gauge, the whole train would, in all probability, have been at its destination long before the transfer of the last article, and without damage or delay.

"There being already about 1900 miles of 4-ft. 8½-in. gauge, and only 270 miles of 7-ft. gauge, and as the broader gauge can be easily reduced, whilst the smaller cannot be enlarged, and as the respective merits were, if not balanced, rather in favour of the narrow gauge for general purposes, the recommendation of the

Commission was that the 4-ft. 8½-in. gauge should henceforth be declared the national gauge, and all railways made upon it. It should not, however, be withheld that the broad gauge has been found to ensure certain advantages over the narrow; these are the increased power and speed of the engines, and the stability and convenience of the carriages; all which are strikingly evident on the Great Western Railway."

Concerning the speed of the broad-gauge engines, there was no doubt as to their superiority. At that time the expresses on the London and Birmingham Railway were doing not more than 24 miles an hour, whereas the Great Western trains were running to Exeter in 4½ hours, or nearly 44 miles an hour. Racing tests were organised between representative narrow-gauge and broad-gauge engines to assist the Commissioners to come to a decision. The narrow-gauge exponents selected the 43 miles from York to Darlington as their racing track. They placed only 50 tons behind the tender; they fed the boiler with warm water, and insisted upon a flying start. The distance was completed at 35 miles an hour, and on a second trip the speed was 48 miles. A third trip was essayed in order to attain 50 miles an hour. The engine knocked off 22 miles in 27 minutes and then jumped the metals.

Brunel and Gooch put their champion to run the 52 miles between London and Didcot. With 81 tons behind the tender, no warm-feed water, and starting from rest, the journey occupied 64 minutes; and the return journey was accomplished in the level hour. For the third trip the load was lightened by 10 tons, which resulted in knocking off a further 3½ minutes, or 55 miles an hour. Nothing could rob the Great Western Railway of the championship in engines, but for the rest they had to acknowledge defeat, and in no case would the narrow-gauge lines be converted to broad-gauge as they had fondly hoped.

It will have been seen that although the Great Western line from London to Bristol had been opened only four years, the Company possessed 270 miles of railways; some constructed, and some purchased from other companies. It was the largest of the seventy railways that were in active working. Not only did it continue to extend its own broad-gauge lines, reaching Birmingham, for example, in 1852, but it absorbed some of the smaller companies wholesale.

In 1848 the narrow-gauge companies induced Parliament to call upon the Great Western Railway to mix the gauges on the Oxford Birmingham line. This was effected by laying down a third rail 27½-in. inside the inner rail, leaving the outside or platform rail common to both gauges. Gradually the length of "mixed" line extended, for the Company's existence depended upon getting traffic, much of which was only obtainable if no breaking of bulk could be guaranteed. By October, 1861, a narrow-gauge train could traverse the Great Western metals between London and Birmingham, and three years later between London and Exeter, and on numerous other smaller sections that need not be enumerated. But though this method worked well in one direction, it did not permit Great Western rolling-stock to travel on the narrow-gauge lines. The only course open to the Great Western was obvious: conversion to narrow gauge was absolutely necessary, unless it desired permanently to remain at a disadvantage compared to the other companies. For years preparations were made quietly in readiness to commence the immense task of conversion, and in the meantime the rolling-stock was kept down to the lowest possible limits; wherever the permanent-way required alteration, it was carried out with an eye to the future; and many bridges that carried a single set of broad-gauge metals were widened in readiness to take a couple of narrow-gauge lines.

First a 7-mile branch line was changed to narrow gauge, simply for experience and as a guide for larger operations. In 1869 the Hereford and Grange Court section was converted. The distance concerned was 22½ miles. The work called for the employment of four hundred and fifty men, who commenced their task on the Sunday morning, and completed it on the following Thursday night. They slept for only three and a half hours each night in covered wagons at the side of the line. The converting operations entailed the removal of the longitudinal sleepers upon which the rails were bolted down without chairs; cross sleepers with chairs were laid down; and a rail moved inwards a distance of 27½-in. From that time conversion was continuous until the year 1872, when 312 miles of line between Swindon and Milford underwent the change; two years later another couple of hundred miles followed suit. Still the work went on at convenient intervals until May 21st and 22nd, 1892, when all traffic was suspended on main lines west of Exeter and most of the branches. In tackling the "mixed" sections the chief part of the work had been already done, but beyond Exeter not a single mile of "mixed" gauge was in existence. The sweltering gangs of men worked with almost superhuman energy; and when their tools were laid down the broad gauge had made its final exit.

For the first eight years of its active work the Great Western Railway obtained its engines from various makers. The "North Star" and "Morning Star," as already stated, were supplied by Messrs. R. Stephenson & Co., but the first engine to be delivered was the "Vulcan," one of half a dozen from the Vulcan Foundry, Newton-le-Willows, and the "Æolus" and "Bacchus" were similar engines of the same make. The first-named was capable of drawing a load of 18 tons at 28 miles an hour, but on the whole was a consistent failure. The "Æolus" was better, and drew

BROAD-GAUGE LOCOMOTIVES AND WAGONS AT SWINDON

Awaiting conversion or breaking up, May, 1892. (Great Western Railway)

32 tons at 50 miles an hour on a trial trip, and 104 tons at 23 miles an hour. On the whole, however, it must be written down as a quite unreliable engine.

Mention must be made of a couple of almost weird locomotives which the Company obtained from Messrs. Hawthorn, of Newcastle. The "Thunderer" consisted of an engine, carriage (four wheels) in front, a boiler carriage (six wheels), and a tender (four wheels). Steam was led from the boiler on to the front carriage by specially jointed pipes. The four coupled wheels of the front carriage, which had a diameter of 6-ft., were not driven directly by the cylinders, but by means of a spur-wheel with wooden teeth, and geared to one of the coupled axles by a pinion wheel. The boiler was nearly 9-ft. long with 135 tubes; the heating surface was 623-ft.; the two cylinders were 16-in. diameter by 20-in. stroke. Weight of engine 12½ tons. The "Hurricane" had very similar dimensions and the same power, but the engine was a six-wheeler with a pair of 10-ft. drivers, the remaining wheels being 4-ft. 6-in. diameter. Neither of these engines ever did any practical work, but there was a commonly accepted story on the line that the "Hurricane" had run 22½ miles in 16 minutes. For some years the last-named was the greatest curiosity of which Swindon could boast. Finally its boiler was turned over to the "Bacchus," a ballast engine, and the boss of one of the 10-ft. wheels was used as a counter-weight on a crane outside Swindon station.

In the year 1846 Swindon works turned out its first engine, that was entirely the product of the Company's own shops. So far the broad gauge had done little or nothing in locomotive powers to justify its existence, and now came the opportunity of showing what could be compassed within the limits of 7-ft. Built in a great hurry, and required to be completed in the space of thirteen weeks, this engine was known in the shops as "Lightning," but was formally christened "Great Western" when it started running in April.

In size and elegance nothing like it had appeared hitherto on the broad-gauge metals. It was a six-wheeler with 8-ft. drivers; the boiler was of large dimensions with a dome-shaped firebox; the weight of the engine was 29 tons. The "Great Western" at once made its mark. On one of its early trips it hauled a train of 140 tons from London to Swindon at 55 miles an hour; and on June 1st, 1846, ran with the express from Paddington to Exeter and back—the double journey of 194 miles each way occupying only 208 and 211 minutes, running time, respectively. The engine, however, was defective in one respect: an undue proportion of weight rested on the leading axle, which broke while drawing a train near Shrivenham. The "Great Western" was rebuilt, and of various alterations the chief was the substitution of four leading wheels for the single pair. It was as an eight-wheeler that the engine was best known, for it ran 370,687 miles before it was broken up in December, 1870.

The mileage accomplished during the lifetime of the "Great Western" was small compared with the records of half a dozen engines that were placed upon the rails a year later, of which two examples will suffice. The "Lightning" made a mileage of 816,601 by April, 1878, and was then condemned; the "Iron Duke" ran 607,412 miles up to August, 1873, when it was fitted with a new boiler, which gave the locomotive a new life that lasted until the final abolition of the broad gauge. These long, strenuous lives were a common feature among broad-gauge, but quite the exception among narrow-gauge engines.

Between June, 1848, and March, 1851, a series of sixteen large eight-wheeled express engines was turned out of Swindon. The average heating surface was about 1900 sq. ft.; the safety valves blew off at 120 lbs. per sq. in.; and the average weight of an engine in working order was 38 tons 4 cwt. The last of the batch was the famous "Lord of the Isles" (page 41). After being exhibited in Hyde Park, the engine commenced work in 1852, and performed regular service until July, 1881; having, during a period of twenty-nine years, run a distance of 789,300 miles with its original boiler still intact. After some years of dignified retirement the veteran appeared at Edinburgh Exhibition in 1890; at the Chicago Exposition of 1893; and later at another exhibition at Earl's Court, by the side of the still older "North Star."

It was hoped that room might be found for these interesting relics in the railway section of the South Kensington Museum to serve as guides and landmarks to the historian of the future. In February, 1906, however, both of the engines were broken up, but one side of the motion of the "Lord of the Isles" was presented to Swindon Technical School, and was set up in one of the class-rooms.

It is a matter for regret that we do not possess a national railway museum. At several museums in the provinces various interesting objects are preserved. At Leicester there is an instructive collection of rails, from a pair of cast iron rails, 3-ft. long, used in 1788, to a 60-ft. length of 100-lb. rail presented by the Midland Railway Company. There is also a model of a "wooden way" that was used at Newcastle-on-Tyne in 1630. This collection is the result of the enthusiasm of Mr. C. E. Stretton, who has a very intimate knowledge of the railway history of the Midland counties.

A few railway companies treasure different objects associated with their own history, but alterations of premises and demand for space to meet the pressing requirements of the present have often led to the destruction of relics that were of real national interest.

In September, 1864, Mr. Gooch resigned his position as locomotive superintendent, and was succeeded by Mr. Joseph Armstrong, who in the thirteen years of his rule rebuilt many of his predecessor's engines, among which were the "Iron Duke" and many others of its class. Mr. W. Dean came into office at Swindon in 1877. He was hampered by the indeterminate dissolution of the broad gauge, which necessitated limiting the stock to the barest requirements, but nevertheless turned out various splendid engines to meet the growing requirements for power and speed.

After the Great Western had settled down to its standard gauge working, the Company woke up from its enforced sloth of many years, which, however, had always been relieved by the brilliance of its long-distance expresses. In 1896 Mr. Dean designed a series of four-coupled bogie express engines, of which the "Pendennis Castle" was a capital example. The extension of the smokebox

"LORD OF THE ISLES"

was a striking feature; the boiler, 11-ft. in length, contained 249 tubes; heating surface, 1400 sq. ft.; working pressure, 160 lbs. per sq. in. The total weight of the engine was 46 tons.

The engines of this class speedily distinguished themselves in running the Hamburg-American boat specials between Plymouth (Millbay) and Exeter, 53 miles. "Excalibur" accomplished the distance in 68 minutes, but the "Duke of Cornwall" made the run in 66½ minutes; really good work considering the heavy gradients and a load of 120 tons. The "Badminton" and "Avalon" classes, which followed in due course, may pass, since the "Atbara" class of 1900 showed an advance upon their fine proportions and capabilities. The "Atbara" (4-4-0) had a large boiler of the domeless type, having about 1660 sq. ft. of heating surface, and carrying a pressure of 180 lbs. per sq. in. Four other engines of this class were the "Roberts," "Pretoria," "Powerful," and "Maine."

In chapter III (page 61) several later examples of Swindon locomotives are mentioned, and in some cases particulars of notable runs are afforded. The "Knight" class of four-cylinder single 4-6-0 express locomotives were splendid additions to the Company's stud. They were practically identical with the "Star" class, as were the engines of the "King" class that followed. The "Bird" class, on the other hand, followed the main features of the "Bulldogs," except that the extended smokebox was longer, and the working pressure was raised to 195 lbs. per sq. in.

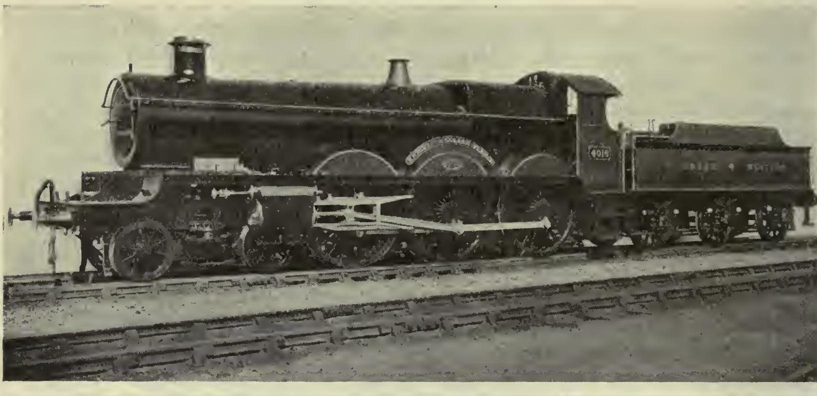
The 3000 locomotives of the Great Western Railway are painted green and black. Until recent years the passenger vehicles were painted tea-brown and cream, but their colour was changed to red-chocolate brown with gold linings. The carriage stock comprises 280 first-class carriages, 3380 third-class carriages, 1566 composites and saloons, and 2500 other coaching vehicles. There are about 70,000 goods vehicles of various kinds.

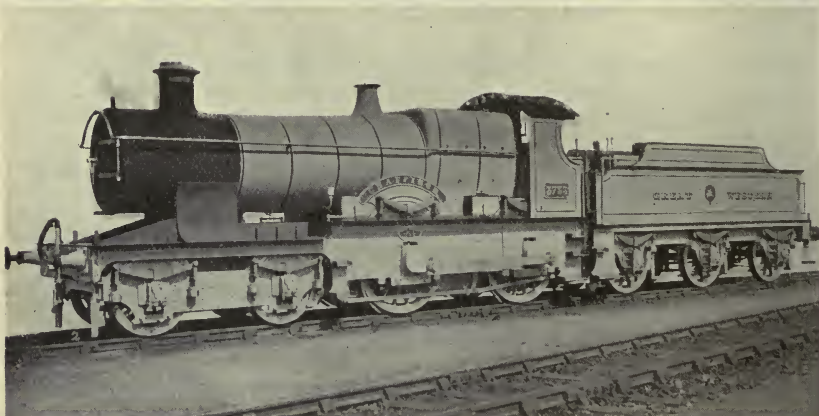
For a moment survey the Great Western Railway present-day map of its own metals. From London, via Birmingham, to Chester on the one hand, to Penzance, via Exeter, on the other, to Fishguard, via Neath, more or less straight on between; take note of Bristol, the centre of the system, Weymouth and Barnstaple in the south, and Gloucester, Hereford, and Worcester in the more northern portion of the Great Western territory. Without any attempt to estimate the network of rails between these points, we obtain a general idea of the most extensive system owned by any British company, comprising 2960 miles of track, or about one-eighth of the railways in the United Kingdom. If we include the sidings, reduced to single track, the Company owns no less than 6450 miles of metals.

The Great Western permanent-way is roomier than is the case with many of our railways, thanks to the original wider gauge. The standard rails for main lines are of bull-head section, weighing 97½ lbs. per yard; the chairs weigh 52 lbs. each. Water troughs are laid down at a dozen different places on the main lines.

In addition to several great engineering works on the line already mentioned, Chipping Sodbury Tunnel is 2 miles 700 yards long, Sapperton Tunnel 1 mile 100 yards, and Merthyr Tunnel 1 mile 736 yards. There are many sections where the gradients are difficult; the Letterston Branch with 1 in 27 is the steepest passenger line; but between Newquay passenger station and the harbour there is a mineral line 1 in 4½, worked by a stationary engine.

Now for the business that is compassed in a year (1910) within this complicated web of rails. The paid-up capital of the Company exceeds £98,000,000. It carries 104,000,000 passengers, excluding season-ticket holders, and for the conveyance of passengers, parcels, and mails it receives £6,794,000. It will be noted that this is about the income of the London and North Western Railway, although the latter carries 20,000,000 less passengers. This may be accounted





1. "KNIGHT OF THE GOLDEN FLEECE" (4–6–0). 2. "CHAFFINCH" (4–4–0).
3. "LA FRANCE" (4–4–2)

for in two ways: the parcel and mail business may be less, and the passengers on an average travel shorter distances. The receipts from the goods and mineral traffic amount to more than £7,000,000. In the course of the year the passenger trains travel over 28,600,000 miles, the goods and mineral trains 19,790,000 miles, to which may be added rail motor services 3,000,000 miles and passenger electric trains 373,000; a grand total of nearly 52,000,000 miles. Roughly, the three chief items of expenditure are maintenance of way and works $1\frac{1}{2}$ million pounds, locomotive power $2\frac{1}{2}$ millions, traffic expenses $2\frac{1}{2}$ million pounds. And all this huge business gains for the shareholders a dividend of $5\frac{3}{4}$ per cent.

The Great Western Railway from Paddington affords the shortest routes and quick services to a number of important places, such as Bristol, $117\frac{1}{2}$ miles, in 2 hours; Taunton, 143 miles, in $2\frac{1}{2}$ hours;

OCEAN EXPRESS LEAVING FISHGUARD
(Great Western Railway)

Torquay, $199\frac{3}{4}$ miles, in 3 hours 53 minutes; Plymouth, $225\frac{3}{4}$ miles, in 4 hours 7 minutes; Penzance, $305\frac{1}{2}$ miles, in 6 hours 35 minutes; Cardiff, $145\frac{1}{4}$ miles, in 2 hours 50 minutes; and capital services to Waterford, Cork, and Kilkenny, via Fishguard and Rosslare. Of other places served, but not by the shortest routes, mention may be made of Chester, 214 miles, in 4 hours 50 minutes; Liverpool, 230 miles, in 5 hours 11 minutes; and Exeter, $173\frac{3}{4}$ miles, in 3 hours. Until 1910 the Great Western Railway route to Birmingham was $129\frac{1}{4}$ miles from Paddington, but the opening of the Ashendon-Aynho section reduced the distance to $110\frac{3}{4}$ miles, allowing a timing of 2 hours 20 minutes to be reduced to 120 minutes, thus agreeing with the London and North Western Railway service to the same town over a slightly longer route.

In an earlier chapter have been mentioned various fine runs on the Great Western Railway, especially between Fishguard, or Plymouth, and London, in connection with the ocean mails; but the "Cornish Riviera Limited" (Coloured Plate III) is one of the finest regular expresses in the country, although its speed averages only 44 miles an hour. West of Exeter there are many steep gradients, and between Truro and Penzance a portion of the route is single-track. The Company claims to be the pioneer of long non-stop runs, and in this particular service there is no intermediate stop between London and Plymouth (225¾ miles). Attendants accompany the train to wait upon passengers, and also to render assistance with invalids and children.

Although royalty may travel greater distances upon other railway systems, the Great Western Railway has had long and close connection with our monarchs, owing to the 22½ miles of line between Royal Windsor and Paddington. In the early days of the railway, Slough, in due course, got its station. The Prince Consort was an early patron of the line, and upon more than one occasion he desired the speed of the train to be reduced. It was not until June 18th, 1842, that Queen Victoria gave the line a trial between Paddington and Slough—the first trip of hundreds that followed during Her Majesty's long and glorious reign. Almost 59½ years later her mortal remains were conveyed along the metals from the capital for interment at Windsor; the great modern machinery of transport, whose rise and development had been coincident with the reign of the deceased monarch, fittingly played a part in almost the last scene. For the final journey from Paddington, the Great Western Railway Company selected one of their latest four-coupled express engines, No. 3373, "Atbara," renamed for the occasion "Royal Sovereign," the train being that usually employed for the late Queen's journeys on the Great Western Railway. Upon either side of the engine were large royal coats-of-arms draped with purple, and in front of the smokebox was a wreath of immortelles with the monogram "V.R.I." in silver in the centre. The crown in front of the chimney was also draped in purple. The sad royal special was preceded by a pilot train, drawn by No. 3374, "Baden Powell," also suitably decorated.

Thus was performed the last railway journey of Queen Victoria, over the same line on which more than half a century previously she had made her first essay in railway travelling.

The last journey of His late Majesty King Edward VII took place on Friday, May 20th, 1910, under circumstances of similar ceremony and solemnity, and constituted a pageant probably never equalled in the history of the world. Nine reigning monarchs, including his successor, King George V, accompanied the gun-carriage bearing the royal remains from Westminster Hall, where the public lying-in-state had been held, to Paddington Station, from which the funeral train set out for Windsor. It consisted of the violet-draped funeral car, used nine years previously, and ten saloon coaches for the accommodation of the royal mourners and their

NO. 4021, "KING EDWARD"
The engine that drew the royal funeral train, May, 1910

suites. The engine that hauled this train was No. 4021, "King Edward"; on its sides were the royal coats-of-arms, and small crowns were fixed upon the head lamps. Mr. G. J. Churchward rode on the foot-plate with the driver and his mate, the trio fully alive to their responsibilities. It is certain that no train ever driven carried so many passengers on whose safety rested the destinies of so many of the countries of Europe.

EXCURSIONISTS' MOTOR TOUR IN CORNWALL
(Great Western Railway)

CHAPTER XIII

MIDLAND RAILWAY

EIGHTY years ago the coal from the Leicestershire collieries was sent into Leicester by carts, while from Nottinghamshire and Derbyshire the fuel came by canal. The success of the Stockton and Darlington Railway gave William Stenson, of Whitwick, the idea that a railway would be a great improvement over horse cartage; and being a thoroughly practical man, he set about surveying a suitable route. He then consulted Mr. John Ellis, who forthwith went off to Liverpool to lay the project before his friend, George Stephenson, who was engaged in constructing the Liverpool and Manchester line. "Old Geordie" was so impressed by the scheme that he and his son Robert went to Leicester with Ellis that same evening. Ellis and Stenson accompanied the Stephensons over the route, and then at the Bell Hotel, in Leicester, a meeting was called, which resulted in the formation of the Leicester and Swannington Railway Company, with a capital of £90,000.

It was hoped that George Stephenson would act as engineer, but he was not at liberty to accept the position, as the Liverpool and Manchester directors believed that the construction of 31 miles of railway was quite sufficient to occupy his energies. Consequently the post was given to Robert Stephenson, his father guaranteeing his capability and becoming answerable for the quality of the work of his son, who was but twenty-seven years of age.

Robert Stephenson resurveyed the route of 16 miles, deciding upon several deviations to avoid difficult gradients; and on May 30th, 1830, the Company obtained its Act on its first application. No matter how he schemed, the engineer was unable to miss the Bagworth incline, 1 in 29, which necessitated working the traffic by an endless rope, empty wagons being hauled up by the loaded ones descending. The Swannington incline, 1 in 17, was worked also by a stationary engine and rope, and that method remains in use to-day. The Glenfield Tunnel was difficult to construct, owing to troublesome running sand that prevented the brick lining being put in until a temporary wooden tunnel was constructed.

The single line from Leicester to Bagworth was opened on July 17th, 1832, and was the occasion of much ringing of bells, playing of bands, and firing of cannon. The engine to draw the first train was the "Comet," which came from Stephensons' works at Newcastle. The opening ceremony was a huge success, until the train reached the middle of the Glenfield Tunnel. The rails were rather too high at one point, and the engine stack was broken

ST. PANCRAS HOTEL AND ENTRANCE TO STATION
(Midland Railway)

off by coming in contact with the roof. The passengers, who were conveyed in open trucks, were liberally sprinkled with soot ; and when the train emerged from the tunnel a stop was made at Glenfield Brook to afford an opportunity of an alfresco toilet, of which the passengers were glad to take advantage. Two notable engines belonging to the Company were the "Samson" and "Goliath." The former was the first engine to be fitted with a steam-trumpet or whistle, which was made to George Stephenson's design by a local musical instrument-maker. Both of these engines pitched very badly owing to their short wheel-base, while they were of greater length than usual. Stephenson therefore fitted each with a pair of trailing wheels behind the firebox, and removed the flanges from the middle pair of driving wheels. This plan proved so effective that Stephenson promptly adopted six-wheelers, such as were seen in the "Atlas," in which he increased the diameter of the trailing wheels and then coupled the three axles. The boiler and cylinders were also larger than usual, and the engine weighed 17 tons.

The opening of the Leicester and Swannington Railway caused an immediate reduction in the price of coal in Leicester, which threatened to ruin the trade of the Erewash Valley coal-owners, whose canal-carried coal could not compete with that brought by rail. A rival line from Pinxton to Leicester was at once proposed, but eventually gave place to a more ambitious scheme (Midland Counties Railway) by which Nottingham, Derby, and Leicester were linked up, effecting a junction with the London and Birmingham line at Rugby. In the meantime George Stephenson had completed the North Midland line from Leeds to Derby, and another of his systems, the Birmingham and Derby, was already in existence. It was thus possible to travel from Derby to London by two routes —by the Birmingham and Derby via Birmingham and Rugby, or the Midland Counties via Rugby, using the London and Birmingham metals from either of the places named. The outcome was a fierce and ruinous competition between the three companies for the London traffic; and only in May, 1844, when the trio were in danger of bankruptcy, did George Hudson, John Ellis, and George Stephenson bring about an amalgamation, by which the three rivals sank their identity in the Midland Railway Company.

The first chairman of the Midland Railway Company was George Hudson, a daring speculator, who brought off many coups during the railway mania, and in particular he was the prime mover in many amalgamations. The Midland came into existence by amalgamation, and under an enterprising directorate it rapidly extended its territory. In 1845 it absorbed the Birmingham and Gloucester line, a narrow-gauge system, and the Bristol and Gloucester Railway, which was a broad-gauge line; and when the latter was altered to conform with the national gauge, the Company possessed a through main route from the north and the Midlands to the west of England. To mention the various extensions, amalgamations, and working agreements that followed each other in rapid succession would occupy too much space, and only a few of the more notable can be cited. The little Leicester and Swannington Railway was absorbed, and was extended to Burton-on-Trent. Communication was opened from Leicester to Peterborough, and access to Worcester was gained by connections with the West Midland system in 1850, in which year also the Midland entered into joint occupation of New Street Station, Birmingham.

George Hudson, in the meantime, had fallen from his high estate. Between London and Edinburgh he had controlled at least a thousand miles of railway, and possessed interests in still more.

REFRESHMENT WAGON, ST. PANCRAS STATION
(Midland Railway)

Some of his transactions were at least on the borderland of fraud, and when, in 1849, he tendered his resignation of the chairmanship of the Midland Railway, the suggestion quite coincided with the views of the shareholders. Later it was discovered that he had betrayed the interests of the Midland by assisting in the promotion of a short line to connect the Great Northern with the Manchester and Leeds Railway, by means of which a considerable amount of Midland traffic passed to the Great Northern. Legal proceedings were taken by the shareholders against their late chairman, concerning shares which had been misappropriated, and judgment was given against the "Railway King." He remained Member of Parliament for Sunderland for a further ten years, but his power in the railway world had vanished, and he retired to the continent, where he would have ended his days in poverty but for the generosity of friends.

The disappearance of George Hudson from the directorate of the Midland Railway did not affect the pushing qualities of the Company. When the Leeds and Bradford system fell into the Midland net in 1851, it only needed the lease of the "Little" North Western, from Skipton to Lancaster, to open up some very great possibilities.

The Midland directorate had cast envious eyes on Manchester as early as 1846, and had arranged to connect up with the High Peak Railway at Ambergate, and thus gain access to the Manchester-Crewe line; but the formation of the London and North Western Railway put an end to the hopes of the Midland in that direction. In 1862 the latter obtained Parliamentary assent to join the Manchester, Sheffield, and Lincolnshire Railway at New Mills, which entailed the construction of a line through the Peak Forest district, which presented marked difficulties in the way of tunnelling and bridging. Piercing the Peak itself with a tunnel over a mile and a half in length was a strenuous task, that constantly called for the diversion of subterranean streams before the boring could proceed; and at Bugsworth a landslip displaced a large brick viaduct which had to be replaced by one of wood, but the engineers triumphed, and the Midland ran into Liverpool and Manchester.

London had always figured in the Midland programme. True, it could reach the metropolis via Rugby and the London and North Western metals, but the latter company did not inconvenience itself to assist the Midland. At the time it seemed likely that the two systems would amalgamate, but the arrangements fell through owing to their inability to agree concerning the value of the respective shares, which led to the Midland initiating a vital departure by the extension of its line from Leicester southwards through Market Harborough, Kettering, and Bedford, to Hitchin, on the main line of the Great Northern Railway. In 1862 the Midland paid £193,000 in tolls to the North Western for conveying its traffic between Rugby and Euston, and in the same year £60,000 was paid to the Great Northern for Midland traffic between Hitchin and King's Cross; yet even these huge payments did not prevent 5 miles of Midland coal trucks being blocked at Rugby sidings at one time, and during a single year 3400 Midland trains were delayed between Hitchin and King's Cross.

Nothing less than running into London on its own metals would satisfy the aspirations of the Midland; in due course an independent main route was constructed from Bedford via Luton and St, Albans to London; and on October 1st, 1868, St. Pancras Station was opened, and the first real Midland express left London for the north.

Having reached its main objective in the south, the Midland was now bent upon pushing farther northwards from Settle, on the Skipton to Lancashire line. The London and North Western Railway opposed this enterprise, but the Midland obtained the consent of Parliament to construct a line to Carlisle, 70 miles of wild and precipitous country that made the stiffest demands on the modern railway engineer in carrying the metals across the

MIDLAND EXPRESS LEAVING MANCHESTER
(Central Station—Cheshire Lines Committee)

Pennine Range. From Settle the line rises for 15 miles with a gradient of 1 in 100 to Blea Moor, where an embankment, tunnel and viaduct occupied 2000 men for over four years. Piercing Whernside was a stupendous task, the tunnel being driven from nine points simultaneously, from both ends and from seven intermediate shafts, sunk in some cases more than 500-ft. to rail level. Although the rock was hard enough to require blasting, the grit, limestone, and shale were somewhat treacherous, and caused the tunnel to require lining all through. After ascending to a height of 1167-ft. at Ais Gill, the line quickly drops in a succession of cuttings, tunnels, embankments, and bridges, one embankment alone, at Dry Beck, containing 400,000 cubic yards. Nearer to

Carlisle the work of construction was easier, but the whole 70 miles involved the expenditure of nearly £4,000,000 before the line was opened in August, 1875.

Having reached Carlisle, the Midland quickly cemented relations with the Glasgow and South Western for entrance into Glasgow, and with the North British for access to Edinburgh, and from thence in later years over the Forth Bridge to Dundee, Aberdeen, and Inverness, by arrangement with the Great North of Scotland and Highland railways, or to Fort William by connections with the West Highland Railway.

Meantime, the Midland had entered Bath in 1869, and in 1874

TRANSPORT OF HEAVY INGOT MOULD

(Midland Railway)

got as far as Bournemouth. Still following the policy of expansion, by joining with the North Eastern in the construction of the Swinton and Knottingley line, the Midland got a through trunk line from York to Bournemouth in the south. Later connections enabled Midland trains to run to Swansea, by several absorbed lines and arrangement with the Great Western; while in the north, from Carlisle via Dumfries, Stranraer was tapped for a service to Larne and Belfast. The construction of Heysham Harbour, near Morecambe, enabled services to be provided for the north of Ireland and Isle of Man boats; the Dore and Chinley line provides a direct track between Sheffield and Manchester; the eastern section of the Midland and Great Northern Joint railways affords a direct and through route to Cromer, Yarmouth, etc., and a direct route to Southampton by means of the Midland and South Western Junction Railway.

The building up of the Midland system has been treated at length because of its association in its early days with Stephenson and Hudson, and because of the manner in which it fought for its very existence against the competition of older and more powerful railways, which had already staked out the eastern and western sides of England as offering the fewest natural difficulties to railway construction. This last point is borne out by the fact that, out of the 54 tunnels in the British Isles over a mile in length, 12 of them are on the Midland system. The North Western owns eleven such tunnels, but three of them pierce the same obstruction at Standedge, and two of them are between Edge Hill and Liverpool.

The basis of the Midland Railway's ubiquity is the irregular St. Andrew's cross formed by its chief lines. The left-hand stroke of the X is the route from Bristol to Leeds and York, and the other, and longer, is the line from St. Pancras to Carlisle, with arms to Liverpool, Manchester, Morecambe, and Heysham. Derby is the point of junction. These are the radical routes of a system which embraces the very body of England. It is not a railway that has made its route the simplest and the most direct from London to one definite point or district of England or Scotland, but the railway that has extended itself in all directions to link the largest number of places together. Its lines are thus sometimes longer, more circuitous, and in construction were of greater engineering difficulty than those of any other company; but its guiding principle has been the sound maxim of railway construction and working, that "a railway should bend itself to the population and not leave the towns." That was the policy of George Hudson, the "Railway King" of sixty years ago, whose great abilities and greater projects have at least one memorial to-day—the Midland Railway.

More capital has been expended (£121,000,000) by the Midland than by any other British railway company, but its authorised capital is very nearly £200,000,000, or about one-fourth of the National Debt. The rolling-stock comprises 2800 engines, carriages 5489, wagons, etc., 117,571. Of road vehicles there are 7000 and horses 5158. During the course of the year nearly 15,000,000 railway telegrams pass over 31,446 miles of telegraph wire. The total number of employés is 69,356, of whom 29,500 form the uniform staff; there are 13,443 workmen in all the shops, the greater number of them at Derby, where there is also a clerical staff of 2500. The salaries and wages amount to nearly £97,000 weekly. Over 10,000 men are qualified to render first aid to the injured. The working expenses amount to 7½ millions sterling, of which one item is £450,000 for rates and taxes. On the revenue side, coaching brings in over £4,000,000, which is less than half the income from the goods, mineral, and cattle traffic (see page 233 for comparison with other companies). The passengers carried number 46,481,000; season tickets 221,862. The passenger trains travel 22,000,000 miles, and the goods and mineral trains about 26,000,000 miles, in conveying 47,533,000 tons. Every week the Company's engines consume 34,000 tons of coal and coke, the annual bill amounting to £625,000; the water for the generation of steam costs nearly £60,000 per annum.

DOUBLE-HEADING ON LICKEY INCLINE
(Midland Railway)

When the three original companies amalgamated to form the Midland Railway, they each possessed locomotive works of their own, which were at once merged into one concern at Derby under Matthew Kirtley, who was the first engine driver on the London and Birmingham Railway. Kirtley found himself superintendent of ninety-five engines all of them four-wheelers. It was not until 1851 that he constructed his first engine at Derby; it was a six-wheeler, No. 158. In 1869 he designed a group of goods engines that were built by Messrs Dübs and Co., of Glasgow. These locomotives are worthy of special notice, for they not only marked progress in type, becoming the standard freight engine of their day, but very little real advance has been made since that time. They had cylinders 17×24 in.; the wheels were 5-ft. 2-in. in diameter; and the boiler provided 1100 sq. ft. of heating surface.

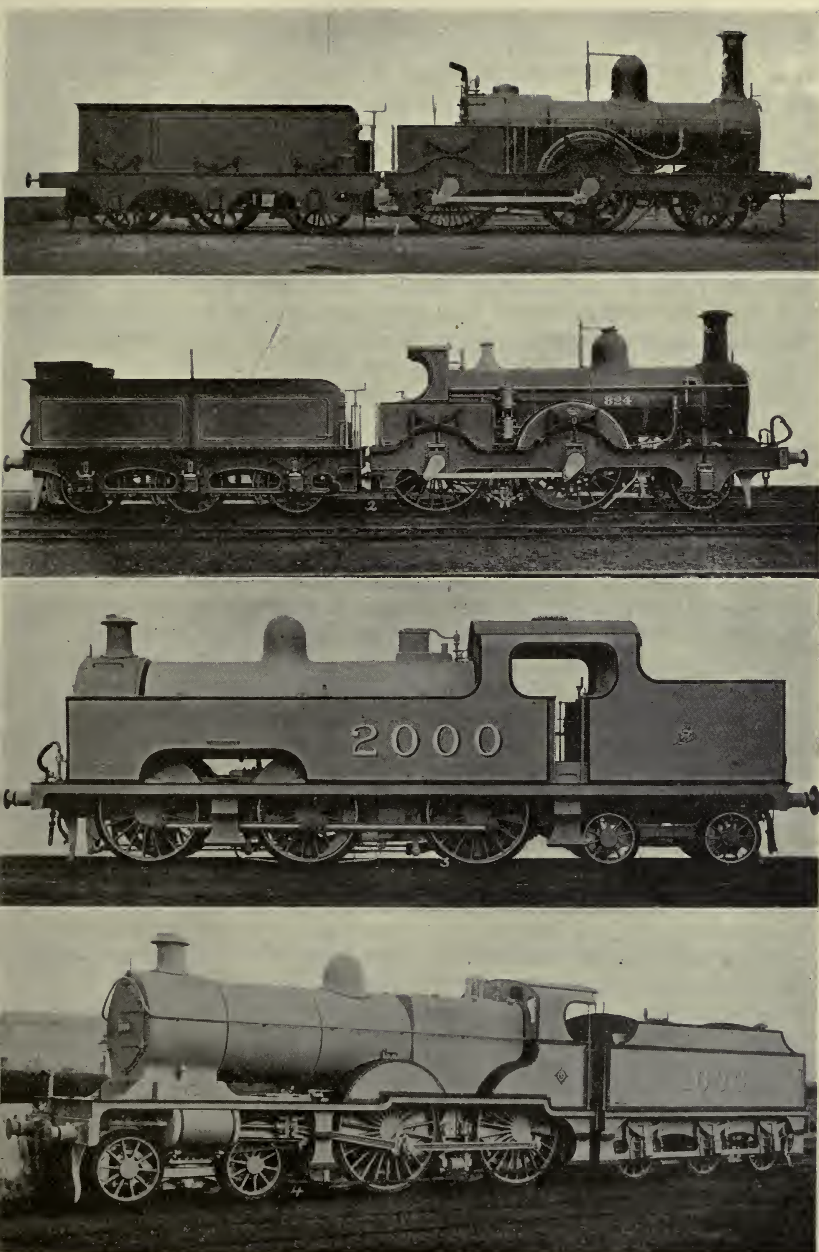
On the Birmingham and Gloucester Railway, which the Midland absorbed in 1845, is the Lickey incline with a gradient of 1 in 37 for 2 miles. At first no British engine could be found to work up this difficult section; Mr. Bury, indeed, built an engine that he calculated would be equal to the difficulty, but it could not ascend the hill, even without a load. A number of engines were obtained from Norris, of Philadelphia, and they performed the task fairly well. They were six-wheelers, of which four belonged to a leading bogie. It is sometimes claimed that these were the first bogie engines to be seen in this country, but "Puffing Billy" at one time used the bogie, as did several other later engines. In 1845, however, Mr. McConnell, in the Birmingham and Gloucester works at Bromsgrove, built a six-coupled tank engine that completely put the American engines into the shade.

Of the locomotives built at Derby works it need only be said that for general excellence they hold their own with the very best engines that run upon British metals. The Midland locomotives and passenger vehicles are painted crimson-lake.

On the opposite page are illustrated two fine examples of locomotives designed by Mr. R. M. Deeley, who was succeeded by Mr. H. Fowler in 1909. No 2000 (0–6–4) passenger tank was a type introduced to cope with heavy local trains. Chief dimensions: cylinders 18½-in. by 26-in.; heating surface 1331 sq. ft.; coupled wheels 5-ft. 7½-in. diameter; coal space 3½ tons; fitted with water pick-up; total weight 71 tons 13 cwt. No. 1000, four-coupled bogie express locomotive presents several rather uncommon features. The inside cylinders are in one casting, forming a support for the smoke-box; the piston valves are actuated by a novel arrangement of valve gear; no eccentrics are used, the valve movement being taken from the crosshead by a rod connected to the expansion link. The engine is fitted with automatic vacuum and steam brake, variable blast pipe, steam sanding gear, and carriage-heating appliances. The coupled wheels are 6-ft. 6½-in. diameter; heating surface 1557·4 sq. ft.; working pressure 220 lbs. per sq. in. Total weight of engine and tender 104 tons 9 cwt.

The Midland Company has been the pioneer in several points that have had an enormous influence on railway travelling. In July, 1840, there was a privately organised excursion trip from Nottingham to an exhibition at Leicester, which proved so successful that the Company commenced running excursions on its own account, and early in August 2000 passengers were conveyed in a single train from Nottingham to Leicester, but later in the month this feat was exceeded.

Eleven months later Mr. Thomas Cook ran his first return excur-



1. AN ENGINE OF 1850. 2. AN ENGINE OF 1870. 3. MODERN GOODS ENGINE
4. A STANDARD PASSENGER EXPRESS LOCOMOTIVE
(Midland Railway)

sion from Leicester to Loughborough, the fare being one shilling for the 25 miles. This was a private speculation; the train was hired from the Company for a fixed sum, the excess receipts being the profit of the organiser. Cook's tourist agency is now a world-famed institution, whose agents will convey travellers to any part of the globe.

For many years it was the custom to carry only first and second-class vehicles by the express trains, leaving the poorer passengers to travel by slow trains, often with wearisome waits for connections. No little stir was caused in the railway world, in 1872, when the Midland announced its intention of carrying third-class passengers on all trains.

Having introduced American locomotives into England, the Midland, in 1874, put an American Pullman-car train upon its metals. The vehicles were imported in sections and erected at Derby. Pullman drawing-room cars did not, in themselves, revolutionise British carriage-building, but they led to our excellent corridor trains of to-day (page 184). But though carriages open from end to end have found comparatively little favour in the United Kingdom, their bogie frames have been adopted very extensively in the construction of our passenger coaches, and this feature alone has meant smooth and easy motion in travelling.

In 1875 the Midland initiated a most startling change in the abolishment of second-class carriages. Whether the alteration would benefit the Company financially was a matter concerning which railway experts disagreed, but there was no doubt about the benefits conferred upon the travelling public. First-class fares were reduced to the former second-class; the third-class fares remained as before, but the passengers enjoyed the accommodation and comforts of the second-class carriages. Most of the leading companies, except the southern lines, have followed the lead of the Midland in the abolition of second-class, but the outstanding effect of the innovation was the general levelling up of third-class accommodation all over the kingdom. Third-class corridor carriages with lavatories are now in common use on all long-distance journeys; third-class dining-cars have met a popular want, and third-class sleeping-cars are bound to come in the near future. For night passengers (any class) who do not wish to avail themselves of a sleeping berth, pillows and rugs are supplied on hire at a charge of 6d. each.

The Midland is emphatically the system of through routes, and while other companies claim greater length of line, and perhaps speed of train on certain routes, none embraces a larger number of important towns than the Midland. It grapples Leicester, Nottingham, Sheffield, Leeds, Bradford, Manchester, Liverpool, Scotland, and Ireland to each other, and to London, with rails of steel and train of the familiar Midland red. All these places in turn are connected with the Midland route to Birmingham, Bristol, and the west. From Birmingham, as from London, there is no place of importance which the Midland Railway does not reach. To this wide radiation of its own lines the Midland adds a service of through carriages to and from stations on other railways unexcelled by other companies. Even from Newcastle-on-Tyne one may travel, without leaving the comfort of a Midland coach, to Bristol and Bath, and places as far apart as Swansea in the west and Cromer and Yarmouth in the east are served by the Midland Railway. The service, indeed, extends to the southern coast itself, for the Somerset and Dorset line is the joint property of the Midland and the London and South Western companies, so that the Midland carries passengers direct, and without changing, from the very north and the Midlands to Bournemouth. Through carriages are also run between Manchester, Bradford, and Leeds to Folkestone, Dover, and Deal, via Kentish Town and Herne Hill, and from Leeds to Southampton, via Birmingham and Cheltenham. Through bookings, though on a local scale, were so much a feature of the early Birmingham and Derby railways, whose amalgamation created the Midland Company, that the Railway Clearing House for the adjustment of such mutual services was first established at the suggestion of Sir James Allport, whose management of the Midland inaugurated the modern era of railway travelling.

The following are a few of the best performances of the Midland in everyday practice: London and Edinburgh, 406 miles, in 8 hours 35 minutes; London and Glasgow, 423¼ miles, in 8 hours 45 minutes; London and Sheffield, 158¼ miles, in 3 hours 2 minutes; London and Manchester, 189¼ miles, in 3 hours 40 minutes; London and Heysham, 267½ miles in 5 hours, 47 minutes. In summer, the longest non-stop run is from London to Shipley, 206 miles, and in winter Rotherham (Masborough) to London, 162 miles.

For the better working of an enormous traffic the Company has undertaken the widening of its line over a large part of its system—a course adopted by all our leading companies to assist development in speed, as well as economy in working. Coal is now brought to London from the Erewash Valley in a single night, and goods are delivered in Glasgow within eleven hours of their departure from St. Pancras—a rate of speed at which travellers were content to, and could only, travel to Scotland a quarter of a century ago. Every night between 5 p.m. and 2 a.m. thirty express goods trains leave St. Pancras for the provinces. Much merchandise is thus carried to Manchester in less than six hours, and to Liverpool in rather more than seven. Goods which are collected in London in the afternoon of one day are in the hands of the consignee at Belfast, Glasgow, and the chief English towns the following morning. This one-day goods service possesses the same speed and directness of the parcel post, or, for that matter,

1. LONDON AND EDINBURGH EXPRESS AT ARMATHWAITE
2. HEYSHAM EXPRESS PICKING UP WATER AT LOUGHBOROUGH
3. LONDON AND MANCHESTER EXPRESS AT AMBERGATE

(Midland Railway)

of the posting and delivery of letters. It is this ease and speed of service, which often is ignored in the comparisons drawn between the goods traffic of British and American railways. In this respect no railway in the United States, or any other country, offers and achieves such services as British railways.

While becoming by the completeness, frequency, and comfort of its passenger service a great passenger line, the Midland has developed and extended its resources for the transport of merchandise and minerals into almost undoubted supremacy as one of the greatest goods and mineral railways in the country.

The mineral traffic of the Midland Railway is in itself a colossal business. The line taps no fewer than eight of the great English coal-fields — those of Yorkshire, Nottingham and Derbyshire, Leicestershire, Warwickshire, South Staffordshire, Forest of Dean, Bristol, and the Swansea district of South Wales. With these are also found the iron ores, and to the blast-furnaces the Midland brings the necessary limestone for the smelting, not only from the neighbouring areas of Leicestershire, Nottinghamshire, and the Peak of Derbyshire, but also from the limestone beds of North-west Yorkshire.

How vast is the mineral traffic of the Midland Railway has its most striking illustration in the case of coal. Serving no fewer than eight of the great English coal-fields, it receives, transports, and distributes throughout the length and breadth of the land more than one-tenth of the entire coal raised and consumed in the United Kingdom. Central to these coal-fields, and at other important junctions of traffic, the Midland has constructed large "gravitation sidings" for the marshalling and making-up of the mineral trains.

The Midland Company claims that the rolling-stock for its goods and mineral traffic is more extensive than that of any other British railway company. It comprises some forty different classes of wagons: trollies, capable of carrying from 15 to 40 tons, bogie rail trucks carrying 30 tons, and other classes of wagons suitable for every description of merchandise, including heavy and bulky articles, such as circular plates, armour-plates, traction engines, iron girders, boilers, large wheels, heavy armament guns, wire ropes, etc. The total stock amounts to 127,000 wagons, about 12,000 of which are covered, refrigerator, ventilated, and fruit vans, so essential for the conveyance of meat, game, and other perishable traffic. At the opposite extreme are the special arrangements and appliances with which the Midland undertakes the conveyance of such monumental articles as the stem and stern frames of ships.

With space remaining for but a few paragraphs, one is at a loss which to choose out of scores of interesting subjects.

Serving practically the whole of England, and being emphatically the railway of the great towns, it has been a wise feature of the

Midland's policy to provide, not only for the expeditious and comfortable transport of its passengers, but also for their lodging and entertainment when arrived at their destination. In the dignity and grace of its architecture, the Midland Grand Hotel at St. Pancras is one of the most beautiful hotels in London, as it is also one of the finest of modern buildings, public or private. It was designed by the late Sir Gilbert Scott, and assists to make St. Pancras Station by far the most striking of the London termini.

The Midland hotels are wonderfully adapted to the various towns in which they stand, but probably of all those under the Company's

THE GARDEN, MIDLAND HOTEL, MANCHESTER

management the Midland Hotel at Manchester stands out most prominently. It has revolutionised the whole idea of what England expects a hotel to be. Combining the latest and most effective features of continental hotels, it is a citadel and a miniature world in one. It is independent of Manchester's infamous weather, for it is ventilated by air which is washed, filtered, and heated before being forced into the halls, corridors, and rooms. Its pivot, as it were, is the central octagonal court, with its columns of delicately tinted marble and lofty white-and-gold dome. On to this debouch the courts, corridors, and dining-rooms ; the coffee-room, a courtly saloon, richly panelled in mahogany and tapestry, and the Louis Quinze Restaurant. From this last great French windows open on to the private terrace beneath the dome, and overlook the garden with its orchestra, seats, and little tables of a *café chantant* in its enclosures of flowering and creeping plants over the steel trellis.

There are 400 bedrooms, each fitted with its own telephone, making a total of 500 instruments within the building ; the English, French, and German restaurants are each under the management of its national cook ; there is an exquisite concert-hall and theatre ; a Turkish bath, visited by 180 persons a week ; a hairdressing saloon patronised by 500 customers ; and the most complete sub-post office in any English hotel. The staff of servants numbers 380, with a wages bill of £24,000 a year. The bakery has to provide every day sufficient bread for 3000 separate portions, and the laundry lists in a year total up 1,500,000 articles. There are 7200 electric lights in the building.

Serving so large a number of our principal towns, the Midland has numerous fine passenger stations, of which St. Pancras is the chief. It is the largest station in the kingdom contained under a single span roof, which covers an area of about 4½ acres. There are ten sets of rails and seven platforms, 800-ft. in length. Underneath the floor of the station are immense cellars, where single firms stock barrels of beer by the ten thousand. Every day throughout the year several train-loads of beer leave Burton-on-Trent for London by the Midland Railway alone.

Adjoining the passenger station is the goods depôt, to make room for which about one hundred houses were demolished.

CHAPTER XIV

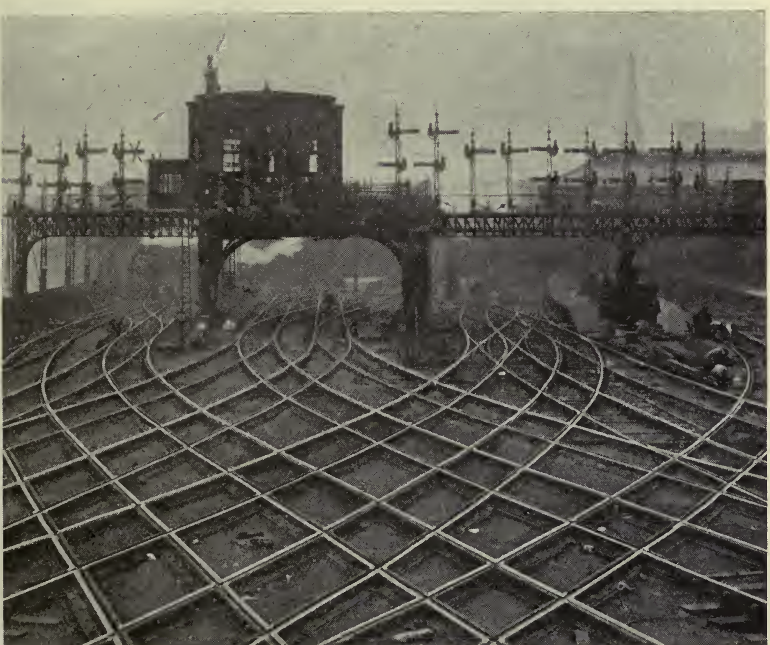
NORTH EASTERN RAILWAY

THE North Eastern Railway officially dates from its incorporation in 1854, when several of "King" Hudson's lines amalgamated. The most important companies concerned were the York, Newcastle and Berwick, the York and North Midland, and Leeds Northern. The amalgamated companies embraced 720 miles of line, and thus in mileage the North Eastern Railway was the most important in the kingdom. In July, 1863, the Stockton and Darlington Railway was absorbed, and consequently the North Eastern system practically dates back to the first public railway in the world.

No railway in the kingdom, except the Great Eastern, can compare with the North Eastern system for compactness of territory and for freedom from competing lines. It now possesses 1734 miles of line with York as the centre of the metal web, which enmeshes Yorkshire, Durham, and Northumberland, and flings out arms into Cumberland and Westmorland. Apart from its own territorial business, the North Eastern is a partner in the East Coast Route to Scotland, linking up with the Great Northern at Shaftholme Junction, 28 miles south of York, and with the North British Railway at Berwick-on-Tweed. The main line is remarkably free from long tunnels, but there are numerous fine bridges, of which those at Newcastle are of outstanding importance.

The famous "High Level" Bridge, the oldest double-decked bridge in the kingdom, is a permanent source of interest to engineers and a monument to the ability of its constructors. The Corporation of Newcastle having insisted that the bridge should carry an ordinary high road as well as a railway, the constructors, Robert Stephenson and Thomas E. Harrison, ingeniously arranged for a carriage-way to depend on the arches of the railway bridge, the lower level thus becoming a portion of the great north turnpike. The river, where the bridge crosses, is about 515-ft. in width, but, to cover the sloping shores, a structure 1372-ft. in length was necessary. There are six spans of 125-ft. each, supported on sandstone piers, some of which are from their rock foundation as much as 146-ft. high. These piers are founded on piles—some of them 40-ft. in length—driven through the hard sand and gravel to the solid rock below. Nasmyth, of steam-hammer fame, had invented a steam pile-driver that drove a pile at the rate of 8-ft. a minute. The piles were 13-in. square, and were placed 4-ft. apart, centre to centre, the spaces between being filled with concrete. The masonry in the bridge was calculated to be 686,000 cubic ft., and the weight of ironwork 5050 tons ; the total cost of the erection was £356,000.

As traffic increased, the necessity for a second railway bridge became more and more apparent ; the daily average of trains and light engines crossing by the three lines available having reached



DIAMOND CROSSINGS, NEWCASTLE-ON-TYNE
(North Eastern Railway)

about nine hundred. In 1900 Mr. C. A. Harrison designed the King Edward Bridge, which crosses the river about half a mile farther up than the High Level, and is approached from the west end of the Central Station. There are four tracks over the bridge, the main north-to-south lines taking the western side of the bridge, while the remaining two accommodate the mineral and goods traffic. The total length of the main bridge, measuring from the abutment on the north side to the abutment on the south side, is 1150-ft. The five main girders of the three north spans are each 4-ft. 6-in. in width, and are placed at 11-ft. centres. They are

27-ft. in depth, and the width from centre to centre of parapets is 48-ft. 6-in., and the breadth of steelwork over all is 50-ft. There is 6-ft. between the tracks, and a pathway for the plate-layers on either side.

The total weight of steelwork is : north span, 950 tons ; the two central spans, 3482 tons ; and the southern span, 1350 tons. As the rails begin to diverge on the pier at the south side of the river, they are some distance apart at the abutment, there being 132-ft. between the parapets. For this span of 191-ft. there are also five girders, but they spread out towards the south like a fan instead of being parallel. The three inside girders are 24-ft. deep, so as to allow for trough flooring to carry the tracks, and the outside girders are similar to the main spans, i.e. 27-ft. deep. The girders are of similar lattice to the girders of the other spans, but the rails are carried on sleepers laid on ballast, resting on the trough flooring which is filled with concrete. This flooring is 16-in. deep, and the span varies from 7-ft. to 27-ft. near the south abutment.

The three central piers of the bridge are built of grey granite, and the greater part of the abutments are the same, while the approach arching is of red sandstone. The north and south river piers each contain about 135,000 cubic ft. of granite, and the centre pier about 195,000 cubic ft.

The foundations of the river piers have all been taken down to the same depth of 69-ft. below high water, and are built in caissons. The caissons were constructed of mild steel, the weight of each being 667 tons ; they are filled with cement concrete and rest on the hard shale. The foundation-stone of the bridge was laid on July 29th, 1902, by Mr. C. A. Harrison, the chief engineer, and the completed bridge was opened by His Majesty King Edward VII on July 10th, 1906. The total cost of the bridge and approaches was £536,000.

Although not on the main line to the north, mention must be made of the fine bridges over the Wear at Sunderland. The first to be erected was the Wearmouth Road bridge, which was opened for traffic in August, 1796. A railway bridge alongside this structure was built during the years 1875–9.

The excavations for the pier on the north side of the river were commenced in May, 1875, and those on the south side in November of the same year. Great difficulty was experienced in the endeavour to discover a foundation for the south pier, and it was found necessary to sink large cast-iron cylinders into the river-bed. A large number of these cylinders, which were 5-ft. in diameter, were sunk, some of them to a distance of 35-ft. below low-water-mark. When once satisfactory foundations were secured good progress was made, and soon two solid ashlar piers began to arise. The approaches to the central span on each side of the river consist of three arches, each arch having a span of 31-ft. 4-in. Before the main central span

PLATE VIII.

THE NEWCASTLE AND SHEFFIELD EXPRESS BETWEEN DARLINGTON AND YORK.
The fastest regular booked run in the British Empire. (North Eastern Railway.)

was begun, large wooden piles were driven into the river-bed, and two large wooden piers formed the base of a network of staging, which rose to a height level with the main girders. The traffic of the river was not stopped during the building, an arched opening being left to allow vessels to pass up and down the water. A tremendous amount of timber was necessary, and some idea of this can be gained when it is stated that the total cost of the staging was upwards of £10,000.

The central span over the river consists of two girders of great strength and cross girders for carrying the permanent-way. The depth of the main girders in centre is 42-ft., and the top and bottom are rectangular, 4-ft. broad by 5-ft. 6-in. deep. The span is one of

A TRAIN OF 14 ENGINES AND 12 TENDERS
Testing King Edward's Bridge, September 29th, 1906
(North Eastern Railway)

300-ft., and the weight of iron used in the construction was upwards of 1000 tons. From high-water mark to the rail level there is a clear distance of 87-ft.

The bridge was tested on Thursday, July 24th, 1879, with 14 of the heaviest locomotives then available, viz. 2 tank engines 48 tons each, 12 express engines 35 tons each, and 12 tenders 25 tons each, the aggregate weight being 816 tons. The works were completed and the bridge and station brought into general use on Bank Holiday, August 4th, 1879.

For some years prior to 1900 the inconvenience of having no more than one road-bridge over the river—Wearmouth Bridge—in the vicinity had been greatly felt, and many suggestions had been put forward to widen the existing structure. However, owing to the town extending westward, and for other reasons, the question ended in an agreement being made between the Corporation of Sunderland and the North Eastern Railway Company to construct a double platform-bridge over the river; the upper platform to carry two lines of rails, and the lower to form a roadway. The terms were that the railway company should be responsible for the erection of the bridge, and that the Sunderland Corporation should pay £146,000 towards the cost.

The site chosen was about half a mile higher up the river than the Wearmouth bridges, and the design for the new structure was prepared by Mr. Charles A. Harrison, engineer to the railway company, and an Act of Parliament authorising its building was passed in the year 1900. One of the chief clauses inserted in the Bill was that the navigation of the river should be kept free and clear, and after full and careful consideration of various schemes, the tender and method of erection put forward by Sir William Arrol and Company, Ltd., of Glasgow, was accepted. Their method was temporarily to convert the main girders into cantilevers and erect the main span by overhang from each pier. The firm had had considerable experience in the erection of the Forth Bridge, but, in the case of the Wear Bridge, the problems to face were, in some respects, very much greater. The centre suspended girder between the cantilevers of the Forth Bridge is 350-ft. in length, with a weight of 850 tons; that of the Wear Bridge is 353¾-ft. in length, with a total weight of 2600 tons, or three times as heavy as the centre girder in the main Forth span. In the case of the Forth Bridge there is only a single platform, but the Wear Bridge is a two-decker, and this, of course, added greatly to the weight of the structure and the problems to overcome. The length of the Wear span is only exceeded by one or two other spans in this country, but, taking weight for length, is greater than any other independent span in Great Britain, the weight working out to 7½ tons per lineal foot. The depth of the main girders is 42-ft., and there is a clear distance of 85-ft. above high-water mark.

By the beginning of October, 1908, the two halves of the span were nearly completed, and at length, after careful measuring, the closing pieces were fixed until there was only a gap of 1¼-in. left to fill up. Temperature and its effects on the expansion and contraction of steel had been allowed for, and just about noon on Thursday, October 15th, the temperature rose sufficiently to allow the steelwork to expand and close up the gap, when the ends were rapidly bolted together. The maximum weight suspended from the temporary structures before the closing lengths were fixed was 2780 tons, and 800 tons of steelwork were employed in the temporary work for the erecting of the span, and about 20,000 bolts were used.

The total length of the bridge and approaches is 1560-ft., and the contract price was £350,000. The total cost, however, including approaches, was close upon £450,000, of which sum about £200,000 was borne by the Sunderland Corporation, and about £11,000 by the Southwick Urban Council.

The opening ceremony took place on Thursday, June 10th, 1909, when the Earl of Durham, handling a pneumatic machine, fixed the last rivet, and the Right Hon. J. Lloyd Wharton announced to the brilliant assembly present that Queen Alexandra had given her gracious consent to the new structure being called the "Alexandra" Bridge.

The North Eastern Railway Company is proud of the fact that the first passenger train in the world was run over what is now part of the North Eastern system, viz. between Stockton and Darlington, on September 27th, 1825. The engine was that day driven by the

BREAK-DOWN CRANE-ENGINE LIFTING A LOCOMOTIVE
(North Eastern Railway)

man who built it—George Stephenson (whose birthplace, a small cottage, is still to be seen at Wylam, between Newcastle and Hexham, by the line side). This first engine—the most interesting and historical railway relic in existence—is now carefully preserved on a pedestal at Darlington (Bank Top) Station, and can thus be seen by passengers travelling to and from Scotland by the East Coast Route. The reader will find this old engine illustrated on page 28.

A notable event in the history of the Company was the celebration of the Stephenson Centenary at Newcastle-on-Tyne on June 9th, 1881. A unique feature of the proceedings was the triumphal passage of seventeen locomotive engines from Newcastle, past the humble cottage where the hero of the day first saw the light, to North Wylam and back. With one exception they represented the practice of the time, and to imagine, for comparison, a similar procession to-day would be to realise in the most forcible manner the great advance in power, weight, and size which the locomotive has made in the comparatively short space of thirty years.

So far as possible for the sake of effect, a light-coloured engine and one with dark painting alternated, in the order which was finally prescribed and carried out. A start was made from Gateshead shortly before 8 a.m., and as the novel "train" passed over the "High Level" Bridge in full view of many thousands of people assembled in the streets and quays below, it presented a spectacle of remarkable interest.

The line, along which the engines passed after leaving the old Newcastle and Carlisle section of the North Eastern Railway just beyond Scotswood, belonged in 1881 to a small independent company called the Scotswood, Newburn, and Wylam Railway, and was the direct successor of the wooden tramroad, afterwards laid with cast-iron plates, and later on with fish-belly rails, on which Hedley's engine "Puffing Billy" (now at South Kensington) exhibited its somewhat feeble powers from 1813 till 1862. The line was in 1881 worked by the North Eastern, and has since been amalgamated with it.

The house in which George Stephenson was born is of a better class than those which most people of his parents' position inhabited, probably, at the close of the eighteenth century. It is built substantially of stone, and partly roofed with thin slabs of the same material. The railway passes so extremely close to the south front of the house that any little future George Stephensons, who may live there, certainly must cause their parents perpetual anxiety as to their safety.

The procession of engines did not stop at Stephenson's cottage, but passed slowly on to North Wylam, the whole trip of about 8½ miles taking upwards of half an hour. They drew up a little beyond the station, and were inspected with the greatest of enthusiasm by a crowd of admirers, who lingered about as long as the engines remained there. At North Wylam the Vicar of Ovingham (the Rev. W. M. Wray) produced the register-book of the parish church, showing the entries of the marriage of George Stephenson's parents and of his baptism. These events took place on May 17th, 1778, and July 22nd, 1781, respectively. In those days baptisms, rather than births, were recorded in the church registers, births being usually noted with great care and pride in a family Bible of considerable size and antiquity. The Stephensons seemed to have lived at Street House till about 1789, when George would be eight years old, removing afterwards to several places in the same neighbourhood.

The procession to Wylam comprised seventeen engines, one having been added at the last moment which does not appear in the official record. The seventeen represented, however, only seven railway companies, and might easily have been more comprehensive, even without increasing the number. No fewer than six belonged to the North Eastern Railway, whose officials naturally considered themselves entitled to the best display, whilst three more represented their partners in the East Coast Service, viz. the Great Northern and the North British Railway. The Lancashire and Yorkshire Company sent three engines, the London and North Western and the Midland two each, and the London, Brighton and South Coast Railway one. Out of the seventeen, three were single engines, nine were four-coupled, and five were six-coupled. There were four tanks, six engines had bogies, and one a radial axle; only two had outside cylinders. One North Western engine, No. 619, "Mabel," named after Stephenson's mother, was a Webb 2–4–0, with 78-in. drivers; the second, "Locomotion" (2–2–2) with 72-in. drivers, was built by Alexander Allan at Crewe in 1842, only 17 years after Stephenson built the first famous engine of that name. It was a pity that the engine shown overleaf could not have joined the procession.

The next stage in the proceedings was the visit of the mayor and corporation of Newcastle to Street House. Accompanied by a large number of representative men, the party, soon after 9.30 a.m., left in a special train of nine saloon coaches, in charge of Mr. Cuthbert Williamson, the oldest guard on the North Eastern Railway. The train ran down without a stop, saluted, like the engines an hour before, by joyful demonstrations of every kind. Pulling up in front of the house, the party got out and proceeded to the field behind it, where at some half-dozen yards from the east end of the building the mayor (Alderman J. Angus) formally planted an oak tree as a memorial of the occasion. A short but most appropriate speech was made by him, after which the party glanced at the interior of the house, especially the room in which Stephenson was born. In the room was a large portrait showing him on Chat Moss, said to have been given personally to an old friend named Jonathan Forster, who long lived at Street House, and died there only a few years before this occasion.

"It is pleasant to think," says Mr. W. B. Paley, to whom we are indebted for this interesting account, "that this memorable occasion was by no means forgotten in other countries which have benefited as much, perhaps, as our own from the genius and energy of George Stephenson. The Austrian Railway Officials' and Engineers' Club celebrated it by a dinner at Vienna, from which they telegraphed their congratulations to the Mayor of Newcastle. At Rome a tablet, bearing an inscription to his memory and erected by the railway men at the terminus, was uncovered in the presence of the British Ambassador and the principal railway and municipal authorities. Several of the leading German papers published articles in his honour. At Turin, Liége, Prague, and Amiens celebrations were held, nor was the occasion overlooked in America. Of a very few people, indeed, can it be said that their fame was ever commemorated on such a world-wide scale, nor have many, perhaps, deserved it so well as the rugged, kindly Northumbrian genius, George Stephenson.

Various early locomotives, such as "Puffing Billy," the "Rocket," "Invicta," etc., are preserved in different parts of the country; but undoubtedly the most interesting engine in existence is one that is *still* at work on Hetton colliery railway. The construction of this 8-mile line from the colliery to the Wear was commenced by George

A NINETY-YEAR-OLD LOCOMOTIVE STILL AT WORK
(Hetton Colliery)

Stephenson in 1819, and was the first public recognition of his capabilities as a railway engineer, since at Killingworth colliery, where he built "Blucher," he was only employed at a wage. That the Hetton colliery should still be in active work is interesting in itself, but that an engine, built in 1822 by George Stephenson and his partner Nicholas Wood, should have been hauling the coal trucks for a period of nearly ninety years is positively remarkable. Of course, as metal is not everlasting, there cannot be much of Stephenson and Wood's original work still remaining in the engine, but in its general design, except for the addition of the cab, the engine appears practically the same as when it left the workshop.

Sir Lindsay Wood, one of the present proprietors of the colliery, is the son of Nicholas Wood, and when the veteran engine is past work, there is little fear that the old-time locomotive relic will be allowed to find its way to the scrap-heap.

When the North Eastern commenced business after the amalgamations in 1854, it found itself in possession of over 370 locomotives, of which no less than 240 had belonged to the York, Newcastle, and Berwick line. One of these was designed by Mr. T. R. Crampton. It was a peculiar kind of tank engine, running on only four wheels, which were all coupled to an intermediate crank shaft, to which motion was transmitted in the usual way from inside cylinders. The coupled wheels were 5-ft. in diameter; the boiler was remarkably small and low-pitched, the firebox being raised above it considerably. Another notable engine in the stock of the York, Newcastle, and Berwick was Hackworth's "Sanspareil," named after the engine that competed in the Rainhill contest. Its driving wheels were 6-ft. 6-in. in diameter; leading and trailing wheels 4-ft. diameter; weight, in working order, 8 tons 6 cwt. This engine was one of the first to have the lagging of the boiler covered with sheet iron, instead of the usual custom of leaving the wood lagging exposed to view. But for an untoward accident, the original "Sanspareil" might have beaten the "Rocket" at Rainhill, and Hackworth was very desirous of trying the finest example he had designed against the best engine turned out by the Stephensons, but no contest was arranged, chiefly because it would have served no useful purpose.

In 1845 the "Battle of the Gauges" was raging, and Messrs. R. Stephenson and Co. put out a specially built engine to compete with the broad-gauge locomotives. At first it had no number, and was known as "A," or "Great A." It was claimed to be the fastest engine that had ever run upon rails. It was one of Stephenson's patent long-boiler type of engines, having the firebox behind the trailing wheels; the driving wheels were 6-ft. in diameter, and total heating surface 903 sq. ft. With a load of seven coaches "Great A" ran from York to Darlington, 44¼ miles, in 47 minutes. The engine afterwards passed into the hands of the York and North Midland Railway, and at the amalgamation became one of the North Eastern stud.

The York and North Midland engines were of particularly good quality, and included some of the finest "single" expresses then in existence. Among them were ten engines, consisting of the original "Jenny Lind" and her sisters. Various companies are sometimes erroneously credited with the ownership of the original "Jenny Lind," but Mr. J. Kitching puts the matter beyond the range of doubt. The first two were delivered at York without any name-plate. On the arrival of the next one (No. 321) the name "Jenny Lind" was attached below the dome cover, and level with its base, on a brass plate with raised letters on each side of the engine. It was from this circumstance that the type ever afterwards was known as the "Jenny Lind." The dimensions of the engine were as follows: driving wheels, 6-ft. diameter; leading and trailing wheels, 4-ft. diameter; cylinders, 15-in. diameter by 24-in. stroke. The boiler contained 124 tubes; total heating surface, 800 sq. ft. Weight of engine in working order, 25 tons.

In 1848 one of these famous "Jenny Lind" engines, attached to a news special from London to Scotland, ran from Normanton to York at 52 miles an hour, a very meritorious performance at that period.

In 1871 Mr. T. Bouch designed at the North Road engine works a class of exceptionally powerful four-coupled bogie engines (4 – 4 – 0), chiefly for working passenger trains on the steep gradients between Darlington and Tebay. Ten of these engines in all were constructed. Their most remarkable feature was the cylinder stroke, being no less than 30-in. in length, and only recently equalled by any other British locomotive. On account of their large proportions these engines became known as "Ginx's Babies." The leading dimensions were: driving and trailing wheels, 7-ft. diameter; bogie wheels $3\frac{1}{2}$-ft. diameter; cylinders, 17-in. by 30-in.; boiler, 10-ft. long, with 210 tubes; pressure, 140 lbs.; heating surface, 1217 sq. ft.; weight of engine, $41\frac{1}{4}$ tons. It was said that "Ginx's Babies" could attain a speed of 60 miles an hour with a train of fourteen passenger coaches.

Thanks to its partnership in the East Coast Route, it has been necessary for the North Eastern to possess engines capable of the highest speed; and consequently the Company has always been in the forefront with the adoption of every aid to efficiency, as shown in the racing records of 1888 and 1895, and in the fact that during a recent summer the "Flying Scotchman" arrived at Edinburgh at or before time sixty-seven days out of seventy-nine. Mr. T. W. Worsdell, who was locomotive superintendent from 1885 to 1890, was a distinguished advocate of cylinder compounding, and, like Mr. F. W. Webb of the London and North Western, put his belief into very active practice. Space will not allow us to follow in full detail the developments in North Eastern Railway locomotive practice during the last quarter of the nineteenth century, and the reader anxious for a chronological account cannot do better than consult Mr. J. S. Maclean's excellent history of the *Locomotives of the North Eastern Railway*.

Coming to the twentieth century, we find Mr. Wilson Worsdell, in 1903, putting out from the Gateshead works large express locomotives of the "Atlantic" or 4 – 4 – 2 type. Some of the leading dimensions were: bogie wheels, diameter 3-ft. $7\frac{1}{4}$-in.; driving wheels, 6-ft. 10-in.; trailing wheels, 4-ft.; distributed over a total wheel-base of 28-ft. Outside cylinders of exceptional size,

1. A "JENNY LIND." 2. POWERFUL MINERAL ENGINE, 0–8–0
3. PASSENGER EXPRESS LOCOMOTIVE, NO. 696, "ATLANTIC" TYPE
(North Eastern Railway)

diameter 20-in. and stroke 28-in. Boiler, 15-ft. 10½-in. long, with diameter outside the plates, 5-ft. 6-in. The firebox casing measured 9-ft. in length; grate area, 27 sq. ft.; total heating surface, 2455 sq. ft. Working pressure, 200 lbs. per sq. in. Weight of engine, 72 tons; tender, 43½ tons, its capacity being 4125 gallons of water and 5 tons of coal. No. 532 was the first of ten of these engines known as the V-class. This pioneer of the "Atlantic" type on the North Eastern Railway was at once christened the "Gateshead Infant" on account of its huge proportions. In a few weeks' time it was returned to the shops to have the cab roof raised, for it was found that the large boiler constituted a difficulty in arranging for a proper look-out for the engine-men. When little more than a month old No. 532 hauled the "Flying Scotchman" from York to Newcastle with 300 tons behind the tender, and gained six minutes on booked time. This was the first run of a North Eastern "Atlantic" engine on an important east coast express. In June, 1910, Mr. Worsdell retired, and is now the consulting mechanical engineer, being succeeded as chief mechanical engineer by Mr. Vincent L. Raven.

The portion of the North Eastern system included in the East Coast Route is only a small portion of the whole system, which provides excellent services to a large number of important towns, such as York, Darlington, Durham, Newcastle, Gateshead, Bridlington, Hull, Ilkley, Harrogate, Leeds, Scarborough, South Shields, Stockton, Middlesbrough, the Hartlepools, Sunderland, Bradford, Sheffield, Doncaster, Carlisle, etc.

In any consideration of the North Eastern services the express trains to the north claim first notice. The term "Flying Scotchman" is applied to the two trains which leave Edinburgh and King's Cross respectively at 10 a.m. and perform the throughout journey of 393 miles in 8¼ hours—an average speed of 47·64 miles per hour. Both the up and down "Scotchman" are duplicated during the summer months. On the up journey the "Scotchman" stops at Berwick, Newcastle, Darlington, York, and Grantham, but on the down journey the stop at Darlington is omitted. If the time standing at stations be deducted, the speed of the down train averages 50·49 miles per hour, and that of the up train 50·82.

The starting time (10 o'clock) of these trains was fixed some fifty years ago. In February, 1859, the train leaving Edinburgh at 10 a.m. was due to arrive at King's Cross at 9.30 p.m., so that very considerable acceleration has taken place since then. Prior to November, 1887, this train carried first and second-class passengers only, and the journey each way was performed in nine hours. Commencing in November, 1887, third-class passengers were conveyed for the first time, and this action on the part of the East Coast companies resulted in the historic railway race of 1888, between the trains on the East and West Coast Routes.

In those days there were no dining-cars, and the train stopped half an hour at York to allow for lunch ; this during the race time was reduced to 20 minutes, On August 31st, 1888, the East Coast train performed the journey from King's Cross to Edinburgh in 7 hours and 27 minutes, notwithstanding a wait of 26½ minutes at York and delays at Selby and Ferryhill.

Although this was a record time for the "Flying Scotchman," yet the actual time between London and Edinburgh was brought down to 6 hours 19 minutes in 1895, when the race to Aberdeen

SCOTCH EXPRESS LEAVING YORK
(North Eastern Railway)

took place. The train in that instance was the 8 p.m. sleeping-car express from King's Cross.

It was in 1900 that dining-cars were first put on to these trains (the first East Coast dining-cars, however, were run in 1893, on the afternoon expresses leaving King's Cross and Edinburgh at 2.30 p.m.), and it was in 1900 that the present time of 8¼ hours was adopted.

Under normal conditions the train now consists of eight corridor bogie vehicles, weighing 279½ tons, with accommodation for 62 first- and 183 third-class passengers. The down train, in addition, conveys the travelling post-office between York and Edinburgh, and the up train a slip carriage from York to Doncaster.

The Leeds to Edinburgh express performs the throughout journey in 4 hours 32 minutes. The train runs via York, and the actual distance covered, therefore, is 230 miles. The timing is as follows:

			Distance Miles	Distance Chains	Miles per hour
Leeds	dep.	9.0 a.m.	25	44	43·8
York	arr.	9.35 ,,			
,,	dep.	9.43 ,,	80	11	57·24
Newcastle	arr.	11.7 ,,			
,,	dep.	11.14 ,,	124	31	54·08
Edinburgh	arr.	1.32 p.m.			

This train was first put on as a daily train in the summer of 1901, leaving Leeds at 8.47 a.m. and arriving at Edinburgh at 1.30 p.m. It ran three days a week throughout the following winter, and daily in the summer of 1902, but was then accelerated to leave York at 9.35 and arrive at Edinburgh at 1.30 p.m. It was discontinued in the winter of 1902–3, but resumed again in the summer of 1903. The original time allowed from York to Newcastle was 90 minutes, but this was brought down to 82 minutes from October 1st, 1904. In April, 1910, an additional two minutes were allowed on account of slacks necessitated by pitfalls in the neighbourhood of Chester-le-Street, but still to-day this train is the quickest by any route from Leeds to Edinburgh.

At the present time it consists of six vehicles from Leeds to York, weighing 152 tons, with accommodation for 292 passengers. Two of the vehicles are for Scarborough, and are detached at York, but an East Coast van is added, and the load from York to Newcastle is 127 tons, with accommodation for 209 passengers. At Newcastle the train is increased to seven vehicles including a dining-car, and the total weight is 195 tons.

Having regard to all the circumstances, such, for instance, as the speed restrictions at Durham, Chester-le-Street, Morpeth, and Berwick, and the very steep banks to be negotiated between Berwick, Grant's House, and Cockburnspath, where there are several miles of 1 in 190 and 1 in 200, the performance of this train is one of the finest in the kingdom.

Coloured Plate VIII of the famous 12.20 Newcastle to Sheffield express travelling at full speed is from a photograph taken by Mr. R. J. Purves, of the signalling engineers' drawing office, Newcastle-on-Tyne. The train depicted has for some years headed the tables of "Fastest Runs on British Railways." The portion of the journey earning for it this distinction is that between Darlington and York, 44⅛ miles, which it is booked to cover in 43 minutes—equal to 61·57 miles per hour—and, on occasion, the log has shown an average speed of 68·5 miles per hour over 36 miles of the distance. The best tribute of all is that contained in Mr. Purves' letter which accompanied the photograph: "I have often timed this train, and find the time-keeping almost monotonous in its excellence. Even in the worst weather time appears to be kept with ease. I am sure there is every credit due to the men on the foot-plate for the splendid running day by day of this 'the fastest train in the British Empire.'"

On February 4th, 1911, this train accomplished the journey from Darlington to York in 41 minutes, which gives an average speed of 64·57 miles per hour.

The North Eastern Railway owns 2000 locomotives, more than

A SECTION OF THE COAL SIDINGS, HULL
(North Eastern Railway)

4500 coaching vehicles, and nearly 112,000 goods vehicles of various kinds. In this last respect the number of vehicles is less than those owned by the Midland Railway, but, nevertheless, the North Eastern is the largest mineral carrier in the kingdom; and consequently its goods and mineral engines altogether outnumber the passenger locomotives in the proportion of seven to two.

It is not generally known that as early as 1865, at Darlington, Mr. E. Fletcher built for the Company his 1001 type of engine, with heating surface of 1578 sq. ft., an area that was not beaten until the eight-coupled engines came out in 1901; many of these earlier engines are still running.

In 1901 were built ten eight-coupled mineral engines, the first batch of what has grown into the very numerous class T. The engine wheels were 4-ft. 7¼-in. diameter; tender wheels, 3-ft. 9¼-in. diameter; cylinders, 20-in. by 26-in.; heating surface, 1675 sq. ft.; tank and wheel capacity, 3701 gallons; coal space, 5 tons. Total weight of engine and tender, in working order, 96 tons 18 cwt. These engines were intended to draw trains of 60 loaded wagons of coal, but proved their capability of drawing 72, equal to a load of 1170 tons for one train, exclusive of the brake-van. Nor is this the limit of their power, for one of these monster engines has hauled a train-load of 1326¼ tons, whose total length was 569 yards, forming the longest train the Company had ever dealt with.

Long mineral trains would appear to be an absolute necessity on the North Eastern Railway, for on its metals in the year 1910 were transported no less than 63,722,862 tons of goods and minerals, of which coal and coke roughly accounted for two-thirds. The Company's own locomotives in the same year consumed 880,000 tons of coal, and the coal bill for the whole system amounted to nearly £530,000. The North Eastern Railway employés number 51,950, of whom nearly 10,000 are employed at the locomotive works at Gateshead and Darlington, and the carriage and wagon works at York, Shildon, and Heaton.

CHAPTER XV

GREAT NORTHERN RAILWAY

The highroad, known as Ermine Street, between London and Lincoln, was originally constructed by the Romans, whose judgment in road-making is well known. That historic road generally was followed by the Great Northern Railway from London to Peterborough, Boston, and Lincoln; but afterwards the main line was made to coincide more with Telford's new road to the north.

It goes without saying that the early railway promoters speedily fixed upon a line from London to York, a journey that the fastest stage coaches performed in four days; Dick Turpin's bonny Black Bess had accomplished it in sixteen hours, but a brother highwayman once rode from Chatham to old Eboracum in the same time, including a delay of nearly an hour in crossing the Thames. The Rennies were the first to moot a railway from the metropolis to Yorkshire as early as 1827, but the idea came to nothing. In 1835 the route of the Great Northern Railway was surveyed, and a Bill sent up to Parliament, but as the Commons refused assent the project was dropped. In 1844 the Direct Northern and the London and York issued prospectuses, and forthwith the advocates of the three schemes commenced to fight for precedence. After a great waste of time and money the three schemes were amalgamated under the title of the Great Northern Railway, its Act being passed in June, 1846.

At this time it was possible to travel by rail from London to York, via Rugby and Derby, on the metals of the London and North Western and Midland railways. The Great Northern route was equally roundabout, for the course lay through Peterborough, Boston, and Lincoln. The contractor for the section between London and Peterborough was Thomas Brassey, who, since his first agreement for a small portion of the Grand Junction Railway, had been engaged in building quite a thousand miles of track in different parts of the kingdom, involving liabilities of £9,000,000 on his own account and a similar sum in conjunction with two partners. Brassey eventually constructed thousands of miles of line, sometimes having in his employ 80,000 men, which gained for him the title of "Navvy King." His employés loved him for his geniality, while his own employers found him to be a man of sterling integrity. When the Great Northern Railway failed to make the payments on account as agreed, the contractor did not take advantage of the difficulty, although quite commonly railway companies made contractors pay heavily for failure to construct lines in the stipulated time. Brassey never allowed thought of gain to mar his reputation, as evidenced by an incident during his construction of the Rouen and Havre line in France. He repeatedly protested against the quality of the material which the French company

NO. 3 DEPARTURE PLATFORM, KING'S CROSS
(Great Northern Railway)

insisted upon using for a viaduct, and its collapse proved the Englishman to be right. Although neither moral nor even legal liability rested upon Brassey, he said that he had contracted to make and maintain the road, and he would be as good as his word. He rebuilt the viaduct, making fourteen million bricks upon the spot, and completed the task in seven months.

A 14-mile section of line in Lincolnshire was ready for traffic in 1848, but the section from London to Peterborough was not completed until two years later. On August 8th, 1850, the first Great Northern train left London for the north, from which date the Great Northern Railway took up its position as one of the leading trunk lines of the country. Until 1852 the London terminus was at

Maiden Lane, but on October 14th of that year King's Cross was opened. At that time it was the largest station in the metropolis, and its roof was the largest in the world.

Hitherto the London and North Western Company held the key to the north of England, and naturally the new route was calculated to divert not a little of its traffic. The London and North Western, therefore, promptly made alliances with various provincial railways in order to retard the development of the Great Northern. In 1860, however, the Manchester, Sheffield, and Lincolnshire entered into a fifty years' agreement with the Great Northern, thus opening up a new route between London and Manchester, and giving the new company access to many places in Lancashire that had been served solely by the London and North Western Railway.

The next move was an incursion into the district west of Manchester, another London and North Western preserve. The Great Northern and its ally, the Manchester, Sheffield, and Lincolnshire, assisted to finance various small local Cheshire lines, and in this direction took the Midland Railway into partnership. The final outcome was the Cheshire Lines (Committee), but with the greater portion of its system in Lancashire, its chief feature being a direct line between Manchester and Liverpool; and thus we find the Great Northern handling traffic that had never appeared within the bounds of possibility when the Company was first promoted. So well did the alliance between the Great Northern and the Manchester, Sheffield, and Lincolnshire work, that at one time it seemed probable that the larger company would purchase the smaller one; in fact, it was only a question of price that prevented the two systems being merged into one.

Another company that the Great Northern would like to have absorbed was the Great Eastern; between the two there was considerable rivalry, for while the former had invaded the territory of the Great Eastern, the latter could not get into communication with the north of England, owing to the opposition of the Great Northern. Amalgamation was suggested, and came to nothing; but in 1879 the two companies went into partnership in the Great Northern and Great Eastern Joint Railway, which extended from Huntingdon to Doncaster, via March, Spalding, and Lincoln.

From the commencement the Great Northern had running powers into Leeds, around which it has since constructed a network of lines that form quite a stronghold in the West Riding, while it now possesses a route of its own into Leeds. In this part of the country the Great Northern and Lancashire and Yorkshire work very harmoniously, running over each other's metals, and using the stations at Leeds and Bradford jointly, as well as at other less important places. To gain an adequate idea of the ramifications of the Great Northern, the reader must consult the Company's map, which will show that there are few towns of importance in the Midlands or the north of England that the system does not touch; but the great feature of the Great Northern Railway is its share in the East Coast Route to Scotland, which may be left until the leading train services come under consideration.

The main line is particularly free from steep gradients; there are several short sections of about 1 in 50, but they are chiefly beyond Wakefield and Leeds. There are only six tunnels over 1000 yards in length, the longest being at Queensbury (2501 yards); other important engineering works are bridges over Newark Dyke, and over the Derwent at Derby, and viaducts at Welwyn and

"FLYING SCOTCHMAN" PASSING HADLEY WOOD
(Great Northern Railway)

Ilkeston. One of the most difficult tasks in constructing the line fell to Brassey, who had to cross the fens near Whittlesea Mere, a quaking bog that reminded one of Chat Moss.

Brassey entrusted this particular work to Stephen Ballard, who followed very much the same method as Stephenson had adopted seventeen years earlier. Upon platforms of faggot-wood, peat sods were laid and sunk into the morass, other layers following until the water was displaced, leaving the solid matter behind. In this manner a strip across the treacherous ground was solidified, and the laying of the rails presented no further difficulty. To secure foundations for bridges, piling was first attempted, but the plan did not answer expectations, and in the end rafts of timber, upon which brick walls were built, were sunk into the earthy sponge. This work was done very gradually so that the weighted raft compressed the peat beneath, and thus with the brick walls afforded a sound foundation upon which to erect a bridge.

For straightness and freedom from speed restrictions the Great Northern main line has practically no equal in this country, although some long gradients of 1 in 200 do not make easy travelling for heavy trains, but the track is laid excellently with bull-head

"FLYING SCOTCHMAN" LEAVING DONCASTER
(Great Northern Railway)

section rails 100 lbs. per sq. yard, and water-troughs are put down at three different points north of Peterborough.

When the Great Northern commenced business amid the keenest competition of older lines, it was enforced upon the directorate that it would be impossible to hold its own unless it put into use the very best rolling-stock obtainable. Before the London to Peterborough section was opened, the Lincolnshire portion of the system was being worked by "Sharpies" (2 – 2 – 2's), small tender engines with single driving wheels of 5-ft. 6-in. diameter and weighing 18½ tons. These engines had been ordered by Benjamin Cubitt, the first locomotive superintendent, but he died before they were put into use. Edward Bury, the well-known engine-builder of Liverpool, succeeded Mr. Cubitt. He at once obtained from Messrs. R. and W. Hawthorn, of Newcastle, a score of engines (2–2–2's), with drivers 6-ft. in diameter, leading wheels and trailers 3-ft. 6-in., heating surface 907 sq. ft.; and total weight 27 tons. From Fairbairns he ordered half a dozen four-coupled engines (0–4–2's), with 5-ft. drivers, and a similar number from his own firm with driving wheels an inch larger; these engines were for working the goods traffic of the line. Among other engines added to the stud was a number of saddle tank engines, and in a very short time the Company possessed about a hundred locomotives. Early in 1850 Mr. Bury resigned, owing to dissatisfaction on the part of some of the shareholders that the superintendent was using engines constructed by a company in which he was financially interested.

The new superintendent was Archibald Sturrock, manager at Swindon and the real head of the Great Western works, since Daniel Gooch took little active interest in locomotive building. The Great Western Railway lost another good man at the same time, for Seymour Clarke, its London traffic manager, went to the Great Northern as its first general manager.

Mr. Sturrock possessed two very fixed ideas concerning speed and power for locomotives; like Gooch, he believed in a large provision of heating surface and a high boiler pressure. Just before his appointment ten engines of unusual design had been ordered. They were built in accordance with one of Mr. T. R. Crampton's patents, one special feature being the employment of a "dummy" crank axle in front of the firebox, with outside cranks coupling it to the driving wheels at the extreme rear of the engine. One of these engines drew the first train out of King's Cross on its way to York on October 14th, 1852. These engines may be written down as failures, chiefly because of the small proportion of weight available for adhesion owing to the position of the driving wheels.

The next year the Great Northern moved its locomotive headquarters from Boston to Doncaster, and Sturrock converted the "Cramptons" into 2–2–2's, placing the driving wheels in the normal position, and moving one pair of the carrying wheels from the front to just behind the firebox. The "Converted Cramptons," as they were called, had cylinders 15-in. by 21-in.; driving wheels, 6-ft. 6-in.; carrying wheels, 3-ft. 6-in.; boiler barrel, 10-ft. long and 4-ft. diameter, containing 168 tubes; total heating surface, 972 sq. ft.; weight in working order, 28 tons 7 cwt.

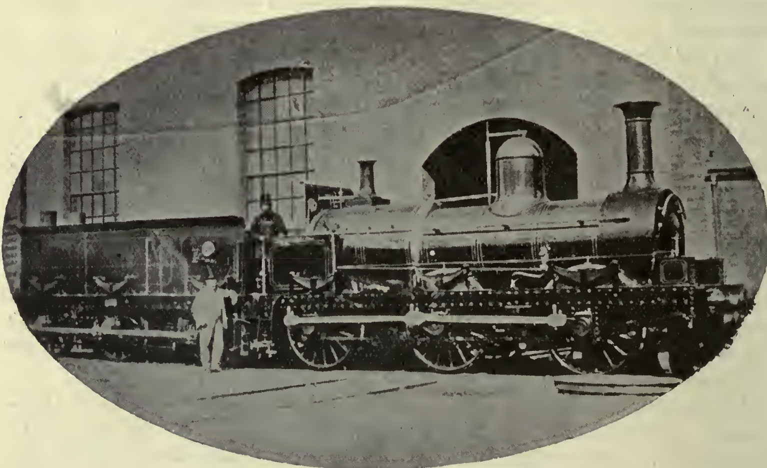
During 1852 and 1853 the Company received a dozen fine engines, that became known as the "Large Hawthorns." They were six-wheelers with leading dimensions as follows: cylinders, 16-in. by 22-in.; diameter of driving wheels, 6-ft. 6-in.; heating surface of firebox 114 sq. ft.; total heating surface, 988 sq. ft.; weight of engine, in working order, 27 tons 16 cwt. The water-tank in the tender was of 1500 gallons capacity.

One of these engines, No. 210, once specially distinguished itself. Mr. Michael Reynolds thus describes the incident: "The down Scotch express was going down Retford Bank, signals all clear, when Oliver Hindly saw a train going east from Sheffield to Lincoln, which would meet him on the level crossing. He could not stop, and with that clear mind, which is so marked in Englishmen in time of danger, he put on full steam, and sent Mr. Sturrock's beautiful express engine clean through the goods train, scattering the trucks like match splinters, and carrying all safe. No. 210 carried the dents and scars like an old warrior, and looked handsomer than ever for this brush with the enemy of express trains."

Mr. Sturrock also designed an engine with 7-ft. 6-in. driving wheels, four carrying wheels in front and a pair of rear carrying wheels; cylinders, 17-in. by 24-in.; boiler barrel, 12-ft. long by 4-ft. 4-in. diameter, containing 240 tubes of 2-in. diameter; heating surface of firebox, 155 sq. ft.; total heating surface, 1719 sq. ft.; weight of engine in working order, 37 tons 9 cwt. The tender ran on six wheels, carried 2505 gallons of water, and in working order weighed 33 tons. This engine was built to prove the practicability of running from King's Cross to Edinburgh in eight hours with four intermediate stops; but as the public did not demand such a service, and there was no competition amongst the railways to provide such a speed, No. 215 remained the only engine of its class, and was in running from 1853 to 1870.

Locomotive designers made many attempts to utilise the dead weight of the tender, so as to obtain more adhesive and tractive force. Mr. Sturrock made a bold attempt to solve the problem by making the tender itself a separate locomotive, driven by steam furnished by the same boiler as supplied the engine cylinders. These engines had six coupled wheels of 5-ft. diameter, in some cases the grate area was 26½ sq. ft.; and the total weight was 35 tons. They proved their capability of drawing forty-five loaded trucks, against thirty-five which hitherto had been the biggest load. There were, however, other considerations that outweighed the mechanical success; long trains were difficult to handle on a line where it was necessary to shunt them on to sidings to clear the way for express traffic, and the repairs ran into a figure that robbed the experiment of any claims to economy. About fifty steam tenders were in use and others were under construction, but the latter were stripped of their tender steam gear before delivery, and those already running were converted to the ordinary type.

Among Mr. Sturrock's later locomotives were two powerful side-tank engines with eight coupled wheels; they were provided with 1550 sq. ft. of heating surface; weighed, in working order, no less than 56 tons. These were put into service in 1866, and were not broken up until 1880. In this same year appeared ten powerful four-coupled passenger locomotives that were at work more than thirty years later, although, in the meantime, their big domed boiler barrels had been replaced by the domeless, flush-topped Stirling boilers. In only a few months' time these were quite eclipsed by half a dozen 2–4–0's, with drivers of 7-ft. diameter, heating surface, 1028 sq. ft.; weight, in working order, 36 tons. The tender had a capacity of 2500 gallons. These were the last passenger engines designed by Mr. Sturrock, who retired at the end of the year after a superintendentship that had lasted sixteen years.



MR. STURROCK'S STEAM TENDER
(Great Northern Railway)

The new locomotive superintendent was Mr. Patrick Stirling, who had occupied a similar post on the Glasgow and South Western Railway, preceded by a most varied engineering experience. The rapidly increasing traffic called for more powerful engines, and Mr. Stirling promptly ordered twenty four-coupled passenger engines, with driving wheels 6-ft. $7\frac{1}{2}$-in.; heating surface, $1085\frac{1}{2}$ sq. ft.; total weight of engine, in working order, $34\frac{1}{2}$ tons. The new superintendent speedily made his mark on the whole of the locomotive stock, adopting fixed designs in various particulars until there was no mistaking a Great Northern engine. For boilers he preferred three telescopic rings with the firebox casing over the largest one. The steam dome he discarded in favour of a perforated pipe running the whole length of the boiler, with the regulator inside the smokebox. The cab was improved and standardised.

Various classes of engines were fitted with the same size boilers, and in different types the cylinders and motion showed common details, the designer's whole plan summing up simplicity and neatness to an astonishing degree.

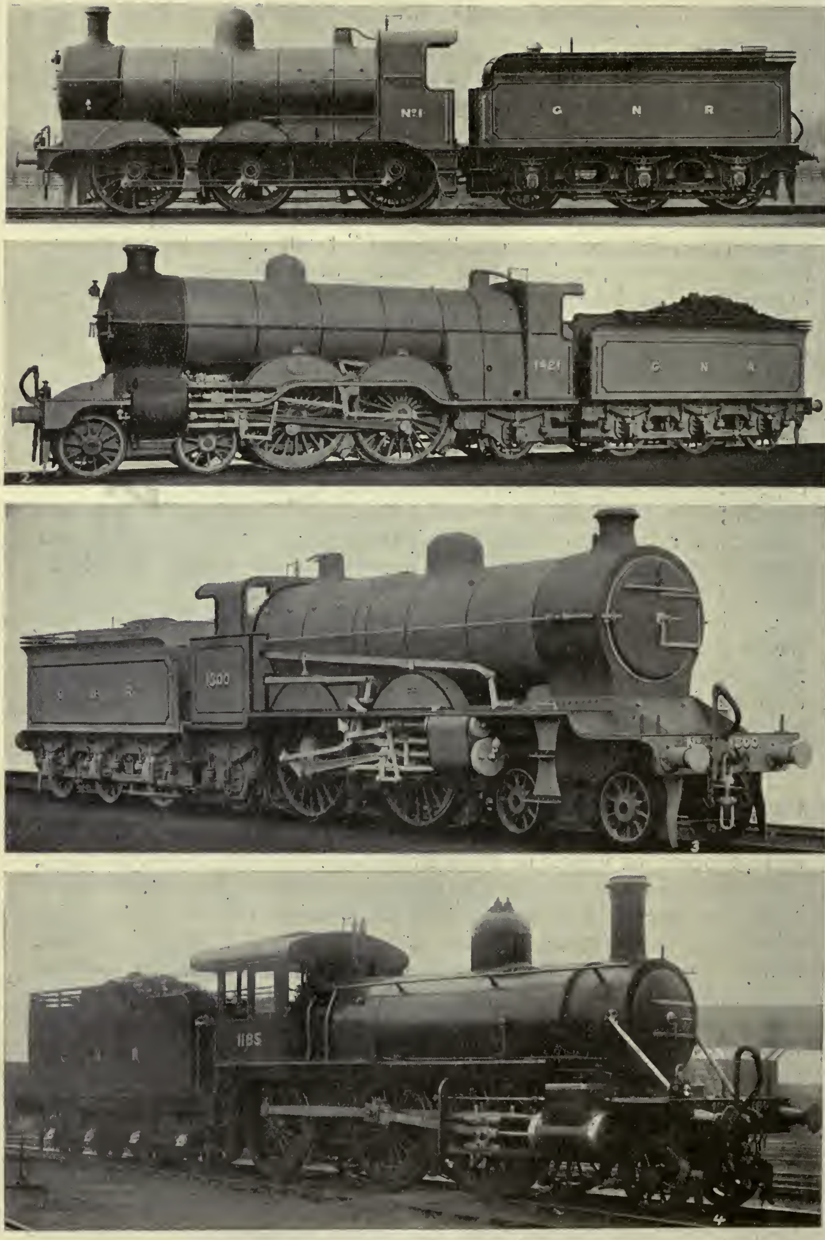
Hitherto the Great Northern had obtained all its engines from outside firms, but Mr. Stirling, at the end of 1867, commenced to build engines himself at Doncaster. No. 18 was the pioneer of a new type, designed to work "mixed" traffic, from heavy excursion to fast goods, and the fact that 153 of these locomotives were eventually put into service indicated that they came up to expectations. Leading dimensions: cylinders, 17-in. diameter by 24-in. stroke; leading and driving pairs of coupled wheels, 5-ft. 7-in. in diameter; trailing wheels under the cab, 3-ft. 7-in.; heating surface: firebox, 100 sq. ft.; tubes, 975 sq. ft.; total, 1075 sq. ft.; total weight, in working order, 31 tons 18 cwt.

Mr. Stirling next fixed upon a new design for a six-coupled goods engine: wheels, 5-ft. 1-in. in diameter; heating surface, 1080 sq. ft.; total weight, 32 tons 11 cwt. This became a standard pattern, for in hundreds of goods engines that followed, of larger dimensions and increased power, there were only trifling modifications of detail.

Patrick Stirling believed in single driving wheels for express passenger engines. Between 1868 and 1870 he turned out a dozen 2 – 2 – 2's, with driving wheels of 7-ft. 1-in., winding up with one engine with 7-ft. 7-in. drivers. These wheels were part of Mr. Sturrock's No. 215, which was broken up. After running for seventeen years they only needed to be retyred.

The best coupled and single-wheel engines were soon taxed to the limits of their power by the weight of the trains and the speed demanded; and Mr. Stirling placed on the metals his celebrated eight-footers, of which he built fifty-three between 1870 and 1895. In these engines there were two marked deviations from his hitherto fixed practice: the cylinders were outside the frames, and a four-wheel bogie was used instead of preserving a rigid wheel-base. No. 1 had 1043 sq. ft. of heating surface, and weighed 35 tons 9 cwt.; the tender carried 3½ tons of coal and 2700 gallons of water, and in working order weighed 26½ tons. In 1887 the weight of these engines increased to 45 tons 3 cwt.; the boiler pressure rose from 140 to 160 lbs. per sq. in.; and the tender carried 5 tons of coal and 2900 gallons of water.

The capabilities of these later eight-footers were shown in the historic races to Scotland. In 1888 the best performances were King's Cross to Grantham, 105¼ miles, in 111 minutes 49 seconds, by No. 22; and from Grantham to York, 82¾ miles, in 88 minutes, by No. 775. In August, 1895, No. 668 hauled a load of 101½ tons from London to Grantham in 101 minutes, and No. 775 worked the same train from Grantham to York in 88 minutes.



1. SIX-COUPLED MIXED TRAFFIC ENGINE. 2. FOUR-CYLINDER EXPRESS ENGINE
3. DE GLEHN COMPOUND (4–4–2) 4. AN AMERICAN BUILT (2–6–0)
(Great Northern Railway)

Leaving these "fliers," we may revert to the four-coupled engines, which constituted Mr. Stirling's maiden design on the Great Northern Railway. Eventually 139 engines of this class were built, for while the eight-footers made the reputation of the line for speed, they were in a great minority as far as numerical strength was concerned. In the course of time the four-coupled class increased in weight to 39 tons. What was quite unusual, the tender weighed a ton more and provided for 5 tons of coal and 3500 gallons of water. The last six express locomotives designed and built by Mr. Stirling came out in 1894 and 1895. They were of the 4 – 2 – 2 type, with leading dimensions as follows: driving wheels, 8-ft. 1½-in. in diameter; bogie wheels, 3-ft. 11½-in., and trailers, 4-ft. 7½-in.; cylinders, 19½-in. by 28-in.; boiler barrel, 11-ft. 1-in. long, diameter outside smallest ring, 4-ft.; boiler pressure, 170 lbs. per sq. in. The firebox was unusually large, providing a heating surface of nearly 122 sq. ft.; total heating surface, 1031 sq. ft. Total weight, 49 tons 11 cwt. The tender, weighing over 41½ tons, carried 5 tons of coal and 3850 gallons of water.

Mr. Stirling died on November 11th, 1895. During his reign at Doncaster he built nearly seven hundred locomotives, while one hundred and sixty were constructed to his designs by outside builders. The fame of his 8-ft. singles was world-wide, as indicated by the fact that an illustration of one of them was chosen as the design of a 5-cent postage-stamp issued by the Republic of Uruguay, the engine being in red on a white ground.

Mr. H. A. Ivatt succeeded Mr. Stirling at Doncaster at the close of 1895, but it was not until about a year later that he produced a passenger engine exclusively of his own design. Externally it showed two marked deviations from his predecessor's practice: a leading bogie was employed, and there was a steam dome on the boiler barrel. It was a 4 – 4 – 0, the coupled wheels having a diameter of 6-ft. 7½-in.; total weight of engine, 44 tons 7 cwt. Engines of this class were intended for general passenger work, express goods, and special traffic.

In the middle of 1898 Mr. Ivatt produced a passenger express locomotive exceeding in power and capacity any engine ever built for the Great Northern, and of a design distinctly novel in this country. This was the first British engine of the "Atlantic" type (4 – 4 – 2). A few particulars concerning it are given on page 55, but an epoch-marking type calls for full details: No. 990, "Henry Oakley," had outside cylinders, 19-in. by 24-in.; two pairs of coupled wheels, diameter 6-ft. 7½-in.; bogie wheels and trailers, 3-ft. 7½-in.—thus embodying the general characteristics of the type. The boiler was of exceptional dimensions, 14-ft. 8⅝-in. long in the barrel, the smallest ring having a diameter of 4-ft. 8-in.; the tubes numbered 191, and had an outside diameter of 2-in. The firebox provided 140 sq. ft. of heating surface which totalled 1442 sq. ft. in all. The working pressure was 175 lbs. per sq. in. In full working order the engine weighed 58 tons, distributed as follows: 15 tons on bogie wheels, 15 tons on the first pair of coupled wheels, 16 tons on the driving pair, and 12 tons on the trailing wheels. The tender weighed 40 tons 18 cwt. when loaded with 5 tons of coal and 3670 gallons of water. This new type proved so successful that ten similar engines were constructed of practically the same design and dimensions; and five years later Mr. Ivatt turned out a larger "Atlantic" (see page 57).

Although it seemed certain that these "Atlantics" fully met the needs of the main-line express services, the directors of the Great Northern Railway offered to take from outside locomotive builders any express engine that appeared to be an improvement on the best Doncaster product, and eventually the Vulcan Foundry Co. proposed an engine that was accepted. No. 1300, a four-cylinder compound, with many features of resemblance to the "De Glehn" type. The high pressure cylinders were placed outside with piston valves on top actuated by Walschaert gear. The coupled axles were placed further apart than in the standard Great Northern Railway "Atlantics"; and consequently the wide firebox was not adopted, but the firebox shell was raised, and had a larger diameter than the boiler barrel. The heating surface was 2514 sq. ft.; working pressure, 200 lbs. per sq. in.; and the weight of engine, in working order, 71 tons.

Some very exhaustive trials were carried out between the Vulcan engine, the Doncaster No. 292, a four-cylinder compound, and No. 294, a standard "Atlantic." The results showed that Mr. Ivatt's engines were undoubtedly superior for the work they were called upon to do.

The modern locomotives built at Doncaster possess all the best developments of modern practice. At the International Exhibition at Shepherd's Bush in 1909 one of the most notable exhibits in the machinery hall was the pioneer 8-ft. single No. 1 of 1870, and No. 1442, "Atlantic" type, of 1908. No. 1 was withdrawn from service in August, 1907, after completing upwards of 1,400,000 miles. It was then partially dismantled, and much of its internal gear and fittings removed, but for the purposes of exhibition it was thoroughly overhauled, and restored as far as possible to its original condition, even to the extent of fitting wooden brake blocks to the tender wheels, as was the practice in 1870. It also stood upon a specimen of the track of that period, with steel rails weighing 80 lbs. per yard. No. 1442, which already had made a mileage of 40,000, rested upon 100-lb. rails, with a portion of a water-trough in the four-foot. The relative capacities of the engines may be expressed in the ratio of their respective weights, 38 tons 9 cwt., and 65 tons 10 cwt. Both engines had been given an "exhibition

THE OLD AND THE NEW

finish," upon which appeared reflections from all around, as curiously shown in the photograph.

For working goods and coal traffic Mr. Ivatt for some years relied upon engines of the 0 – 6 – 0 type, but the latest productions have eight-coupled wheels. Engines of this class have 1442 sq. ft. of heating surface, and weigh, in working order, 54½ tons; and are capable of drawing loads of nearly 1000 tons. Some of these engines, like the big "Atlantics," are fitted with Schmidt superheaters.

In August, 1911, appeared No. 65, 4 – 4 – 0 superheater passenger locomotive, one of a new series similar in design and dimensions to the No. 1326 class, which first made its appearance in 1898. The introduction of the Schmidt superheater necessitated certain changes in the boiler dimensions, and the position and design of the smokebox to allow for the superheater header. The cylinders are of increased diameter, 18½-in., as against 17½-in. in the earlier class; the boiler pressure has been reduced from 170 to 160 lbs. per sq. in. The heating surface is materially altered in its distribution owing to the superheater elements. The total heating surface is 1230 sq. ft.: firebox, 120 sq. ft.; tubes, 852 sq. ft.; superheater, 258 sq. ft.; grate area, 19 sq. ft. Total wheel-base, engine and tender, 43-ft. 8-in.; total length over buffers, 52-ft. 11-in. Total weight in working order: engine, 53 tons 6 cwt.; tender, 43 tons, 2 cwt. This was the fifteenth engine of this class built between March and the end of September, when Mr. H. N. Gresley succeeded Mr. Ivatt at Doncaster. In the Great Northern stud there are now about 1300 locomotives, which are painted light green.

The Great Northern Railway claims to provide the shortest and fastest routes from London to more cities and towns of note than any other company. Being a partner in the "East Coast Route" to Scotland gives the line an initial importance, and the "Flying Scotchman" is one of our most famous express trains. It leaves King's Cross at 10 a.m. every week-day throughout the year for York, Newcastle, and Edinburgh, with through coaches for Glasgow, Perth, Dundee, and Aberdeen. Grantham is the only stop between London and York, which is reached at 1.42 p.m. The Great Northern metals end at Shaftholme Junction, 4 miles north of Doncaster and 28 miles short of York, at which city the North Eastern horses the "Flying Scotchman," which is due at Edinburgh at 6.15 p.m. In some of the East Coast trains the North Eastern takes charge at Doncaster. Sufficient has been said about this service in earlier pages; but it may be remarked, that the 8¼-hour times of both the down and up "Scotchman" could easily be improved by half an hour, but for an agreement with the West Coast companies.

By comparing time-tables it will be seen that the Great Northern is the fastest route to most points where it competes with other

NO. 65, FOUR-COUPLED PASSENGER LOCOMOTIVE FITTED WITH SUPERHEATER railways; Cambridge, Nottingham, Manchester, and Glasgow being the only exceptions, and in these cases the Great Northern is considerably the longer route. Among the Company's quickest trains are Peterborough to London, 76¼ miles, in 79 minutes; or nearly 58 miles an hour; Grantham to London, 105¼ miles, in 110 minutes; King's Cross to Doncaster, 156 miles, in 165 minutes; King's Cross to York, 188 miles, in 215 minutes; and Nottingham to King's Cross, 128 miles, in 145 minutes.

The first Great Northern engine ran into Nottingham on August 1st, 1852, and remained there for seven months. The Midland Railway, strongly disapproving of this entrance into its preserve, manœuvred the Great Northern engine into a shed and then tore up the rails at the entrance to keep it a prisoner while the rival companies went to law. In the end the Great Northern won the day, and has run to Nottingham without question ever since.

Concerning the passenger coaches, which now number 3300, it need only be said that the Great Northern vehicles compare favourably with those of any other company. In the early days the Great Northern ran "fourth"-class coaches at ½d. a mile, so as to compete with the steam packets on the Witham Navigation, which eventually the trains drove off the water. Consequently, the Great Northern third-class accommodation was better than that of some of its rivals. The carriages, nevertheless, were nothing to boast about, for although they were weatherproof and closed in, they were only provided with wooden seats, and were without partitions. The first dining-car in the United Kingdom was run in the London and Leeds service. It was a Pullman car obtained from America, which was followed by dining-cars built at Doncaster. At first these were provided only for first-class passengers, but in 1896 the privilege was extended to the third class; and now the Great Northern dining-cars are among the best in the country. During the year the passenger trains travel over 12 million miles, carrying 37 million passengers.

The capital of the Great Northern Railway amounts to £51,000,000, which is small compared to some of the foregoing companies, and with its mileage of 992 it ranks only ninth in the British Isles. The receipts from passengers, parcels, and mails amount to over £2,000,000 per annum, but the goods, minerals, and livestock yield nearly £3,000,000. The goods vehicles total quite 40,000, a number proportionately larger than those owned by any other railway company. The goods traffic of all our chief companies is very similar on the whole, but that of the Great Northern presents various features worthy of notice. The Company possesses every type of vehicle to meet any particular requirements that may arise, some of which have been illustrated in an earlier chapter. Not a few of the goods trains are worked by "Atlantic" passenger express engines at speeds of 40 to 50 miles an hour, by means of

1. LOADING QUAILS AT KING'S CROSS. 2. BANANA TRAIN

which there is quick transit to Scotland, and goods despatched from King's Cross in the evening are delivered next morning after a journey of 400 miles. Some of the special traffic consists of fish from Yarmouth and Lowestoft, as well as from Scotland; machinery from Yorkshire and Lincolnshire; train-loads of bananas from Manchester docks; no inconsiderable share of the woollen trade of Yorkshire; and there is a great transport of Shire horses to such ports as London, Liverpool, and Glasgow for export abroad. The accompanying illustration shows a train-load of bananas. One of the strangest and most awkward consignments any railway has been called upon to handle was a train-load of aeroplanes, for conveyance to Blackpool.

LEEDS LUNCHEON-CAR EXPRESS PASSING HUNTINGDON AT SIXTY-FIVE MILES AN HOUR

(Great Northern Railway)

The coal traffic of the Great Northern amounts to 10,000,000 tons a year, which calls for miles of storing and sorting sidings. The sidings at Peterborough accommodate 10,000 goods and coal vehicles, half the number being coal wagons on the New England sidings; but the largest coal sidings are at Colwick, near Nottingham, closely rivalling Crewe and Edge Hill for immensity. The Great Northern was the first railway to give London a real large coal supply, and it has maintained its position as a coal carrier to the metropolis; the wagons for the London district being sorted chiefly at Ferme Park.

King's Cross Goods Station possesses every means for handling traffic speedily. Possibly no more interesting consignments arrive at any goods depôt than the vast numbers of quails, which are shipped especially at Alexandria and Algiers for Marseilles *en route* for British markets. They are conveyed in crates holding a hundred live birds each. Attendants feed the birds on the way, and of the 200,000 quails that reach Leadenhall Market each month during the season, only a very small percentage die in transit. The immense goods depôt at Deansgate, Manchester, is quite modern and is perhaps equal to any goods station in the kingdom. It is connected with the Manchester ship canal, and there is every facility for dealing with traffic by barge or rail. King's Cross passenger station is no longer the largest in the metropolis, but, nevertheless, with its six departure and five arrival platforms is a fine station. At present it is not equal to the demands upon it, for which reason it is proposed to enlarge it at a cost of £300,000.

CHAPTER XVI

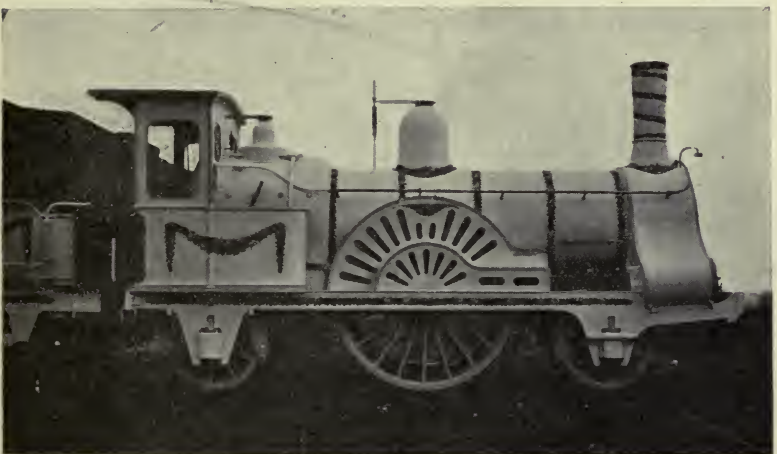
GREAT EASTERN RAILWAY

To ascertain the genesis of the Great Eastern Railway we must go back to the year 1836, when the Eastern Counties Railway was incorporated to construct a line from London (Devonshire Street) to Yarmouth, via Chelmsford, Colchester, Ipswich, and Norwich; but the railway was completed no farther than Colchester, which was reached in 1843.

John Braithwaite, whose name appeared as part builder of the "Novelty" in the Rainhill contest, was the engineer for the Eastern Counties. Between Shoreditch and Stratford he found that it was no easy task to throw an embankment across the marshes, the materials, for quite a long time, sinking out of sight; and even when the marshes ceased to swallow the embankment, they prevented the materials holding together. Braithwaite was by no means dismayed. He adopted a method of staging in advance, driving the piles with an American steam pile-driving machine, while for his cuttings he requisitioned the Yankee excavator; both these implements, be it noted, were new aids in British engineering. It was too much trouble to root up the piles when they had served their immediate purpose, and so they were left to add stability to the embankment.

When Braithwaite came to lay the metals he made the mistake of adopting a 5-ft. gauge, chiefly, he affirmed, to afford him additional space for his engine boiler tubes; yet, after all, his boilers were of less diameter than that of Stephenson's "Rocket." He built half a dozen locomotives, all four-wheelers, with leaders of 4-ft. 6-in. diameter and drivers of 6-ft.

The first portion of the new line, from the temporary station at Devonshire Street to Romford, was opened on June 18th, 1839, when two special trains, containing the directors and friends, ran abreast, one on either line, each with an engine at the front and another in the rear. The journey was enlivened by a band in the front carriage of each train, and on arrival at Romford the visitors partook of a dinner in a field near the station. Two days later the line was opened to the public, and on the day following one of Braithwaite's engines distinguished itself by running off the line between Bow and Stratford, causing the deaths of the two men on the footplate. The extension of the railway was delayed by landslips, and when at length an attempt was made, on February 27th, 1843, to open the line to Colchester, the special train conveying the directors and three hundred shareholders could get no farther than Mountnessing; but a month later the difficulties were overcome. Colchester was then the tenth station from London, whereas to-day it is the twenty-third. The needs of Forest Gate were met by one train a day in either direction, while now the station is reputed to be used by more season-ticket holders than any other station in the kingdom.



THE LOCOMOTIVE WHICH DREW THE ROYAL WEDDING TRAIN, MARCH 28, 1863
When the Prince and Princess of Wales (afterwards King Edward VII and Queen Alexandra) travelled to Sandringham
(Great Eastern Railway)

In the latter part of 1844 the Eastern Counties Railway was converted from the 5-ft. to the 4-ft. 8½-in. gauge, the train service being carried on one line of rails whilst the other was being altered. Earlier in the year the Company leased the Northern and Eastern Railway (5-ft. gauge), which ran from Stratford to Bishop's Stortford and to Hertford, via Broxbourne Junction.

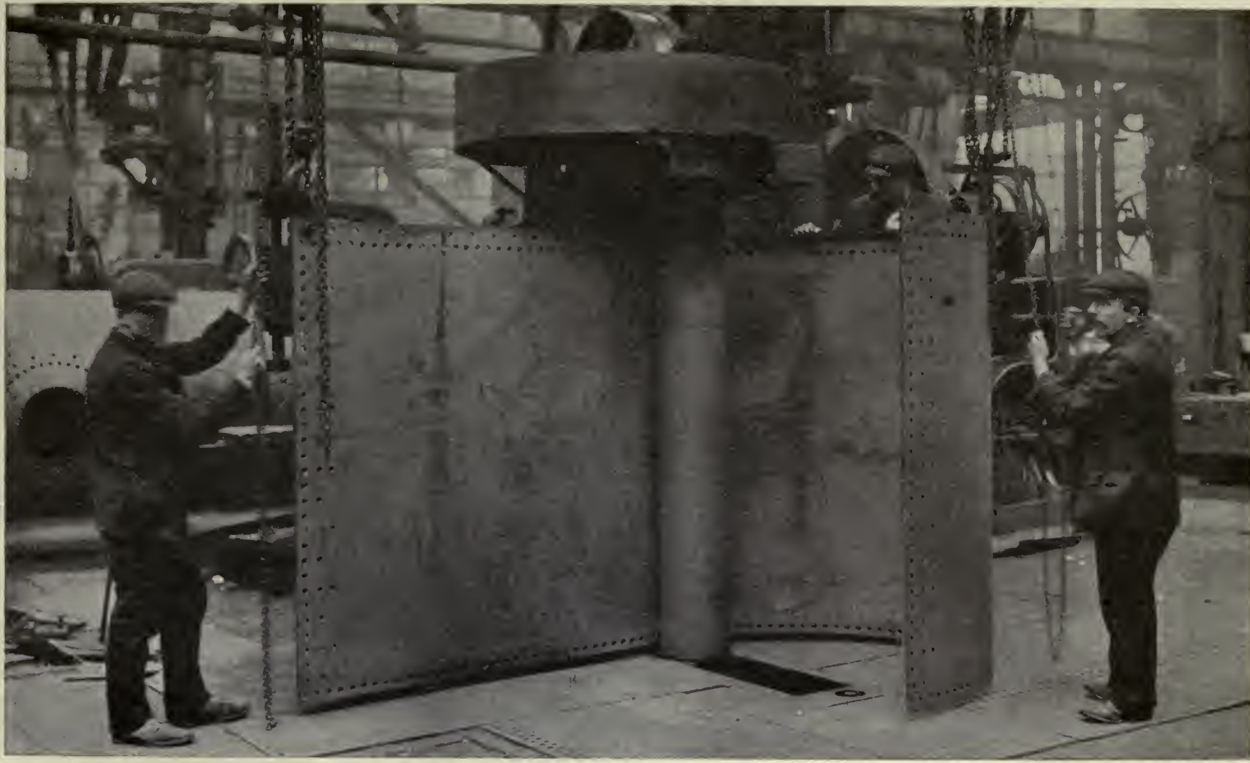
During the next ten or fifteen years various East Anglian railways came into existence, and there were numerous leases, workings, and amalgamations that cannot be given in detail; but on July 1st, 1862, the Eastern Counties, Norfolk, East Anglian, Eastern Union and East Suffolk railways amalgamated to form the Great Eastern Railway. Part of the Norfolk Railway was the Norwich and

Yarmouth line, on which an engine had run a mile in 44 seconds, a record that was unbeaten for some years; this short railway boasted of another distinction, in being the first to adopt the telegraph system to aid the working of its trains.

Probably no British railway ever possessed more varied types of locomotives than the Great Eastern, owing to the large number of separate lines which formed the united system, and the numerous changes in the superintendentship of the locomotive department. In the year 1867, owing to financial difficulties, the Company's creditors seized many of its locomotives, upon which were placed plates which stated that the engine was the property of this or that creditor, and that it was rented by the Great Eastern Railway Company.

Nowadays the Company holds a leading position amongst British railways. Viewed from the point of mileage of metals, it is the sixth of our great lines. Monopolising the counties of Norfolk, Suffolk, and Essex, with branches extending into Cambridgeshire and Herts, the 1217 miles of line form a veritable metal web, enmeshing not only all the chief towns, but many spots that the casual observer would account of no importance. Viewed territorially, one would not look for any abnormal traffic where great industrial centres are practically unknown; but there is the south-west corner, with an enormous suburban traffic to take into account, about which something has already been said (page 196). Every morning 200 workmen's trains convey about 50,000 passengers, chiefly at fares of 2d. or 3d. for return distances up to 21 miles; and on the Walthamstow branch there is an all-night service of passenger trains, an innovation on the Great Eastern that no other company has yet imitated. During the year the Company carries about 96,000,000 passengers, or only 8 million passengers less than the Great Western with its much longer mileage.

When Braithwaite left the Eastern Counties, he was succeeded by William Fernihough, and he was followed by J. V. Gooch, who constructed the first engine turned out of Stratford works. A remarkable little engine was built by an outside firm and shown at the Great Exhibition of 1851. "Ariel's Girdle," as it was named, had only four wheels, the hind part of the engine being connected with a composite carriage, underneath which a tank was suspended. The cylinders were 9-in. diameter by 15-in. stroke; driving wheels, 5-ft. diameter. A receptacle over the firebox held 6 cwt. of coke. The tank under the engine was of 304 gallons capacity, and one under the carriage 533 gallons. The composite carriage was mounted on four wooden wheels with wrought iron tyres. The engine weighed about 16 tons. It is doubtful whether the engine and car, as exhibited, ever worked on the Eastern Counties Railway, but in the early sixties the engine drew passenger trains between Wisbech and Cambridge. In 1868 it was converted at Stratford



BENDING A BOILER PLATE, STRATFORD LOCOMOTIVE WORKS

works into a four-coupled. For some time it worked on a mineral branch, and in 1872 was transferred to the Millwall Extension Railway, the little locomotive being then fitted with a spark arrester to minimise fire risks in passing large timber stores in the neighbourhood of the docks. In 1878 "Ariel's Girdle" was past repair, and was broken up a year later.

Robert Sinclair became locomotive superintendent in 1856. His singles, with drivers 87-in. in diameter, made quite a mark in their day, even though he had some of them built by Schnieder, of Creusot; and his eight-wheeled tanks were noteworthy in several directions, especially the cab, which was so great an improvement, from the point of view of comfort, that the enginemen presented a testimonial to the designer. A "Sinclair" engine is shown on page 355.

Mr. S. W. Johnson was locomotive superintendent at Stratford during the years 1867–72. Among his productions were forty four-coupled engines with four-wheeled tenders, thirty of them being built by Messrs. Sharp, Stewart & Co. to Mr. Johnson's design, and ten were constructed at Stratford. These "Sharpies" were all rebuilt after 1889, and most of them experienced a second rejuvenation. Although unable to haul the modern heavy trains, a few of the old engines are still at work, and doing good service on various branch lines, A good day's work averages about 150 miles, nothing remarkable in the way of speed, but not a bad performance for a locomotive designed not far short of half a century ago

Mr. Johnson left the Great Eastern in 1872 to take similar office at Derby, on the Midland Railway. He was succeeded at Stratford by William Adams, who transferred himself to the London and South Western in 1878. For three years Massey Bromley held the reins, when Mr. Thomas W. Worsdell came into power for four years before entering the service of the North Eastern, where he paid marked attention to the subject of compounding.

The next locomotive, carriage and wagon superintendent was Mr. James Holden. He commenced railway work on the York, Newcastle, and Berwick Railway (now the main line of the North Eastern), and then for twenty years was connected with the Great Western Railway, so that he brought ripe experience to bear upon his rule over the Stratford works, which practically he reorganised. Aiming at standardisation and interchangeability of parts, he was able to produce locomotives economically, and much more rapidly than before. The still unbeaten record of erecting a six-coupled goods locomotive and tender in ten working hours speaks for itself.

Mr. Holden not only converted many of the Company's earlier locomotives into far more serviceable machines, but those of his own design and building became known for their general excellence, while in several directions the Great Eastern practice interested railway engineers all over the world. He invented a system of combined oil and coal burning, that was put into practical operation on a number of Great Eastern Railway locomotives, and that has been found easy of adaptation to various other forms of steam generators. Owing largely to the demand for petrol for motor vehicles, the price of liquid fuel, as compared with coal, has prevented the Holden system becoming generally adopted in this country; but where mineral oil is reasonable in price the apparatus is successful, as proved by its adoption in numerous regions in Europe, Asia, and America.

In chapter III is illustrated Great Eastern Railway oil-fired goods locomotive No. 611, together with particulars of its leading dimen-

MR. JAMES HOLDEN'S "DECAPOD"
Converted into an eight-coupled goods engine (Great Eastern Railway)

sions; but one of the first of the liquid fuel burners was "Petrolea," of the 710 class of four-coupled express engines, of which there were a hundred and ten put into running. This engine was a 2 – 4 – 0; cylinders, 18-in. by 24-in.; coupled wheels, 7-ft.; heating surface, 1230 sq. ft.; weight of engine, 42 tons; tender, 32¼ tons; and the latter carried 500 gallons of oil. For long the smart appearance of the engine, coupled with the fact that it was oil-fired, made it an object of more than common interest to the public. In 1903 it was rebuilt and fitted with a Belpaire firebox, and the name was removed.

On St. Patrick's Day, 1900, there issued from the Stratford shops a four-coupled bogie express locomotive, No. 1900, "Claud Hamilton," which represented the Great Eastern Railway Company at the Paris Exhibition. The splendid proportions of this engine were in strict keeping with modern tendencies regarding size and power—cylinders, 19-in. by 26-in.; coupled drivers, 7-ft. diameter; boiler, 11-ft. 9-in. long and external diameter 4-ft. 9-in.; firebox, 7-ft. long by 4-ft. wide; 274 tubes of $1\frac{3}{4}$-in. diameter; total heating surface, $1630\frac{1}{2}$ sq. ft. The engine was fired with oil. The tender carried 2790 gallons of water, 715 gallons of oil fuel, and 30 cwt. of coal; and was fitted with a water scoop, operated by an ingenious arrangement through the medium of compressed air.

The "Claud Hamilton" was the forerunner of many locomotives

POLISHING SHOP, STRATFORD WORKS
(Great Eastern Railway)

more or less similar in design, and one has only to note the performances of the Great Eastern passenger engines generally to realise how fully they come up to requirements.

In the carriage and wagon departments Mr. Holden was equally energetic and markedly resourceful. He increased the capacity of the suburban trains without adding to their length, which would have entailed extension of station platforms, by adapting old and building new carriages to seat two additional passengers in each compartment—a method since followed on other lines. He also introduced larger capacity wagons, and substituted steel for wood in their frames. Reference already has been made to one of the most notable locomotives ever placed on British metals, namely, the mammoth "Decapod" tank engine. Further details need not be given, satisfying ourselves with showing an illustration of the engine as rebuilt for service in the more prosaic goods traffic.

Mention of carriage-building reminds one that a certain amount of female labour is requisitioned in most of the carriage-building works of the leading British railways. At Stratford the majority of girl workers are orphans of old servants of the Company. They are engaged chiefly in the trimming shop, or as wood-polishers

TRIMMING SHOP, STRATFORD WORKS
(Great Eastern Railway)

and machinists. In the polishing shop the interior carriage panels and mouldings are dealt with, as well as office and station furniture generally; here also the cast-metal coats-of-arms that adorn the locomotives are painted by the girls. The work of the machine shop is exceedingly varied, including the making up of cushion cases in leather and cloth, back linings, carpets, window-blinds, window-straps, etc. The sewing machines are driven by electric motors, and the operative can put her machine in or out of gear by a movement of her foot.

When Mr. James Holden retired from office in January, 1908, he was succeeded by his son, Mr. S. D. Holden. This appointment was but one of not a few notable examples of heredity in locomotive engineering. The first superintendent at Crewe was Francis Trevithick, son of Richard, the inventor of the locomotive. Five sons of Francis made their mark in the railway world—one served in India (G.I.P.R.); two in Japan; Mr. F. H. Trevithick is chief mechanical engineer on the Egyptian State Railways; and Mr. A. R. Trevithick is superintendent of Earlestown Wagon Works (L. & N.W.R.). There were the Stephensons; Daniel Gooch and his brother John Viret; the Beatties, father and son, of the South Western; William Adams, of the Great Eastern and South Western, and his son, J. H. Adams, now of the North Staffordshire; and Matthew Kirtley, of the Midland, and his nephew, William, of the South Eastern. There were the brothers Stirling, James, Patrick, and Robert—James and Patrick in turn were on the Glasgow and South Western, and later of the South Eastern and Great Northern respectively; Robert Stirling was superintendent on the Anglo-Chilian Nitrate Railway; and Matthew, son of Patrick, is superintendent at the Hull and Barnsley locomotive works. There were the brothers Worsdell, Thomas William, who left Stratford works to enter the service of the North Eastern, and Wilson Worsdell who succeeded him there; the Drummonds, Dugald, now of the South Western, and Peter, his brother, of the Highland; and the Whiteleggs, father and son, of the London, Tilbury, and Southend, the latter succeeding to office in 1910.

Notable additions to the locomotive stud have been built at Stratford to the designs of Mr. S. D. Holden, of which two examples must suffice. His new tank locomotives of the 2–4–2 class differ from earlier engines of this type in the shape of the cab and chimney, and the boiler is pressed to 180 lbs. per sq. in. The leading dimensions are: cylinders, 17½-in. by 24-in.; diameter of leading and trailing wheels, 3-ft. 9-in., and of coupled wheels, 5-ft. 4-in.; total wheel-base, 23-ft.; total heating surface, 1114·7 sq. ft., of which the firebox contributes 96·7 sq. ft.; grate area, 15·42 sq. ft.; total weight in working order, 56 tons 8 cwt. 2 qrs.

For the express services new six-coupled locomotives commenced building in 1911. The design fully maintains the gracefulness of outline that is characteristic of the Great Eastern Railway standard express class. Outwardly they suggest the later "Claud Hamilton" engines, but the resemblance proves to be almost entirely superficial. Mr. Holden has furnished some particulars of his first-class express engines, giving a few of the chief dimensions in comparison with those of the four-coupled class:—

	No. 1500 class. Six-coupled (4 - 6 - 0).	No. 1850 class. Four-coupled (4-4-0)
Boiler	Telescopic Superheating	Telescopic Non-superheating
Length of barrel ..	12-ft. 6-in. ..	11-ft. 9-in.
Internal diameter	5-ft. ..	4-ft. 8-in.

FIREBOX	Belpaire ..	Belpaire
Length of casing ..	8-ft. 6-in. ..	7-ft.
Width at top of casing	5-ft. $3\frac{3}{8}$-in. ..	4-ft. $10\frac{1}{4}$-in.
Width at bottom of casing	4-ft. $0\frac{1}{2}$-in. ..	4-ft. $0\frac{1}{2}$-in.
Working pressure ..	180 lbs. ..	180 lbs.
CYLINDERS :—		
Number and type ..	2 high pressure ..	2 high pressure
Diameter	20-in. ..	19-in.
Piston stroke	28-in.	26-in.
DIAMETER OF WHEELS :—		
Driving	6-ft. 6-in. ..	7-ft.
Bogie	3-ft. 3-in. ..	3-ft. 9-in.
WHEEL-BASE :—		
Bogie	6-ft. 6-in. ..	6-ft. 6-in.
Centres :		
Rear bogie wheels to leading drivers ..	8-ft.	8-ft.
Driving wheels to intermediate wheels	7-ft.	—
Intermediate wheels to trailing wheels ..	7-ft.	—
Engine wheel-base ..	28-ft. 6-in. ..	23-ft. 6-in.

The cylinders are placed horizontally between the frames and are fitted with 10-in. piston valves. A rocking shaft is employed to transmit motion from the expansion link to the valves. The connecting rod is 7-ft. 3-in. long. Forced lubrication is supplied to the cylinders, piston rods and valves by means of a mechanical lubricator having eight feeds.

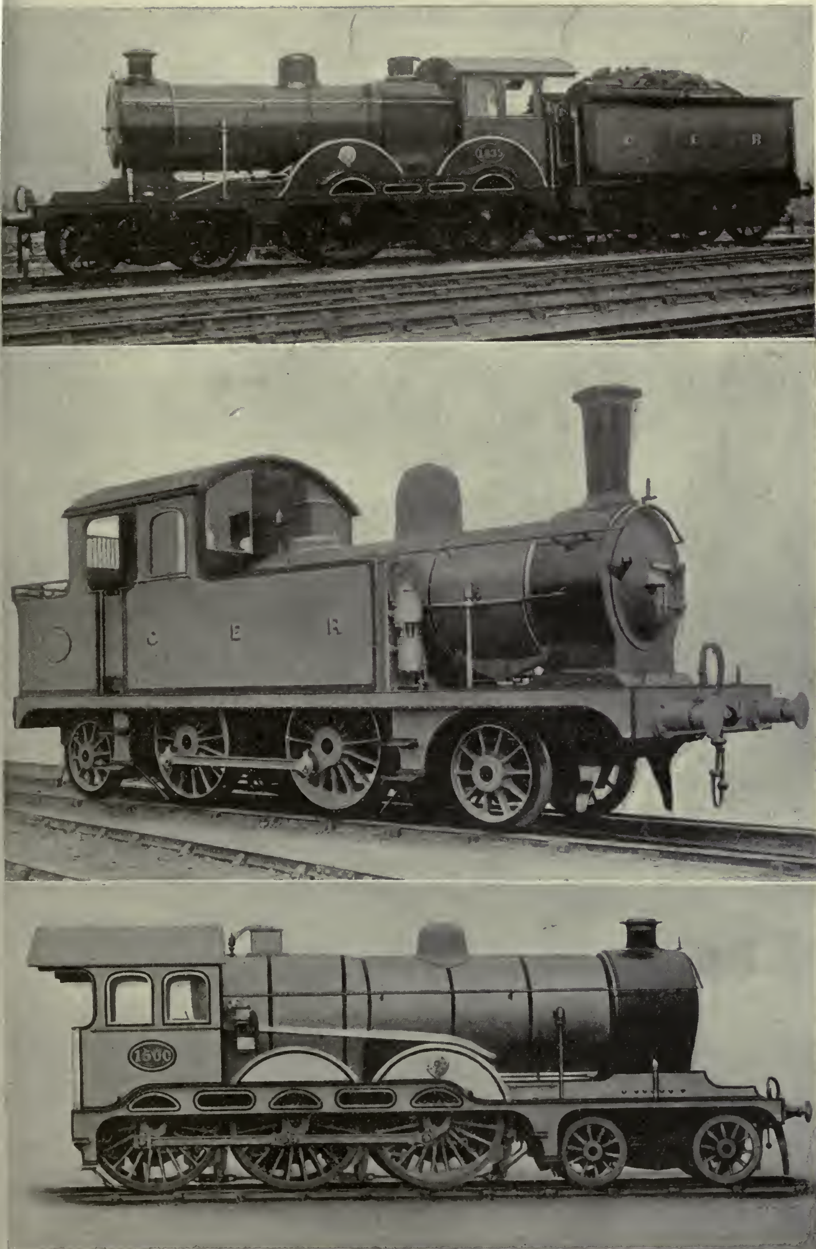
The Westinghouse automatic brake is fitted to all Great Eastern passenger train vehicles. The donkey-pump may often be heard at work, when an engine is standing in a station, pumping air into the reservoir beneath the engine in order to restore the requisite pressure of 75 to 80 lbs. Some of the Company's engines are also furnished with the automatic brake for the purpose of working trains of vehicles that come from lines where that system is in vogue. The Great Eastern wagons, too, that run in the express goods trains, are fitted with the vacuum brake. The passenger locomotives are coloured ultramarine-blue lined with red ; buffer beams and coupling rods red ; lettering in gold. The goods engines are black, with other details as in the passenger locomotives.

East Anglia is usually described as very flat, but contour diagrams of some sections of the Great Eastern Railway system show some really severe gradings. At only a mile out of Liverpool Street outward-bound trains have to face an incline of 1 in 70, and on the Colchester main line, beyond Stratford, a 15-mile rise culminates in Brentwood Bank, $3\frac{1}{2}$ miles long, with gradients that average 1 in 95. Somewhat in atonement there is a steady fall of 10 miles down to Chelmsford, but it is only preparatory to a trying switchback all the way to Ipswich; after Colchester locomotives with heavy trains have no easy task, for within 17 miles there are three separate inclines, each over two miles in length, averaging from 1 in 125 to 1 in 145. From Ipswich we have choice of two routes: to Norwich and Cromer with very similar grades, or to Lowestoft and Yarmouth, which is very much worse. Mr. Cecil J. Allen describes the profile as resembling "a saw with jagged teeth more than anything else." If we take another route, viz. Liverpool Street to Ely, we find that from Tottenham there is uphill work for the greater part of the 25 miles to Elsenham.

In addition to the question of grading, there are a number of important junction stations and other portions of the line which cause substantial reductions in speed, commonly known as "service slacks"; for example, the environs of Norwich call for a slack to 15 miles an hour, between Beccles and Yarmouth there are two swing bridges that must not be crossed more speedily than 3 miles an hour, and other instances might readily be quoted.

Contrast the Great Eastern line out of London with several other lines for similar distances. On the London and North Western Railway, except for Camden Bank with 1 in 70, there is no gradient steeper than 1 in 264, and the one service slack at Rugby is 40 miles an hour; the Midland's hardest pull is 1 in 119 on the 3-mile ascent to Sharnbrook summit; and on the Great Northern for 120 miles there is no grading steeper than 1 in 200, except for a short 1 in 105 out of King's Cross. It stands to reason that the Great Eastern must accomplish some smart running over the easier sections to make up for hindrances, and thus we find the up Norfolk Coast Express accomplishing the 14¼ miles downhill between Haughley and Ipswich at 61·1 miles an hour. Shenfield to Chadwell Heath takes 10 minutes for the 10¼ miles, but as the 2 miles to Brentwood take 3 minutes, because of the steep rise to Ingrave Summit, the remaining 8¼ have to be done at 70 miles an hour. To take a longer section, we may note the 94 miles from Shenfield to Trowse in 105 minutes, or an average speed of 53·7 miles an hour notwithstanding five marked service slacks. It says much for the quality of the Great Eastern locomotives that, notwithstanding the general difficulties of the system, the average of speed, taking all trains into account, compares favourably with that of any other line.

The Great Eastern Railway provides the shortest, and in many cases the only, route from London to a large number of important East Anglian towns; by means of the Great Northern and Great Eastern Joint Line through trains serve Spalding, Lincoln, Doncaster, and York, and arrangements with the Great Central provide various important connections as Chesterfield, Sheffield, etc. The Company's continental traffic necessitates still wider ramifications.



1. STANDARD PASSENGER EXPRESS ENGINE (4–4–0)
2. SUBURBAN TANK ENGINE (2–4–2)
3. LATEST PASSENGER EXPRESS ENGINE (4–6–0)
(Great Eastern Railway)

In connection with the service between York and Harwich (Parkeston Quay) through carriages work to Birmingham by London and North Western Railway via Peterborough, to Sheffield, Manchester, and Liverpool by Great Central via Lincoln, and also by the Lancashire and Yorkshire via Doncaster. The summer traffic calls for through express trains from Liverpool, Manchester, and Sheffield to Yarmouth and Lowestoft, and through carriages from Gloucester and Cardiff. These few meagre details show how the Great Eastern goes wide and far in search of traffic.

The longest non-stop runs are from Liverpool Street to North Walsham, 131 miles, and to Yarmouth, 121¾ miles. A few of the quickest services are: Colchester, 57¾ miles, in 64 minutes; Ipswich, 68¾ miles, in 84 minutes; Parkeston Quay, 69 miles, in 87 minutes; Norwich, 115 miles, in 2 hours 26 minutes; Yarmouth, 121¾ miles, in 2½ hours; Cromer, 138¾ miles, in 2 hours 55 minutes.

The Norfolk Coast Express trains, Liverpool Street to Cromer, commenced running on July 1st, 1907. These trains consist each of twelve vestibuled corridor coaches, accommodating 96 first-class and 320 third-class passengers, with restaurant-cars and a kitchen car. The total length of each train is 638-ft., and the weight about 320 tons, without the engine and tender.

The corridor dining-car train on the "Hook of Holland" service between Liverpool Street and Parkeston Quay is a handsome *train de luxe*. The passenger cars, panelled exteriorally with teak, varnished, have the corridors at the side, and the restaurant cars centre passages, the whole being connected with vestibules. The interiors of the first-class compartments are panelled and moulded in black and burr walnut relieved with gold; the ceilings and partitions above the hat-racks being in white with tinted borders picked out with gold. The smoking compartments are trimmed with crimson leather, and the non-smoking with blue cloth. The second-class compartments are fitted with dark oak framing relieved with light oak panels; these carriages are trimmed in crimson and black plush. The train is electrically lighted and steam-heated. Coloured Plate IX shows the Hook of Holland express travelling by night.

Leaving the ordinary every-day services, we may briefly review a couple of special features. Half a century ago Wolferton was a tiny roadside station, with apparently nothing to suggest that it would become one of the most notable stations on the Great Eastern system. The purchase of the Sandringham estate in 1862 by the Prince of Wales, and his marriage in the year following, at once raised little Wolferton to world-wide prominence. On March 10th, 1863, the whole country-side turned out to see their future King bring home his royal bride. The train was drawn by one of the "Sinclair" engines, suitably decorated for the occasion, and from that time onwards royal and other distinguished visitors arrived

THE NORFOLK COAST EXPRESS

at and departed from the station in constantly increasing number. Mr. H. L. Saward, who was appointed station-master in October, 1884, attended on 645 royal special trains that have worked in and out of the station during the last twenty-seven years. He can recall many interesting events, among them the marriage of their present Majesties, King George and Queen Mary; the marriage of Princess Maud to Prince Charles of Denmark (now King Haakon VII of Norway); visits of foreign monarchs and their consorts, and numerous famous personages in every walk of life.

Engine No. 1828 is an example of a present-day Great Eastern

H.M. THE QUEEN'S WAITING-ROOM, WOLFERTON STATION
(Great Eastern Railway)

"royal locomotive." It is of standard type, and is maintained upon the road in a high state of efficiency, specially and critically examined before leaving the running shed to undertake a royal trip. Royal trains are not usually worked from Liverpool Street, but from St. Pancras.

In 1876 a handsome suite of royal station waiting-rooms was erected and suitably furnished, which have often been used for luncheon parties, when the Wolferton coverts were being shot over. During the festivities at Sandringham, when Prince Albert Victor (the late Duke of Clarence) came of age, the station was the scene of excitement that formed no part of the prearranged programme. Sanger's circus was giving a command performance

PLATE IX.

The Hook of Holland Express by Night.

to the employés on the royal estate. When loading up, a large elephant objected to enter a covered carriage-truck. Temporarily the animal's chain was secured to a lamp-post, which the elephant promptly uprooted, preparatory to demolishing the station gates, which he threw into the road. He was evidently pleased with this bit of gentle exercise, and decided to give no further trouble, for which the railway officials were very thankful.

Attention has been drawn in an earlier chapter to the heavy demands made upon railway organisation by race traffic, and that connected with Newmarket is controlled solely by the Great Eastern. Of the various meetings, celebrated racing events, and ordinary,

ROYAL ENGINE NO. 1828
(Great Eastern Railway)

special, and excursion trains that carry sporting passengers, particulars need not be given, rather will we deal with the special feature of Newmarket's horse traffic all the year round.

The majority of the racehorses running in the United Kingdom are trained at Newmarket, and, consequently, there is practically no race-meeting anywhere that does not call for the despatch of at least one special train of horses from Newmarket, and some meetings will call for as many as eight or nine. In a recent year 154 special trains conveyed 3065 horses in 1846 horse-boxes, in charge of 4570 attendants.

Newmarket's own eight race-meetings call for about 900 horses coming inwards in nearly 700 horse-boxes, while more still pass outwards; but the event which gives rise to the heaviest traffic is the annual Bloodstock Sales, held in December. Messrs. Tattersall often pass 800 horses through the sale ring, purchasers coming from France, Germany, and other continental countries, and even the Argentine. During the sale week some 500 or 600 horses will come to Newmarket in about 360 horse-boxes, and over 600 horses will be forwarded to their purchasers in about 450 boxes. Entraining high-spirited horses presents a scene replete with life and vigour, for it is nothing unusual for a score of boxes to be loaded up in exactly as many minutes.

Now for some facts and figures to sum up the Great Eastern Railway's energies. The capital expenditure has exceeded 57 millions; roughly, it disburses 3¾ million pounds, while its receipts amount to nearly 6 millions sterling. It carries about 100,000,000 passengers annually, exclusive of season-ticket holders. The receipts from passengers, parcels, and mails exceed those from goods, minerals, and livestock by about £500,000. The locomotives number 1085; coaching vehicles, 5307; goods wagons, etc., 26,513; lorries, vans, carts, etc., 1286; motor omnibuses, 21. The train mileage during the year 1910 was: passenger trains, 13,659,337, and goods and mineral trains, 8,104,872 miles.

Compared with some of our great lines, the Great Eastern's goods and mineral traffic is small in proportion to its passenger business. Although it carries twice as many passengers as the Midland Railway, its income from that source, together with parcels and mails, is less by about £1,000,000, accounted for by the shorter distances and lower fares paid by the hordes of workmen who travel to and from Liverpool Street. Concerning goods and minerals, the Midland's income is more than treble that of the Great Eastern, for the latter's coal traffic only amounts to 7½ million tons, and that was only got by a tremendous fight with the Great Northern, which resulted in the joint line which gives the Great Eastern access to the coalfields. After untiring effort the Company now carries 7½ million tons of coal per annum out of the 400 million tons that pass over British metals in the course of the year. It must be borne in mind that our coal pits yield only about 260 million tons of fuel per annum, so that the greater portion of it must be recorded on rail twice over. London uses about 24 million tons of coal a year, but only about one-third of it enters the metropolis by rail, the remainder coming chiefly by sea.

Although East Anglia is principally engaged in agriculture, and farm and dairy produce bulk largely in the Great Eastern goods traffic, the Company handles as varied freights as any line in the country. From Harwich may come anything that the Continent supplies to our markets; and to it go all our manufactures in fullest variety. Fish from the coast; mustard and shoes from Norwich; rifles from Enfield; explosives from Waltham and other places; and even sea-water in little casks, for those who fancy a sea-bath at home—all bring grist to the Great Eastern mill.

In conclusion, we may compare past and present. In 1867 financial difficulties threatened the very existence of the Great Eastern; but the Marquess of Salisbury accepted the chairmanship, additional capital to the tune of three millions was obtained, and the crisis was averted. During the next few years the Company made

PORTION OF CONTINENTAL WAREHOUSE, BISHOPSGATE GOODS STATION
(Great Eastern Railway)

steady, if slow, progress, but in 1875 C. H. Parkes came into power to put the line on the sure way to prosperity. Bishopsgate was then the terminus, which he removed to Liverpool Street; this fine station has now 18 platforms and 20 roads, and the site occupies 16 acres of ground. The Company's trains at that period were a byword for unpunctuality, and the new manager resolutely set himself to the task of effecting improvement. He succeeded too, and earned for himself the enviable cognomen of "Punctuality Parkes." To-day the Great Eastern is the punctual line of the kingdom, and business men in particular call its name "blessed." Careful record one morning showed that all the "business" trains between 8 a.m. and 11 a.m. arrived at Liverpool Street on time, with the exception of one which was two minutes late. This, of course, meant that the departures also were correspondingly exact, and as some 160 trains were concerned, it probably represented a record, even for the Great Eastern Railway.

CHAPTER XVII

LANCASHIRE AND YORKSHIRE RAILWAY

If we judge the Lancashire and Yorkshire Railway solely by the mileage of its metals, we find that it appears to be but a small concern, for with its 596¾ miles of line it is only about one-fifth of the size of the Great Western, little more than one-fourth of the North Western, and one-third of either the Midland and North Eastern railways. In fact, of the ten longest lines in England and Wales the Lancashire and Yorkshire ranks last.

Yet the Company owns over 1550 locomotives, a number which is exceeded on only four of the ten great lines mentioned above; and as locomotive power should be the measure of a company's business, we may survey the system from another point of view. If we take earnings into account, the Lancashire and Yorkshire rises to the fifth position, and large earnings on a small system point to an intensification of energy and great concentration of business in a restricted area. That this is the case is borne out by the figures: the receipts on the North Western average about £8000 per mile per annum, on the Great Western, £5000; but on the Lancashire and Yorkshire the receipts work out at more than £10,000 per mile per annum.

Among the numerous railway schemes to claim early attention, not one seemed to be of more importance than the linking up of Manchester and Leeds, the establishment of rapid communication between Cottonopolis and the chief seat of the sister industry, the woollen trade. The Manchester and Leeds Railway was in the air in 1825, but trade was depressed with a corresponding tightness of money, and it was not until October, 1830, that the project was brought definitely before the public, whose appetite for investment had been quickened by the successful opening of the Liverpool and Manchester Railway.

In the main there was little room for discussion concerning the route, since the hills that separate Lancashire from Yorkshire are intersected only by the Valley of the Calder, which in its narrowest parts appeared to be so fully occupied by the river, canal, and turnpike road that there seemed no room to lay down a railway. The apparently inevitable George Stephenson was the engineer, and he was not the man to magnify difficulties. He could be trusted to scheme out the line, and in any case Alexander Nimmo was assisting him, and the latter knew more than a little about engineering, as much of his work, especially in Ireland, still testifies. At first it was proposed to start from a junction with the Liverpool and Manchester line at Salford, and lay the rails for a distance of 33½ miles to Brighouse, pending the decision as to the most promising route for the final portion of the railway to Leeds. All told, it was estimated that the line would entail the construction of about thirty each of cuttings and embankments, at least ten tunnels and a score of viaducts. These works were called for particularly

MECHANICS' INSTITUTE, HORWICH
(Lancashire and Yorkshire Railway)

where the valley narrowed, demanding diversions of the highway for it to be carried over the river by viaduct or over the canal by bridge, and where still more space was wanted it could be got by tunnelling into the hill-side.

The first Bill was presented to Parliament in March, 1831, but it was not until after several rebuffs that Royal Assent was obtained in July, 1836. In the meantime the Company had been largely reconstituted, and from Brighouse the line was to proceed by way of Sowerby Bridge, Dewsbury, and Wakefield to Normanton, where it would join the North Midland Railway for the remaining 9½ miles to Leeds. It was also decided not to effect a junction with the Liverpool and Manchester, but for the line to commence at the Manchester end from the Company's own station in Oldham Road. There was no gainsaying the fact that the project possessed marked elements that made for success. Within 3 miles of either side of the line the population averaged over 1800 per sq. mile, compared to 260, which was the average for the whole country; the cotton and woollen industries were bound to yield much profitable railway business; and in addition the promoters had in view a great line from Liverpool to Hull, of which the Manchester and Leeds would form the central portion.

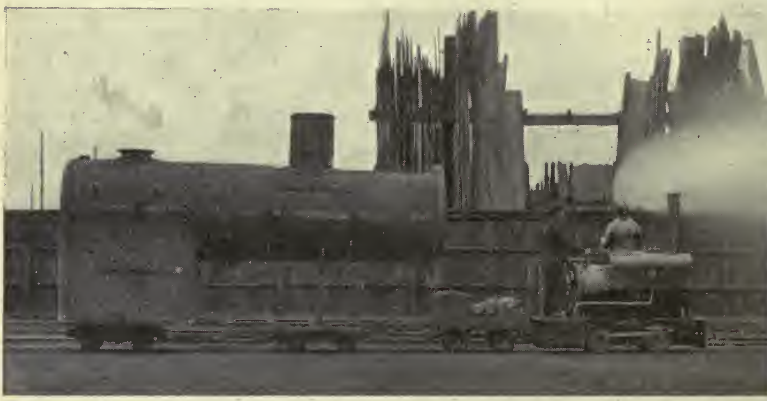
When the construction of the line was commenced in August, 1837, the work proceeded apace, there being quite 5000 men engaged at one time. Nowhere in the whole 50 miles was there a straight section 4 miles in length. The bridges and viaducts may pass, but three features must receive brief notice. By no means could the grading be called easy. From Manchester to the summit level, a distance of 16½ miles, the line rose 340-ft. by inclinations averaging 1 in 184 for a little more than half the distance, and 1 in 460 to the summit, where Littleborough Tunnel (commonly called Summit Tunnel), 2885 yards long, was pierced through rock shale and clay at a depth of 110 yards. A thousand men laboured at the task night and day for four years; and in places could keep the treacherous strata in check only by lining with ten concentric rings of brickwork, the whole of the bricks required totalling up to 23,000,000, set in 8000 tons of Roman cement. To haul the excavated material out of this tunnel, longer than that of Kilsby and the most difficult of construction up to that time, kept thirteen stationary engines at work.

At Charlestown a tunnel of 250 yards had been projected, but the hill was found to consist of "moving, sliding, sandy earth" for a distance of 50-ft. above rail surface. The tunnel was abandoned in favour of carrying the railway round the hill in curves of 12 and 15 chains radius for a space of nearly 400 yards. This method of hill-climbing, instead of piercing, has been adopted extensively abroad, and in later pages attention will be drawn to several notable examples.

Near Kirkthorpe there was no room in the Vale of Calder for the railway, and two more costly bridges appeared to be inevitable. The engineers, however, preferred to make room, which they accomplished by the diversion of the river, a much cheaper operation than bridge-building.

Stephenson adopted an unusual gauge for him, namely 4-ft. 9-in., to allow a play of ¼-in. on each side of the wheels, and thus ease running on the curves. The rails, in 15-ft. lengths, were held in the chairs by a ball and key. The balls, of cast iron and ¾-in. diameter, fitted into a socket formed in one side of the stem of the rail; the keys were of wrought iron, 8-in. long, ⅝-in. wide at one end and tapering to ⅜-in. at the other end.

Various sections of the new railway were opened at different times, but on March 1st, 1841, the line was opened from Manchester to Normanton to the accompaniment of much popular jubilation at the consummation of hopes some sixteen years old. From his perch aloft the guard, imposing in his scarlet coat and tall beaver hat, blew a fanfare on a long horn, and the train set out, the strains of the band aboard competing, not always successfully, with the whistling and general noise of the engine. Some of the early railway carriages already have been described, but the chairman of the Manchester and Leeds Railway had designed one vehicle, of which the body was quite novel. From the floor, which was wider than usual, the sides bulged outwards to join a semicircular roof, a



A TRAMWAY LOCOMOTIVE
For hauling materials at Horwich Locomotive Works
(Lancashire and Yorkshire Railway)

portion of which was fitted with wire gauze to afford ventilation, but which could be covered with waterproof material by manipulation of a handle. The whole of the sides of this unique carriage were glazed with plate glass, and on a hot day the passengers easily could imagine that they were seated in a horticultural hot-house. The opening ceremony passed off without a hitch, and the special trains at times attained a speed of 30 miles an hour.

In 1846 the Manchester and Leeds Railway amalgamated with the Manchester and Bolton, which was opened in May, 1838. The promoters of this last-named line were the owners of the Manchester, Bolton, and Bury Canal. Believing that canal navigation was doomed, they proposed to fill up their water channel and construct a railway on the site, but eventually the canal was allowed to remain, while the metals were laid by the side of it for nearly the whole course of the line. Passing through very rugged country, this railway cost £60,000 per mile, far exceeding the original estimate; longitudinal sleepers of stone or timber were employed, that eventually had to be removed at additional expense.

Continuing the process of absorption, the Manchester and Leeds directorate also acquired the Liverpool and Bury and the West Riding Union railways. The system was increased by various extensions, and in 1847 the Manchester and Leeds dropped its original title for that of the Lancashire and Yorkshire Railway.

The locomotives with which the Manchester and Leeds Railway commenced business were six-wheelers, obtained from Robert Stephenson and Co., Sharp, Roberts and Co., and Taylor and Co. The cylinders were 14-in. diameter by 18-in. stroke; driving wheels 5-ft. diameter; weight of engine about 16 tons. Shortly the Company erected locomotive works at Miles Platting, where some ten-score men were employed. In 1847 Mr. William Jenkins, the locomotive engineer, produced an engine with 5-ft. 9-in. drivers, the first of fourteen passenger locomotives completed in that same year; some of them were singles and the others four-coupled. In 1848 a dozen engines were built, but the next year the works could not keep pace with the demand, and nearly four dozen locomotives had to be purchased from outside builders.

The anticipations that the line would prove to be successful were quite justified in its very first year, when a dividend of 7 per cent was declared upon the ordinary stock, a figure that was not reached again, however, until twenty-three years later, and has only been equalled three times since—the last in 1873. Railway earnings may be reviewed generally for a moment. In the history of the London and North Western Railway it was stated that the dividend for the first year (1846) was 10 per cent, and the shares were quoted at a premium of 100 per cent; but the Company has never paid more than 7¾ per cent since, and that was as long ago as 1872. The Furness Railway Company has declared dividends of 10 per cent upon five occasions in its history, but no other company has ever reached the figure once, save the Taff Vale, whose remarkable figures are given on page 233.

The Hull and Barnsley Railway only paid one dividend of ⅝ per cent in the first seven years of its existence. The Great Central has paid none at all in the last ten years; the M.S. & L.R. once paid 5 per cent, but only upon four occasions did it reach 3 per cent after the year 1846. Going to Scotland, we find that the North British Railway has failed to return a penny to the ordinary shareholders in eleven separate years, three of them in succession, 1851–3, and five in succession, 1867–71.

At first glance it may seem strange that, with the vast increase in our trade and commerce, railway earnings have not gone up accordingly; but against an ever-multiplying volume of business has to be set the ever-increasing cost in working, that is an unavoidable concomitant of modern conditions.

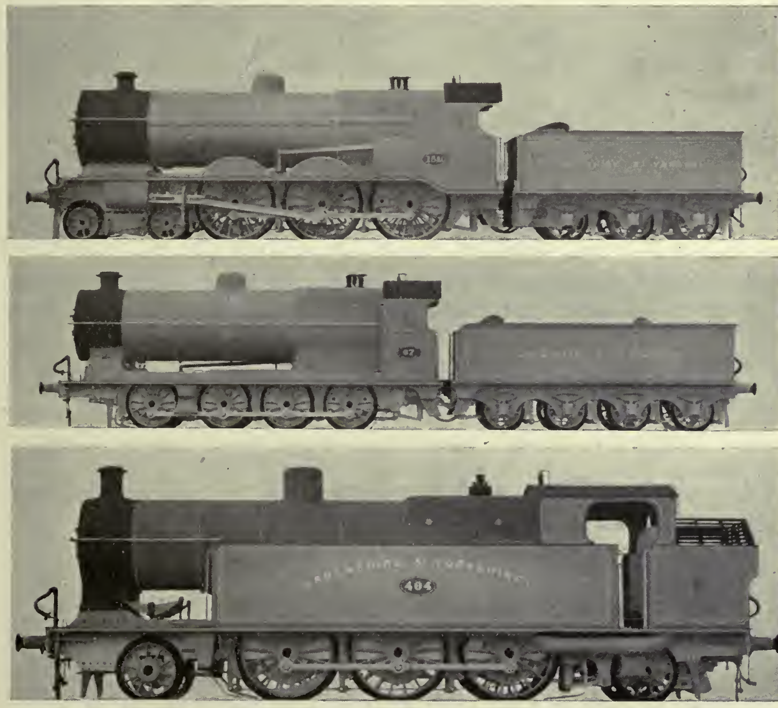
In 1859 the Lancashire and Yorkshire effected an important amalgamation with the East Lancashire Railway, which brought 68 locomotives to add to the stock of over 250, which were all too few to cope with the growing business. At the end of another twenty years the locomotives numbered over 700 for the hauling of over 2000 carriages and nearly 19,000 wagons.

During the next seven years the Company built and bought locomotives at the rate of about forty a year; the workshops at Miles Platting and Bury could not make all the engines that were required. Mr. John Ramsbottom, who figured so prominently in the development of Crewe works, joined the directorate of the Lancashire and Yorkshire Railway upon his retirement from active engine-building. Influenced by his expert advice, the Company decided to build new locomotive works at Horwich, which were opened in 1886, with Mr. John A. F. Aspinall as chief mechanical engineer. The first Horwich product appeared in 1889, in the shape of a 2 – 4 – 2 radial tank, of which type some hundreds have been built. As a matter of fact, more than a half of the whole passenger engine mileage is run by these tank engines. Some of the lines comprised in the Lancashire and Yorkshire system are very steeply graded, yet these tanks, with a load of over 250 tons, average about 37 miles an hour. Their water tanks have a capacity of 1500 gallons; they are fitted with a pick-up apparatus that takes water from the troughs equally well whichever way the engine is running.

Mr. Aspinall resigned office in 1899 to become the general manager of the line, after having designed and built 667 engines, among them the first "Atlantic" type locomotive owned by the Lancashire and Yorkshire. His ten-wheeled express engine, No. 1400, attracted considerable attention in railway circles, and particularly the points of difference between the Lancashire and Yorkshire representative of the type and the Great Northern, No. 990. It will be interesting to give a running comparison of the leading dimensions of each of these pioneer engines on their respective lines.

While Mr. Ivatt adopted cylinders 19-in. by 24-in., Mr. Aspinall chose 19-in. by 26-in.; the coupled wheels of the Great Northern engine were 6-ft. 7½-in. diameter, which in the Horwich product were 7-ft. 3-in. By far the most notable difference between the two engines rested in the boilers, for, with a length of 17-ft. 1⅜-in., Mr. Aspinall exceeded that of the Great Northern by very nearly 2½-ft., eclipsing anything hitherto attempted in this country. There was a similar advance in several other important respects. In the Great Northern No. 990 there were 191 tubes, the firebox provided 140 sq. ft. of heating surface, and the total heating surface measured 1442 sq. ft.; in the Lancashire and Yorkshire No. 1400 there were 239 tubes, the firebox afforded 175 sq. ft. of heating surface, and the total heating surface amounted to 2052 sq. ft. The working pressure in both cases was the same, viz. 175 lbs. per sq. in. The Great Northern engine weighed 58 tons against 58 tons 15 cwt. of the Horwich champion ; but the tender of the latter weighed only 30 tons 13 cwt. as against 40 tons 18 cwt. of the former.

No. 1400 was put to work in the passenger service between



1. FOUR-CYLINDER EXPRESS LOCOMOTIVE (4–6–0)
2. STANDARD GOODS ENGINE (0–8–0). 3. POWERFUL TANK ENGINE $(\frac{2-6-2}{T})$
(Lancashire and Yorkshire Railway)

Manchester and Blackpool, where its performances were watched with much interest. It realised the expectations of its designer, and now it has forty lineal descendants in the engine-sheds of the Company, which are used largely in working the lighter express trains, the six-coupled engines being requisitioned for the heavier passenger loads.

Mr. Aspinall was succeeded at Horwich by Mr. Hoy, who added 220 locomotives to the Lancashire and Yorkshire stock by 1904, when Mr. George Hughes was appointed chief mechanical engineer. In 1907 the 1000th locomotive built at the Horwich works was placed upon the metals; it was No. 1471, a compound mineral engine (0 – 8 – 0).

As an example of Mr. Hughes' work at Horwich we cannot do better than consider the 4 – 6 – 0 four-cylinder express locomotives, of which, by April, 1909, a score had been completed. In chapter III No. 1511 is illustrated partly end on, and now is presented a broadside view of No. 1510, which was the fourth of the class to make its appearance. In a paper read at a meeting of the Institution of Mechanical Engineers, Mr. Hughes devoted considerable attention to these engines, which goes to prove that not only are they up to the highest standards of modern practice, but embody various details of a more or less novel character. The following is Mr. Hughes' own description, but abridged to fit the limitations of space:

"This design was brought about by the further increased weight of trains and the necessity of accurate time-keeping with the accelerated train schedule of the Liverpool, Manchester, and Hull expresses, the Leeds, Bradford, and Fleetwood boat trains, and to cope with gradients on the Bradford, Huddersfield, and Sheffield sections. An engine embodying rapid acceleration, great hauling power, with a suitable wheel-base for the easy negotiation of curves, was essential, and as the four-cylinder arrangement possesses many advantages from a mechanical standpoint, such as division of stresses and superior balancing, this type was decided upon. A simple was preferred to a compound engine, owing to a greater range of expansion obtainable with express trains.

"To obtain rapid acceleration and great adhesive power the wheels were made of moderate size, and three pairs coupled. The wheel-base was kept as short as possible by placing the inside cylinders well in advance of the bogie centre. Flexibility was attained by giving $\frac{3}{16}$-in. lateral play to the trailing coupled wheels, and the coupling rods are provided with ball and socket joints which give vertical as well as lateral movement.

"The inside cylinders drive on the first axle, and a reasonable length of connecting rod results. The outside cylinders are fixed behind the inside, and about midway between the bogie axles; these drive on to the second axle. By this disposition the steam and exhaust pipes can be kept within the smokebox, thus minimising the additional condensation brought about by exposed steam pipes, and also obviating the increased back pressure which necessarily follows when the exhaust has to be led through long and tortuous passages.

"The boiler has been made of large proportions to meet the demand of the four cylinders, and has been so disposed that there is practically the same weight upon each driving axle—the weights are thus obtained naturally and not by adjustment of springs.

"The engine weighs in working order 77 tons 1 cwt. 2 qrs., and is provided with a standard tender, with water pick-up apparatus, weighing 30 tons 13 cwt. 1 qr. loaded, the total wheel-base of engine and tender being 48-ft. $0\frac{1}{2}$-in., and the length over buffers 57-ft. $5\frac{3}{4}$-in."

At the end of 1910 the Lancashire and Yorkshire Railway led the van in the matter of superheating. The London and North Western, Midland, Great Central, and Caledonian railways each possessed only 1 engine fitted with a superheater; the Great Western had 2; the London, Brighton, and South Coast superheated engines numbered 15; the Great Northern's 17; but the Lancashire and Yorkshire's totalled 32. During 1911 superheating made marked progress. Five other companies fitted superheaters to a few of their locomotive stock, chiefly for experimental purposes, but in some cases the new aid to speed and power was adopted unreservedly, indicating the satisfactory results of previous tests. The Great Central raised its one superheated engine to 30; the London and North Western its single superheater to 50; the Great Northern fitted another 30 engines with the apparatus, the Lancashire and Yorkshire Railway another score, and the London, Brighton, and South Coast another 10. The foregoing figures refer solely to the Schmidt apparatus; but the Swindon superheater has been fitted to a large number of Great Western engines, and most of the new locomotives are superheated.

The Lancashire and Yorkshire Railway locomotive works at Horwich rank high among similar establishments, the equipment generally being of the most up-to-date description. Of the Company's total staff of 38,000, about 3500 are employed at the locomotive works and 1920 at the carriage and wagon works at Newton Heath. Reference has been made already to the mechanics' institute and technical school at Horwich. We append an illustration of the handsome building, the expense of which was shared between the Company and the late Mrs. Fielden, whose husband served on the Lancashire and Yorkshire directorate for many years. Attached to the institute there are recreative branches of every description.

Mechanics' institutes are a common feature of many important railway centres, and where a technical school is not in existence there are usually classes and lectures to improve employés in the technique of their calling; but the Lancashire and Yorkshire Railway Company has adopted an interesting system, and certainly the first of its kind in this country. In imitation of a method that is fairly common in American railway practice, Mr. George Hughes equipped an instruction car as a portable lecture-room. The car visits the various locomotive depôts on the system, where mutual improvement classes have been formed, and lectures are given by qualified persons to the engine drivers, firemen, mechanics, etc., with the object of familiarising them with the various mechanisms with which they have to deal when engaged on locomotives. The interior of the car is fitted up with a number of seats for the audience, with lecture table, models, drawings, and a small library of books. There is no doubt that this method of diffusing knowledge results in the members of the locomotive staff obtaining a keener intellectual grip of the machine placed in their charge.

The permanent-way of the Lancashire and Yorkshire Railway

INSTRUCTION CAR
(Lancashire and Yorkshire Railway)

to-day is a vast improvement upon what was originally laid down. Bull-head section rails, 45-ft. long and 95 lbs. to the yard, and chairs weighing 56 lbs. each, form the standard for use on express passenger lines. The original line does not comprise all the engineering difficulties of the system, as evidenced by five later tunnels each exceeding $\frac{3}{4}$ mile in length, which are found here and there, in addition to many smaller ones. Considering the short mileage, it is remarkably well provided with water troughs, which are laid down at ten different points. With this we may compare the London and South Western Railway which, with a mileage of nearly 1000, has only one set of water troughs, and at time of writing only one tender fitted with a scoop. The grading between Manchester and Leeds has been referred to, but there are gradients still more severe in other places, viz. 1 in 27 for $\frac{3}{4}$ mile on the Oldham incline; an average of 1 in 44 for $1\frac{1}{2}$ miles on the Shawforth branch; 1 in 40 for $1\frac{3}{4}$ miles at Accrington, and the same for $1\frac{1}{4}$ miles on the Padiham branch.

Examination of the Lancashire and Yorkshire system at once reveals the difficulty of attempting to define the main line with exactitude. One point only is clear, namely, that Manchester is the centre, from which it is possible to travel to any important

THE MANCHESTER AND BLACKPOOL EXPRESS
(Lancashire and Yorkshire Railway)

town in Lancashire and a great many of the chief towns in Yorkshire. At Victoria Station, Manchester, over 700 trains pass in and out daily, while 500, in and out, are dealt with every twenty-four hours at the Liverpool terminus (Exchange Station).

The mileage of the system permits no non-stop run exceeding that of 76 miles, between Blackpool and Holbeck. The quickest trains between various points show nothing remarkable in the way of speed, chiefly because of the limitations imposed by the gradients, and the service slacks at points where junctions and other complications occur. First we will note the 40-minute Liverpool-Manchester expresses, which entail an average running of 54¾ miles an hour for the 36½ miles. Leaving Manchester, a speed of 50 miles an hour is usually attained at 2 miles out, and when the rise at Moorside has been negotiated the speed is accelerated, and the 13¾ miles to Pemberton is commonly done under 13 minutes, the hard gradings in the section being atoned for by a speed nearing 75 miles an hour near Atherton, and again after leaving Hindley. On the Orrell Bank 48 miles an hour is good running, and frequently it is much less; but from Upholland to Sandhills, 12¾ miles, a 200-ton load behind the tender is no bar to a timing of 10½ minutes, thanks largely to a burst of speed down the 1 in 200 incline beyond Rainford, at the bottom of which 80 miles an hour is often recorded. Taking into consideration the difficult road, it will be recognised that the Lancashire and Yorkshire engines exhibit power and speed in a marked degree.

Leaving the maze of services, which occupy sixty pages of Bradshaw, and which include the fastest trains that gradings and slacks will permit, we may for a moment glance at the Lancashire coast between Fleetwood and Liverpool. Fleetwood, Blackpool, St. Anne's, Lytham, and Southport are visited by holiday-makers from all over the kingdom, but this stretch of seaboard is immensely popular with the toilers of the cotton and woollen trades. Practically every mill has its "holiday" club, into which payments are made all through the year, so that when the annual "wakes" or "feasts" fall due the thrifty artisans can enjoy a brief spell of leisure. The Lancashire seaboard is near, excursion tickets are correspondingly cheap, and thither hordes of holiday-makers betake themselves during the succession of wakes and feasts that commences about the middle of June and terminates only at the end of September.

Of all the various resorts, Blackpool is the very mecca of the holiday-making toilers, the high-water mark of traffic usually being reached on August Bank Holiday. On Saturday, August 13th, 1910, over 200 ordinary and special trains ran into the Talbot Road and Central Stations, depositing 92,000 passengers upon the platforms; and on the same day 222 departing trains conveyed 98,000 persons whose seaside holiday terminated that day. On the following Monday 207 trains brought in 95,000 passengers, and 216 trains transported 100,000 persons back to their homes. The handling of 395,000 passengers within such a short period demands the most skilful organisation at Blackpool; it is not the number of passengers in themselves, but the number of trains that presents the problem. Although there are 77 excursion sidings, containing 20 miles of railway lines, very often the accommodation is insufficient, and some trains have to be sent to outside stations, there to wait until the time of their return.

The Lancashire and Yorkshire Railway Company owns about 4700 passenger vehicles of various kinds; their upper panels are painted light brown, and lower panels red-brown. As the system can boast of no lengthy trunk line, one might not be surprised to

OVERHEAD TRANSIT AT VICTORIA STATION, MANCHESTER
(Lancashire and Yorkshire Railway)

find that dining-cars form no part of its equipment. Such, however, is not the case. Luncheon-cars are run between Manchester and Leeds, and between Liverpool and Newcastle. The Leeds to Fleetwood service, forming part of the route to the north of Ireland, also is furnished with dining facilities.

When the Manchester and Leeds Railway was opened the terminus was at Oldham Road, as before stated. Very soon it was found desirable to have closer connection with the Liverpool and Manchester line, and therefore the two companies decided to build a joint terminus at Hunt's Bank. This station was at that time not only the largest in Manchester, but the largest in the kingdom. It was opened in January, 1844, receiving the name "Victoria," in honour of the then reigning monarch.

Victoria Station, Manchester, no longer holds pride of place in the country for size, but, nevertheless, it ranks high among our most important and busiest stations. Under its roof are to be found every modern contrivance to aid the transport of passengers, but we content ourselves with describing and illustrating an ingenious device for facilitating the handling of parcels and passengers' luggage.

Where station platforms are numerous, and of great length into the bargain, it is no easy matter for porters to wheel parcels and luggage to the vans of the various trains, although subways and lifts are extremely serviceable in that direction. But at Victoria Station there is an electric overhead trolley, practically the same principle as an electric tramcar, except that the machinery and hauling apparatus are suspended beneath the rails, which are half a mile in circuit, and traverse the whole breadth of the station.

The photograph is practically self-explanatory. From the engine is suspended a basket, capable of being lowered to the platform. At the parcels or luggage office the basket is loaded with the articles for despatch by any particular train ; the engine attendant hoists the load ; and at once sets out for the departure platform, where the basket is lowered handy to the waiting van. The little engine is capable of travelling at 12 miles an hour, but as there are numerous sharp curves, the speed is generally about half that rate. Mr. John A. F. Aspinall invented the apparatus, and for quick transit it is really inimitable.

CHAPTER XVIII

GREAT CENTRAL RAILWAY

The Great Central Railway came into existence under its present title on August 1st, 1897, and has developed at such an astonishing rate as to be quite the railway phenomenon of the kingdom. Any one with a knowledge of our railway map some fifteen years ago would assert unhesitatingly that there was no room for a really great new railway, and really much of the Great Central was new in name only.

Before George Stephenson had completed the Liverpool and Manchester Railway a line was projected to link Sheffield with Manchester; and in the year 1831 an Act was obtained authorising the construction of a railway across the difficult country lying between the two towns. The great problem awaiting the solution of the engineers was the piercing of the Pennine Range, where the railway had to be driven through the toughest millstone grit; but, in any case, the original scheme failed rather from lack of capital, be it said, than deficiency in the skill of the engineers.

The success of the Liverpool and Manchester undertaking, and the opening of other lines, had the effect of intensifying the desire to join Manchester and Sheffield, and in November, 1836, the Sheffield, Ashton-under-Lyne, and Manchester Railway deposited its Bill, to which Parliament assented in the following year.

Mr. C. B. Vignoles was the engineer of the new line, but such little progress had been made by the end of 1838 that he resigned, and Joseph Locke was appointed in his place. Although Locke imported more energy into the work, progress was still slow, and the Woodhead Tunnel in particular was a sad and costly stumbling-block. Two tunnels were pierced side by side for a distance exceeding 3 miles; the first occupied 6 years 2 months in construction, being completed in December, 1845; this single-line tunnel cost £200,000.

In the meantime a single-line section of the railway had been opened between Manchester and Godley, three tender engines built by Kirtley and Co., and fourteen carriages forming the rolling-stock. The traffic speedily necessitated the doubling of the line, and the directors raised the fares in the hope of increasing the profits, although it was hopeless to expect the 20 per cent dividend which the promoters had estimated would be the result of the undertaking. There quickly promised to be no dividend at all, for the higher fares induced coaches to take to the highway again, with the result that there was a slump in the railway passenger traffic until the fares were restored to their old footing.

The earlier operations of the Company had been hampered by want of money, but an improvement in trade increased the business of the yet uncompleted railway, and strengthened its financial position, and several extensions of the line were undertaken, while other companies were at work in various directions.

When the 7-mile section of the original line from Dinting to Wood-

THE FIRST GREAT CENTRAL TRAIN INTO LONDON
February 12th, 1899

head was opened on August 8th, 1844, " King " Hudson proposed that the North Midland and the Manchester and Birmingham railways should lease the Sheffield, Ashton-under-Lyne, and Manchester Railway, guaranteeing the shareholders 5 per cent upon the capital, together with a share of the profits over and above an agreed sum. Upon the top of this proposal came another from the Manchester and Leeds Railway offering 6 per cent. Neither offer was accepted, and very shortly the directors were engaged in considering an amalgamation scheme that presented very promising possibilities.

On July 14th, 1845, the railway from Sheffield to Dunford Bridge was opened for traffic, and there only awaited the excavation of the final portion of the tunnel for the whole line to be open from Manchester to Sheffield. It was a great occasion for the directors and officials of the Company, when a special train of guests and friends set out from Sheffield to Manchester at 10.5 a.m. on December 22nd. Dunford Bridge was reached in three-quarters of an hour, and the engines took in water before entering the tunnel. Tunnels of any kind were viewed with general apprehension in those days, and the "Summit" Tunnel was not only of fearsome length, but from the eastern entrance it had a falling gradient of 1 in 201. Whatever the feelings of the passengers during the 10¼ minutes occupied in passing to the western end of the tunnel, the band, which was a standing feature at railway openings, played "See the Conquering Hero Comes" with much gusto as the train steamed into Woodhead Station; after which the journey was resumed and Manchester reached at 12.15 p.m. Two days later the line was opened to public traffic, as was the branch to Ashton-under-Lyne; the latter would have been ready much earlier only for a viaduct having proved a failure.

In view of the difficult grading in both approaches to Woodhead Tunnel, the Sheffield and Manchester Railway required locomotives of undoubted power, if the traffic came up to expectations. One engine was obtained from Sharp Brothers and Co., in 1844, which embodied Bodmer's patent for confining the strain to the pistons, piston rods, connecting rods, and cranks. The leading feature was two pistons in each cylinder, the steam being admitted into the centre where the pistons met, thus forcing them apart; when they reached the ends of the cylinder, steam admitted at the back drove them to the centre again to complete the stroke of the two pistons. The cylinders were 14-in. diameter by 20-in. stroke, the latter being obtained by the 10-in. stroke of each of the two pistons in each cylinder. The driving wheels were 5-ft. in diameter, and the boiler was pressed to 90 lbs. per sq. in. This locomotive evidently gave satisfaction, for an order was given for four goods engines (0 – 6 – 0), which Bodmer declared would be capable of hauling 1000 tons on the level; but in actual practice they failed to fulfil their designer's undertaking.

Sharp Brothers and Co. then constructed an engine designed by Mr. Beyer, who was in their employ. The "Atlas," as it was named, had inside cylinders of 18-in. diameter by 29-in. stroke; the framing and bearings were within the wheels, which were of cast iron and 4-ft. 6-in. in diameter. In about a year and a half the "Atlas" ran over 40,000 miles with a consumption per mile of 36·5 lbs. of coke, which was the common fuel for locomotives until the fifties. This engine was evidently approved, as shown by an order for five of similar design. Later, Mr. Beyer founded the firm of Beyer, Peacock, and Co., whose locomotives are well known at home and abroad.

On January 1st, 1847, the Sheffield and Manchester Railway amalgamated with the Sheffield and Lincoln Junction and the Great Grimsby and Sheffield Junction railways, including the various extensions of these three lines together with the Grimsby Docks. The combined railways took the title of Manchester, Sheffield, and Lincolnshire Railway.

The Manchester, Sheffield, and Lincolnshire Railway in due course

WOODHEAD TUNNEL

(Great Central Railway)

acquired various other local lines, some of them apparently insignificant, but nevertheless swelling into a system that could do good work east and west, though doomed to remain of secondary importance unless it could force its way into London as, for example, the Midland had done in 1870.

Sir Edward Watkin, who was interested in the Manchester, Sheffield, and Lincolnshire Railway, not only formulated a scheme to "land the old Sheffield Company in London," but by linking with his pet idea the Channel Tunnel, imaginative shareholders dreamed dreams of entrance perhaps even into Paris.

Eventually, in 1893, Parliamentary sanction was obtained for extension to London, and a new line of 92 miles was constructed via Nottingham, Leicester, Rugby, Woodford, and Brackley, to join the Metropolitan Extension Railway at Quainton Road, and thence via Aylesbury, Harrow, and Neasden, to Marylebone Road, which was selected for the terminus. The new line necessitated tunnelling under Lords' cricket ground, St. John's Wood. By means of a joint line with the Great Western there is an alternative route via High Wycombe. In fighting its way into London, the Great Central, as the old Manchester, Sheffield, and Lincolnshire Railway was now called, learnt to its cost how Metropolitan ground values had risen since the Midland established itself at St. Pancras in 1868. One has only to look at the spacious entrance at Euston to understand the difference between 1838 and the fag end of the nineteenth century. Part of the site for the terminus was given to the London and North Western Railway by some eager local authorities, and it is asserted that a world-famous artist offered to paint frescoes for the booking-hall.

The Cinderella of the British railway world had to pay stiffly for every yard of ground it required ; but in some respects it claims to have been born lucky and rich. As one writer recently expressed it, " The Company did not get cash on delivery, and the cheque it received from the Fates was post-dated." Speaking of geographical position, the same writer divides the Great Central territory into two sections : minerals and farming. The first section of industry supports the great bulk of our population, which is equivalent to saying that population is synonymous with coal and iron fields. " Now, the Great Central runs through, not one, but several coal fields, besides getting a fair ' whack ' out of the cotton trade, both in its raw and finished stages. Therefore we get our own coal at the best pit-mouth rate, besides a handsome amount for carrying other people's supplies. The southern lines may pay perhaps twice as much for their coal, and the difference goes not to the colliery companies, but to the northern trunk lines.

" Concerning the second heading in the broad classification of English industry, it must not be forgotten that if a greater proportion of our vegetable and animal foodstuffs are produced in the south, a great quantity of both has to be brought up to Lancashire and Yorkshire to feed the denser population there ; and in regard to food imported, the Great Central, either alone or with others, is at Liverpool ready for anything, in addition to handling a goodly share of the continental traffic on the opposite coast."

During the half-century of its existence, the Manchester, Sheffield, and Lincolnshire Railway, if it were but little known out of its own immediate borders, took advantage of all the improvements that were constantly appearing in railway practice. Among the locomotive stock with which the new Company commenced its broader activities was a class of four-coupled express engines that deserve at least brief attention. No. 79 was one of the very best of the class. The illustration shows that the coupled wheels had outside bearings, which was the usual practice in engines emanating from the Gorton locomotive works, but the leading wheels had inside bearings only, being almost the only instance of such a combination. The coupled wheels were 6-ft. 9-in. in diameter, and the cylinders were 18-in. by 26-in. As an instance of the capabilities of the engine may be mentioned the running of a special race train from Manchester Central Station to Aintree, on November 6th, 1888. Hauling five twelve-wheel bogie coaches, No. 79 accom-

A FOUR-COUPLED EXPRESS LOCOMOTIVE
(Manchester, Sheffield, and Lincolnshire Railway)

plished the distance of 35 miles in 34 minutes, an average speed from start to stop of $61\frac{3}{4}$ miles per hour—although a strong wind was blowing, and speed was reduced by more than a half to pass round Halewood Curve.

It was quite natural that the Great Central should increase its rolling-stock at a much faster rate than had met the necessities of the old line. Among the new stock were single bogie expresses, but the most noticeable additions were several "Mogul" goods engines from the Baldwin Works, Philadelphia, almost exactly similar in design to those which the Midland and Great Northern railways had obtained from the same source. There was, however, a difference in the driving wheels of each set: in the Midland engines the balance weights extended over four spokes, five in the Great Northern and six in the Great Central. Mr. J. G. Robinson, who became chief mechanical engineer in 1900, was doubtless satisfied at first with completing the schemes of building which he found in progress when he acceded to power.

Jumping to the end of 1902, we find unwonted activity at Gorton in meeting the requirements of the growing traffic; and within the ensuing twelve months there were various developments that would demand far too much space if they were detailed as fully as they deserve.

Already the recognised type of main-line engine was the six-coupled drivers and a bogie, outside cylinders, the connecting rod being fluted and of a good length. Engine and tender in working order weighed 104 tons 14 cwt. By January, 1903, half a dozen of these engines had been delivered by Messrs. Neilson, Reid and Co., Glasgow; and the same firm was supplying heavy eight-coupled goods engines that with the tender weighed 100 tons 11 cwt.

The fact that the Vulcan Foundry Co., Ltd., of Newton-le-Willows also had a dozen four-coupled, ten-wheeled tanks under construction, indicated still further that Gorton works alone could not cope with the requisite increase in the locomotive stock. They were exceptionally fine engines, with inside cylinders 18-in. diameter by 26-in. stroke; the four-coupled driving wheels being 5-ft. 7-in., the bogie wheels 3-ft. 6-in., and the radial trailing wheels 3-ft. 9-in. in diameter. The total heating surface was 1143 sq. ft., of which the firebox contributed 110 sq. ft. and the tubes 1033 sq. ft. The side tanks held 1450 gallons of water, and the bunker capacity was 3½ tons of coal. In running condition engines of this class weighed 62 tons 17 cwt.

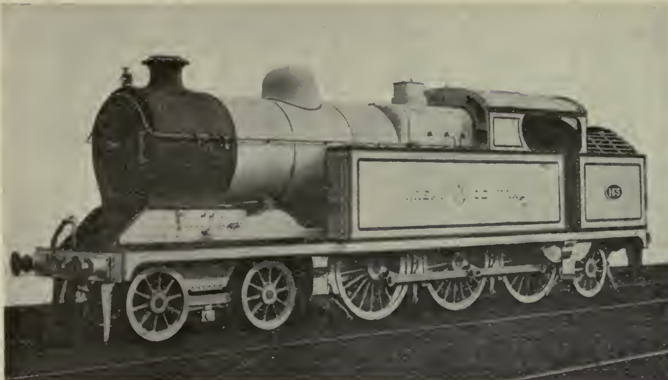
Before the end of the year appeared a new "Atlantic" express locomotive, No. 192, built by Messrs. Beyer, Peacock and Co., Ltd., of Gorton. This was the first "Atlantic" constructed for the Great Central Railway, and was one of four engines that were to be built to the same general dimensions, designed on such generous lines as to reach almost the extreme limits of the loading gauge. The second engine was to be of the "Atlantic" type, but the other two were to be of the six-coupled type. In all other respects the engines were identical, and when the two types were tested with similar trains valuable data would be afforded concerning coal consumption, repairs, etc.

Hand in hand with new engines, various improvements were in progress in other directions. New water troughs were laid down at Eckington and Charwelton. The last-named are among the best modern examples of these aids to long-distance running, and at the risk of a little repetition of matter may be noticed in some detail. The troughs have a total length of 874 yards, the width inside at the bottom being 16-in. and the depth in the centre 6-in. for a distance of 755 yards. At each end of the level portion of the trough there is an inclined plane of 1 in 360, bringing the bottom of the trough up to the surface level. In the central portion of the trough the depth of water is 5-in. The troughs are made of $\frac{1}{4}$-in. steel plate, pressed to the required shape and put together in sections, and are laid upon longitudinal sleepers, secured to the ordinary permanent-way sleepers. Underneath the full length of the troughs is a $1\frac{1}{2}$-in. steam pipe, which in frosty weather keeps the water from freezing. The steam is furnished from the steam pumps, which supply the troughs with water from a deep well sunk by the side of the track.

An experimental installation of automatic block signalling on an electric system was laid down in 1903 near the Woodhead Tunnel. In the several trial trips that were made over the two block sections the new system answered admirably. When an engine was traversing one section, the glow of a white incandescent electric lamp in the cab notified the driver that the succeeding section was clear. If the block was occupied, a red lamp was shown. If the lamps failed for any reason, "line clear," or otherwise, was shown by a small semaphore. Entirely new signalling apparatus has since been installed.

At the end of 1905 twelve express "Atlantic" engines were under construction at Gorton works, two of them being three-cylinder compounds; and twelve others, all simples, were being built by the North British Locomotive Co., Ltd. These locomotives were practically identical with the first Great Central Railway "Atlantic," No. 192, except for a slight increase in the firebox heating surface, a higher boiler pressure, and a certain accession of weight, and they were also provided with larger tenders. The two compounds had one high-pressure cylinder below the smokebox, driving the leading pair of coupled wheels, and two low-pressure cylinders outside the frames, driving the trailing pair of coupled wheels. Otherwise these engines did not differ from the twenty-two simples. On page 63 is illustrated locomotive No. 365, a three-cylindered compound "Atlantic" engine that was put into service early in 1907. This particular engine was named after the general manager who brought the line to London. Sir William Pollitt was knighted soon after the opening, and resigned office at the end of 1901. He was succeeded by Mr. Sam Fay, the very man to pilot the Great Central Railway to success, if wide experience in railway matters could effect it; he had been superintendent of the line of the London and South Western, and previously had raised the Midland and South Western Junction Railway from almost bankruptcy to prosperity.

At Wath concentration sidings, which have been described in an earlier chapter, may be witnessed remarkably smart shunting operations. It is nothing unusual for a train of 60 trucks to come in from a neighbouring colliery for distribution to a dozen or more destinations; and the whole 60 will be uncoupled and redistributed to perhaps as many as 15 different roads in considerably less time than as many minutes. The mammoth shunting engines will push a train of 50 loaded trucks up a gradient of 1 in 107 preparatory




1. LARGE TANK ENGINE (4–6–2). 2. SHUNTING ENGINE $\left(\frac{0-8-4}{T}\right)$ AT WATH CONCENTRATION SIDINGS
3. STANDARD EXPRESS LOCOMOTIVE (4–4–2)

to sorting and redistribution. The shunting engines for the "hump" are of the $(\frac{0-8-4}{1})$ type; they have three high-pressure cylinders, 18-in. diameter by 26-in. stroke, and they weigh 97 tons each.

There will be little or no advantage in following the output of Great Central locomotives year by year, 4 – 4 – 2 engines being consistently employed on the express passenger services. Placed in service in 1911 was a series of new tank engines (4 – 6 – 2) that call for notice, being the first of the type built for service in this country, and only a few had yet been seen abroad. The following are a few of the chief dimensions: cylinders, 20-in. by 26-in.; coupled wheels 5-ft. 7-in., bogie wheels 3-ft. 6-in., and trailing wheels 3-ft. 9-in. diameter; boiler barrel, 11-ft. 6-in. by 5-ft.; total heating surface, 1435 sq. ft. (172 tubes yielding 1294 sq. ft., and firebox 141 sq. ft.); grate area, 21 sq. ft.; working pressure, 180 lbs. per sq. in.; coal capacity, 4 tons; water tanks, 2330 gallons; total weight, in working order, 86 tons. No. 165 of the series is provided with a Schmidt superheater of 18 elements, bringing the total heating surface to 1649 sq. ft. The boiler has ample capacity to develop 1100 indicated horse-power when using superheated steam. All of the series are fitted with the Wakefield lubricator, a combination ejector for the automatic vacuum brake and a steam brake, a water pick-up, and steam-heat apparatus. Eight of these engines are stationed in London, working as far as Leicester and Nottingham.

At the end of 1910 the Great Central Railway owned 1179 locomotives, of which nearly a third were tanks. The coaching stock consisted of about 1900 vehicles of various kinds, and the goods vehicles numbered nearly 35,000. The passenger engines are painted green; the standard colour for goods engines is black picked out with red lines. Gorton, Manchester, is the head-quarters for locomotive construction, but the carriages and wagons are now built at the new works at Dukinfield.

If one examines the map of the Great Central system, it will be found that it touches or crosses other companies' metals at an astonishing number of points, making it one of the most competitive lines in the kingdom; but in one respect it is at a notable disadvantage: while from Marylebone it is possible to travel to almost anywhere between Glasgow and Dover, or Grimsby and Penzance, unlike most of our great railways, it possesses very few important towns on its route for which Marylebone is the only metropolitan starting-point.

Barely to enumerate the passenger services would be a lengthy operation, and to attempt to outline them briefly would be almost futile, since a great feature is the "cross-country expresses," which link up the great provincial towns and health resorts by means of luxurious corridor trains that claim to be the last word in modern carriage-building.

The principal towns served by the Great Central Railway from London are Leicester, 103 miles, in 109 minutes; Nottingham, 126½ miles, in 2 hours 22 minutes; Sheffield, 164¾ miles, in 2 hours 57 minutes; Manchester, 206 miles, in 4 hours 10 minutes; York, 209 miles, in 4 hours 22 minutes; and Huddersfield, Halifax, and Bradford, 191, 201¾, and 203½ miles respectively, in 4 hours 2 minutes, 4 hours 27 minutes, and 4 hours 47 minutes.

LONDON AND SHEFFIELD EXPRESS
Fastest train out of London. (Great Central Railway)

The running of express services on all of our great lines is more or less similar in character, but it is of special interest to note how the "new competitor" for a share in the traffic from London set about its task. Strangely enough, Huddersfield, thriving and wealthy, was outside the pale of the through main-line services from the metropolis, and it only needed to take Halifax and Bradford into account to sum up a population equal to that of Cottonopolis. The Manchester, Sheffield, and Lincolnshire Railway had never carried much of the Manchester-London traffic, and consequently the Great Central in 1900 decided upon a bold stroke.

By diverting some of the through Marylebone expresses at Penistone and sending them on to Bradford by way of the metals of the willing Lancashire and Yorkshire, Manchester was reduced practically to a branch terminus, served only by a through corridor carriage. From Sheffield the main train, headed by a Lancashire and Yorkshire engine, ran straight to Huddersfield, and from thence to Exchange Station, Bradford. In this manner at a single stroke Bradford got a couple of complete dining-trains twice a day; Huddersfield enjoyed the novelty of a through main route from London; and Halifax was provided with a through coach. Nor was this all. At the same time Leicester and Nottingham got a new route equal to the Midland's to Bradford, while that to Huddersfield was better than that of any other line. At that period the quickest time from Marylebone to Huddersfield was 4 hours 23 minutes, while to Bradford the quickest was 4 hours 52 minutes. The new move on the part of the Great Central stirred up both the Midland and the Great Northern, and there were various accelerations on all three routes. In 1911 the fastest Great Northern train to Bradford was quicker than the best Great Central by 72 minutes, not to be accounted for solely by the 11½ miles longer route; to Huddersfield the Great Central beat the Great Northern by 4 minutes; while to Manchester the Midland beat both its competitors, by 26 minutes over the Great Northern and 30 minutes in the case of the Great Central; but, then, the Midland route is shorter than the Great Northern by 13¾ miles and the Great Central by 16¾ miles.

A good example of the running of a Great Central express, and incidentally the everyday performances of the British 4-6-0 type of engine, is afforded us by the "Sheffield Special," a non-stop booking over the 164¾ miles in 177 minutes. Leaving Marylebone there is a slack at Neasden, where large running sheds are situated, and another at Rickmansworth. The long bank to Amersham reduces speed to about 40 miles an hour, but in the neighbourhoods of Great Missenden and Stoke Mandeville 70 miles an hour is frequently exceeded, so that the 14½ miles between Amersham and Aylesbury are covered in 14 minutes. From that point speed averages 60-2 miles an hour, varying at different points from 54 at Helmdon to 76 at Whetstone. Leicester (103 miles) is passed in 108 minutes from the start; the 23½ miles to Nottingham are covered in 22 minutes despite recovery from a slack at Leicester. Near Ruddington 80 miles an hour is frequently touched, and thus Nottingham (126½ miles) is passed in 130 minutes from Marylebone. From Nottingham to Heath there are 20¼ miles on rising grades of some severity, for which good timing is 26 minutes, and the remaining 18 miles to Sheffield include several slacks that will not allow of quicker time than about 20 minutes. The booked time from start to stop is often improved upon by two or three minutes.

A few years ago the train ran under a 170-minute schedule, which was raised certainly not on account of the engines.

Marylebone Station, when it was opened, appeared to be in the very wilderness compared to other termini in the metropolis, but with the opening of the "Bakerloo" tube railway, with which there is a subway connection, the station was put into easy communication with the whole of London generally.

The mileage of the Company's lines owned, leased, and worked at the end of 1910 was 993 miles. The passenger trains ran 11,227,000 miles in carrying more than 22,000,000 passengers, exclusive of season-ticket holders. The goods and mineral trains ran nearly 10,000,000 miles.

STUFFED ELEPHANT CONVEYED FROM LONDON TO FRANKFORT-ON-MAIN
(Great Central Railway)

CHAPTER XIX

LONDON AND SOUTH WESTERN RAILWAY

For strategic, as well as economic reasons, London had long desired safer access to the south coast than by sea, and speedier than by coach; and during the wars with France it had been proposed to cut a ship canal direct to the English Channel, since the Strait of Dover lent itself to the blockading of the mouth of the Thames. No sooner was the Liverpool and Manchester Railway project brought to a successful issue than a scheme was afoot for connecting London and Southampton. In many quarters the idea was ridiculed, for the population of Southampton was less than 20,000, and Winchester, with 8000 inhabitants, was the biggest town between the two ends of the route. It was jocularly asserted that the shareholders could look only to "parsons and prawns" for any hope of dividends, the former from the cathedral city, and the latter from the port.

Nevertheless, the "parsons and prawns" line was not to be laughed out of court, and its promoters went ahead with the scheme. There was the keenest opposition on the part of the coaching interest, and it was evident that the railway, if only partially successful, would spell ruin to what was an enormous, and more than fairly lucrative industry. One man, who possessed 70 coaches and 1500 horses, read the sign of the times better than his fellows; he sold his business, invested the proceeds in the new railway, and in later years reaped his reward by succeeding to the chairmanship of the Company.

The line presented no special difficulties for the solution of the engineers, except that to carry the rails over some portions of the Downs necessitated great embankments and not a few steep gradients. On May 12th, 1838, the directors made an experimental trip from the London terminus at Nine Elms, Vauxhall, to Woking and back, the special train accomplishing 20 miles an hour; and a week later, in another trial trip, the speed was 30 miles an hour. On May 23rd the line was opened publicly; there were six stations between London and Woking, and five trains in each direction daily. Four months later the line was extended to Winchfield and opened; on June 10th, 1839, Basingstoke appeared in the time-tables; and on the same date the line from Southampton to Winchester was opened. For eleven months the journey between Winchester and Basingstoke had to be covered by coach, but on May 11th, 1840, the whole line from Nine Elms to Southampton was an accomplished fact.

A full chronological table of important additions to the system would occupy too much space, but extensions were recorded in no

THE DOWN BOURNEMOUTH EXPRESS NEAR SWAYTHLING
(London and South Western Railway)

less than forty-three separate years out of the first seventy that the Company had been in existence. The line now attains a total length of 979 miles, a long ribbon of metals extending from London to Plymouth and Padstow, with streamers thrown out to Havant, Portsmouth, Southampton, Bournemouth, Weymouth, and Sidmouth on the south, and to Windsor, Reading, Bath, Ilfracombe on the north.

In 1848 the terminus was removed from Nine Elms to Waterloo, at a cost of nearly £2,000,000, and the railway was designated the London and South Western, instead of London and Southampton, Originally it was proposed to extend the railway to London Bridge; Parliamentary consent was obtained, and considerable property was purchased to allow the work to be pushed forward. Unfortunately, about that time the money market was exceedingly tight; there was difficulty in raising the necessary capital, and the scheme was abandoned. In the course of time it became more than ever apparent how advantageous it would be for the London and South Western metals to be extended along the Surrey side of the Thames; but meanwhile the necessary land had increased in value enormously—the opportunity had gone, never again to present itself.

With its numerous extensions, the London and South Western Railway naturally came into conflict with other companies. Competition with the Great Western was very keen, but a dispute with the London, Brighton, and South Coast Railway necessitated recourse to the Law Courts. In 1858 the direct Portsmouth line from Godalming to Havant was completed by an independent company, which then leased its property to the South Western in perpetuity at a yearly rental of £18,000. The original company had obtained running powers over the London, Brighton, and South Coast line from Havant to Hilsea, in order to run over the joint line from Hilsea to Portsmouth. The London and Brighton Company strongly opposed the transference of the running powers to its rivals, the London and South Western Railway. The latter gave notice that its first train would arrive at Havant about 10 o'clock, but hoping to take the officials of the London and Brighton by surprise, the train reached the junction three hours earlier. The South Western's ruse did not succeed, for it was found that not only had the Brighton men taken up several rails at the junction, but they had placed an engine on the crossing, and had chained and padlocked it to the metals. Later on there was a scrimmage between the servants of the two companies, and eventually the London and South Western Railway train was forced to return to Guildford. Before the end of the month, however, the London and South Western Railway ran the first through train from Waterloo to Portsmouth by the new direct route.

This incident calls to mind railway rivalry in other parts of the country. At Manchester the London and North Western went to the length of arresting passengers for entering their station via the Manchester, Sheffield, and Lincolnshire Railway. Upon one occasion a lawyer was unceremoniously detained; he promptly went to law and taught the offenders a lesson. When the first Great Northern train entered Nottingham station on August 1st, 1852, the engine that hauled it was blocked by several Midland locomotives, and then shunted into a shed, where it remained for several months (page 350).

The first locomotive engine possessed by the London and South

Western Railway was the "Lark," a four-wheeler with single driving wheels, 66-in. diameter, the small leading pair being 42-in. diameter. The cylinders, which were placed inside, were 12-in. diameter by 18-in. stroke. This small engine was built by E. Bury and Co., and had been engaged on ballasting work on the new line before the Company acquired it from the contractors. The first locomotive superintendent, Mr. Henry Wood, obtained his engines from outside makers, trusting to the standard designs of the period. Probably the most notable of these early engines was a set of four constructed by Messrs. Fairbairn and Co., of Manchester. They had

SINGLE TANK ENGINE, "TARTAR" (1852)
(London and South Western Railway)

leading and trailing wheels 3-ft. 4-in. diameter, and single driving wheels 5-ft. 6-in. diameter, with outside cylinders 13-in. by 18-in., and working at a pressure of 75 lbs. per sq. in. They had iron fire-boxes instead of copper, which latter was at that time the general rule. One of the quartette, the "Elk," was the first engine fitted with expansive link motion. In the summer of 1846 this engine ran a special train of three carriages from Southampton to Nine Elms, 78 miles, in 93 minutes, or at the rate of over 50 miles an hour.

In December, 1843, the "Eagle" left the shops at Nine Elms, being the first engine built by J. V. Gooch, who left Nine Elms about 1850 to go to Stratford works. During his service with the London and South Western Railway he designed and constructed between 30 and 40 locomotives, among them being some very fine single expresses, while he obtained about 50 engines from outside makers. When Gooch came into office the locomotives numbered 49 or 50; when he resigned they had increased to about 124, some half-dozen unsatisfactory engines having been broken up. When the line was first promoted, it was suggested that five locomotives would be sufficient for the Company's business, and sceptics were not lacking to declare that even that small number would not be worked unduly; yet in just ten years the Company owned six score locomotives, and more were building to cope with the increasing business of the line.

Mr. Joseph Beattie, who succeeded Mr. Gooch at Nine Elms, in the course of about ten years increased the locomotive stud in numbers, and still more in efficiency. In 1852 half a dozen fine tank engines were supplied by Messrs. Sharp, Roberts and Co. The "Tartar," which we illustrate, was one of the best-known engines of this batch of tanks. They had single driving wheels, 6-ft. 0½-in., the leading and trailing wheels being 3-ft. 8-in. diameter; outside cylinders, 14¼-in. by 20-in.; boiler barrel, 9-ft. 11-in. long, diameter 3-ft. 4-in., and containing 141 tubes of 1⅞-in. external diameter. The total heating surface was 780·7 sq. ft. Tanks were placed under the footplate and under the boiler, with a total capacity of 478 gallons.

Of many capital locomotives built at Nine Elms by Mr. Beattie, mention must be made of three six-wheeled express engines that appeared in 1859, and probably the smartest running in the south of England. Their chief dimensions were: coupled wheels of 7-ft. diameter; outside cylinders, 17-in. diameter by 22-in. stroke; total heating surface, 1102 sq. ft.; boiler pressure, 130 lbs. per sq. in.; weight of engine in working order, 35 tons 11 cwt., tender 20 tons 15 cwt.; total weight of engine and tender, 56 tons 6 cwt. One of the trio, the "Castleman," was in service until June, 1887. It ran a total of 869,000 miles, and thus beat the record of the famous Great Western engine, "Lord of the Isles." Beattie was resourceful to a degree, and was the inventor of several more or less useful patents. He was carriage superintendent before he took charge of the locomotives. Railway wheels were in most cases made of iron; but wooden wheels were no novelty. Beattie experimented with wooden wheels rimmed with iron, a combination hitherto untried. The novelty proved successful, and some of Beattie's wheels ran over 70,000 miles before returning to the shops.

Passenger carriage wheels are now usually built up of segments of wood 3½ in. thick, strongly bolted between the steel boss and disk. The tyre is of steel, shrunk on to the wooden body, while the axle is forced into the boss at a pressure of at least 60 tons, and such is the fit that no key is required. The wheel has various recommendations: it is practically noiseless; it does not whirl up dust; if the tyre fractures it does not fall off; and it is easier to balance than a wheel wholly of metal. This wheel was invented by R. C. Mansell, of the South Eastern and Chatham, upon which line at least two large goods engines ran upon wooden wheels.

As the London and South Western Railway absorbed various minor undertakings, it added a varied assortment of locomotives to its stock, but they had little or no effect upon the general practice of the line. Mr. George Beattie succeeded his father, and the production of engines was accelerated. Between the years 1862–74 the works at Nine Elms turned out 126 locomotives, and in the same period Messrs. Beyer, Peacock and Co. supplied 120. Of the latter 18 well tanks came in 1863. They were capital little engines of about 30 tons weight ; and after 20 years' service Mr.

"WHITE STAR" BOAT TRAIN
(London and South Western Railway)

William Adams, who was then at the head of Nine Elms, converted the whole batch into tender engines, and it was not necessary to supply all of them with new boilers.

Mr. Dugald Drummond became chief mechanical engineer at the Nine Elms works in August, 1895, by which time the carriage works had been transferred to Eastleigh, and thither the locomotive works have followed. It will be possible to mention only a few engines of outstanding merit. In 1897 appeared No. 720, 4-cylinder bogie express engine (4–2–2–0). It had independent drivers of 6-ft. 7-in. diameter, and 4 cylinders 15-in. diameter by 26-in. stroke. The boiler was unusually large, with a heating surface of 1700 sq. ft., the firebox being provided with cross water tubes to assist in securing so large a total. The two inside cylinders drove the front pair of drivers ; the outside cylinders operated the rear pair. The tender, which carried 4500 gallons of water and

5 tons of coal, ran on two four-wheeled bogies. As the heating surface proved to be insufficient, in 1905 No. 720 was fitted with a larger boiler, affording 60 sq. ft. of additional heating surface. This handsome engine is over 60-ft. in length, and with the tender in working order weighs over 107 tons.

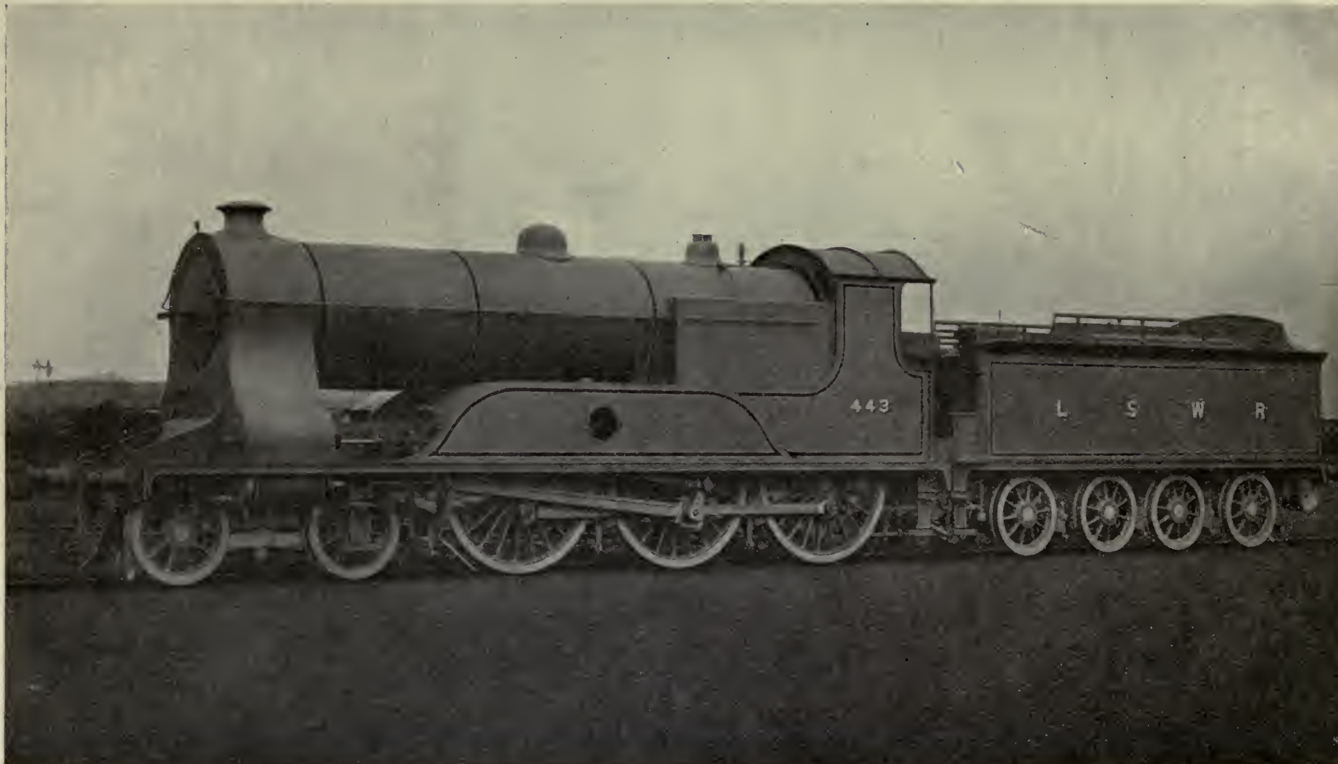
In chapter III reference was made to a six-wheel coupled four-cylinder engine, No. 330, one of five built specially to work heavy express trains over the severe gradients on the Salisbury and Exeter section, which includes Honiton bank with a rise of 1 in 80 for 5 miles. The leading dimensions need not be repeated. The engines proved their ability at hill-climbing, and were later put to work hauling heavy goods trains on the same section, or 60 loaded coal wagons between Salisbury and Southampton.

The first passenger tender engines to be built at the Eastleigh locomotive works were five 4–6–0 four-cylinder simple express locomotives, Nos. 448–52, which in 1911 were put to work chiefly between Salisbury and Exeter. These engines had the following leading dimensions: cylinders (four) 15-in. diameter by 26-in. stroke, with piston valves; diameter of six coupled wheels 6-ft., and of bogie wheels (engine and tender) 3-ft. 7-in.; heating surface: firebox 140 sq. ft., 84 firebox cross tubes 200 sq. ft., 247 boiler tubes 1580 sq. ft., total 1920 sq. ft.; grate area 31·5 sq. ft.; boiler pressure 175 lb. per sq. in.: total length of wheel-base, engine and tender, 53-ft. 5-in., total length over buffers 63-ft. 0¼-in.; capacity of tender 4500 gallons of water, 4 tons of coal; heating surface of tubes in tender well for heating feed water 382 sq. ft.

These giants of the South Western stud were followed almost immediately by a still larger 4–6–0 class, of which No. 443 was the first to make its appearance. Some repetition may be avoided by simply stating where these locomotives differ from preceding engines of the same general type: coupled wheels, 6-ft. 7-in. diameter; boiler pressure 200 lbs.; weight of engine in working order 74 tons 10 cwt., of which 18 tons rest on each of the first and second drivers and 16 tons on the third; weight of tender 44 tons,

The Company owns 770 locomotives, a large proportion of them being tanks such as exhibited on page 71, although there are other classes varying chiefly in wheel arrangement. These excellent machines work the heavy suburban traffic, which includes many workmen's trains of eighteen vehicles. The South Western locomotives have a livery of green, picked out with chocolate and black and white lines.

The coaching stock consists of nearly 3000 passenger carriages, and about half as many miscellaneous traffic vehicles. Nearly the whole of the passenger services are performed by bogie carriages. The trains, perhaps, present a more uniform appearance than on other lines, due to the system of "set working," in which complete trains are viewed as units instead of coaches. The



FOUR-CYLINDER PASSENGER LOCOMOTIVE, NO. 443 (4–6–0) average suburban services are worked by 140 close-coupled four-coach trains known as "bogie blocks," but for the busiest periods of the day a couple of bogie coach blocks are coupled together. The trains are provided with a guard's brake at each end, and being interchangeable can run in any direction. They are steam-heated and electrically lighted, the latter controlled by a main switch, operated from either van in a single or double train.

The coaching stock for the longer distance services illustrates in every particular the comfortable and commodious means of transport now available for the travelling public, in sharp contrast to the discomforts endured by past generations. The corridor carriages are 54-ft. and 56-ft. in length, and 6-in. wider in the body (8-ft. 6¾-in.) than the ordinary carriages.

Compartments are ventilated by means of air extractors and sliding panels, covered with fine wire gauze to prevent the ingress of dirt. Electric lighting and steam heating are under the control of the guard, and there is a heat regulator in each compartment, enabling passengers to reduce or shut off the steam heat when desired. Portable tables which can be easily fitted up in the compartments are carried on all the corridor trains, and in each compartment there is electrical bell communication with the dining-car. The upholstery in the first-class is figured moquette, plush in the second and third, and there is no rigid adherence to one particular colour, several pleasing shades having been introduced. Compartments are finished with polished panels of various fancy woods, and framed photochrom views of places of interest on the system are displayed beneath the luggage racks. Lavatory fittings are of whiteware and marble, the old-fashioned folding metal basins having been abandoned.

Some particularly comfortable saloons for pleasure and family parties have been built at the Eastleigh works to the designs of Mr. Surrey Warner, the carriage and wagon superintendent, the most notable being the combined invalid and family saloons. The saloon compartment, with its cosy tapestry arm-chairs and couch and handsome velvet pile carpets, bears all the appearance of a tastefully furnished drawing-room. By a simple contrivance, the couch can be arranged for the reception of a portable bed; or, if preferred, an ordinary bedstead is provided. These vehicles are in great demand for the conveyance of invalids to Bournemouth, Sidmouth, and other well-known recuperative resorts.

The dining-cars which accompany the corridor vehicles are arranged with kitchen and pantry in the centre. Eleven first-class seats are provided at one end, and seventeen second and third-class at the other. They are the only South Western carriages (apart from the royal saloon) having clerestory roofs, which are more suitable for dining-cars than the standard elliptical pattern. These cars are fitted with movable tables and lift-up seats of the hammock spring type, upholstered in figured moquette and plush, and the interiors are finished with panels of polished satinwood, walnut and mahogany.

The South Western was one of the earliest companies to make use of Pullman cars, and two were in service between Waterloo and Bournemouth until the end of 1911. These drawing-room cars, though of rather old type, were extremely popular, especially during the winter months, when the south-coast health resort is visited by many well-to-do people.

4-4-0 EXPRESS LOCOMOTIVE, NO. 773
Decorated for working a special train conveying Lord Kitchener

The outstanding feature of the 1000 miles of line owned by the London and South Western Railway is the manner in which the branch lines interloop with each other, or link up with other systems. Take a view of all the loose ends of the system, and it will be found that about half of them are seaside termini; most of the others form a junction with another line, except a few such examples as Windsor, ending on the bank of the Thames, or Bulford Camp, which is a military post.

The express train services fall into three groups, viz.:—

1. London, North Devon and North Cornwall via Salisbury, Exeter, and Plymouth.

2. London and Southampton, Bournemouth, Swanage, and Weymouth.

3. London, Guildford, and Portsmouth.

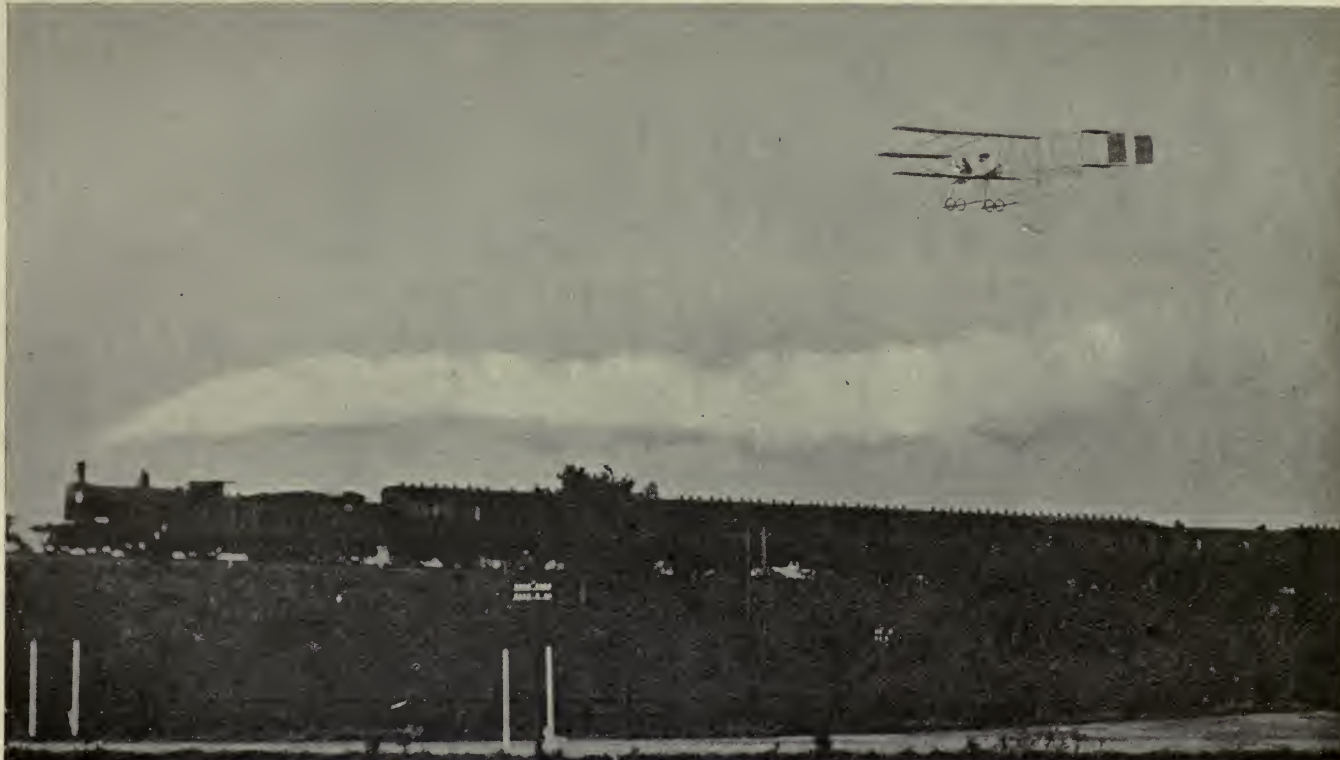
On June 2nd, 1903, the London and South Western cut by 15 minutes the existing record in the run from London to Exeter, which then stood at 3½ hours for the 171¾ miles against the Great Western's 3 hours 35 minutes over a longer but more level route. This achievement initiated a series of runs that nearly every day were effected in less than scheduled time, including such performances as Waterloo to Salisbury, 83¾ miles, in 82 minutes, and Salisbury to Exeter, 88 miles in 92 minutes, which entailed climbing Honiton Bank at 35 miles an hour. The present schedule allows 3 hours 12 minutes for the 171¾ miles, including a 5 minutes' stop at Salisbury to change engines, which gives 55 miles an hour for the actual running.

The quickest booked train to Southampton occupies 100 minutes for the 79 miles, or less than 48 miles an hour. This comparatively poor running is strange considering that the old "Elk" in 1846 performed the journey at over 50 miles an hour; but on June 5th, 1901, No. 708 hauled a special boat train of four bogie carriages from Southampton to Waterloo in 76 minutes, a speed of over 70 miles an hour being maintained during a great part of the journey.

To Bournemouth, Swanage, and Weymouth the fastest express is the 4.10 p.m., which reaches the first-named 108 miles non-stop, in 2 hrs., or at a rate of 54 miles an hour; the 147¾ miles to Weymouth take 3 hours 5 minutes.

But the energies of the South Western are not limited to business south of the Thames, for numerous convenient services are provided by running arrangements with other companies. In the Great Western chapter was mentioned the through train service from Manchester and Birkenhead to Bournemouth. Great Western carriages work between Manchester and the south coast, while South Western carriage stock is employed between Birkenhead and Bournemouth, and South Western engines haul the trains over the Great Western line from Basingstoke to Oxford—a rather wonderful commentary on the old fighting attitude which for many years the two companies exhibited towards each other. Bournemouth and Southampton, thanks also to the Basingstoke route, are connected with the Great Central and North Eastern systems, and thus, travelling via Banbury, there are through carriages for Bradford, Manchester, and as far north as Newcastle-on-Tyne. These are but examples of long journeys without the trouble of changing carriages, and saving passengers a journey across London to reach one of the more recognised termini from which to set out for the north.

The London and South Western suburban traffic is equalled in volume only by that of the Great Eastern. Every morning before



M. LOUIS PAULHAN FLYING ABOVE A PASSENGER TRAIN WHILST PASSING BROOKLANDS MOTOR TRACK AND AVIATION GROUND

10 o'clock 100 trains bring about 50,000 passengers into Waterloo Station, the corresponding evening "rush" hours being between 5 and 7 o'clock.

One very marked feature of the line is its racing traffic, for the system extends to various popular racecourses. The Company's earliest attempt to cater for race-goers is described elsewhere. Nowadays it is nothing unusual to despatch 14,000 passengers to a race-meeting from Waterloo alone, and, naturally, there is also a heavy transportation of horses.

At Weybridge the main line runs parallel for some distance with the Brooklands motor track and aviation ground; and in the illustration can be seen Mons. Louis Paulhan apparently racing a South Western train, a few days after the intrepid airman won a £10,000 prize for the first aeroplane flight from London to Manchester.

Being in communication with Portsmouth, Plymouth, and Southampton, and also with the military camps of Aldershot, Bordon, and Bulford, makes the line of immense strategic importance for imperial purposes; and thus we find that the South Western was the first to construct lines specially to assist in the movement and despatch of large bodies of troops. Of such a character are the Bentley and Bordon light railway and the Alton and Basingstoke line. No other railway has a greater special train mileage than the London and South Western, of which the movement of troops to and from the great military camps forms no inconsiderable portion. During the Army manœuvres in 1910 over 25,000 officers and men, 6800 horses, and 1200 guns and vehicles were conveyed from stations in the manœuvres area to their depôts in the short space of little more than 48 hours.

A remarkable instance of the South Western line's importance and the skill of its officials in army transport was afforded during the South African War. In four consecutive days in October, 1899, over 21,000 officers and men, nearly 1700 horses, 40 guns, and 242 military vehicles of various kinds were conveyed from different parts of the Company's system to be shipped at Southampton. This work called for 89 special trains; 7 of them came from other systems, but completed their journeys on the metals of the South Western, which provided the remaining trains. During the whole period of the war over 25,000 officers, half a million men, nearly 30,000 horses, baggage, etc., were despatched for embarkation at the docks. Yet, after all, even these vast movements, spread out over a period of several years, do not strike the lay mind with nearly the same force as consideration of the fact that Mr. Henry Holmes, the Superintendent of the Line, thinks nothing of providing 60 special trains from Waterloo alone on Ascot Cup day, and yet without any marked interference with the everyday traffic—and all helping towards the total 65,000,000 passengers carried yearly

1. CHANNEL ISLANDS FLOWER TRAIN

2. TRAIN OF LOADED MEAT CARTS FROM SOUTHAMPTON TO LONDON

(London and South-Western Railway)

(exclusive of season-ticket holders) and the 15,000,000 miles run by the passenger trains.

The London and South Western Railway cannot claim to be a large goods and mineral carrying line, but during the year its goods trains travel nearly 4½ million miles, bringing in an income of about 1½ million sterling. Any line running in and out of London must deal with an infinite variety of consignments, and in this respect the South Western can present several particularly interesting aspects. The contents of the freight-carrying vehicles on the various London trains would disclose Brixham soles and Dartmoor rabbits, Cornish herrings and Devon beef and cider, Dorset pork and butter and Hampshire mutton and game; cream, cheese, and watercress from Somerset and Wilts, vegetables and fruit from Surrey and Middlesex, and even West Indian turtles. These are conveyed in such vast quantities as to necessitate the frequent running of special trains, and the climax is reached when the Hampshire strawberries ripen.

Something has already been said about the strawberry and milk traffic on the London and South Western line; and it has its share in the conveyance of flowers, especially those that come to the British markets from France. From Southampton Docks there is a large meat traffic. Much of it is conveyed in the ordinary refrigerator vans, but we show an illustration of a train of loaded meat carts, which, upon their arrival at Nine Elms goods station, only need horses being put into the shafts and are then ready for delivery.

At Waterloo Station a visitor may often see what he might imagine were ingots of tin, if the close attention of the railway police and various other lynx-eyed officials did not negative the idea. The blocks are really silver bullion, of which great quantities are carried by the South Western Railway between London and Southampton, together with gold and silver specie. Consignments of bar gold from the Cape often exceed one million sterling in value. The vans employed are of specially strong construction, and have asphalt floors. The Company has one service as unique as it is melancholy. Every morning a train leaves the London Necropolis Company's private station at Waterloo, conveying those who have "one by one crept silently to rest," to the Brookwood Cemetery amid the Surrey pines and heather.

When Waterloo Station was opened, the Chairman of the Company announced with pride that "four distinct lines of rails had been placed between Nine Elms and Waterloo, in order that there might be no trouble or inconvenience in the traffic"; and up to 1878 the terminus could boast of only three platforms. In that year the south station (suburban lines) was opened, and six years later the north station was added, the lines into the whole station numbering 7 and the traffic necessitating 12 platforms. For some years work has been in progress to improve Waterloo out of all recognition. The portion on the south side has already been completed, and the whole work will be accomplished about 1914. With 23 commodious platforms, the London and South Western Railway terminus will be the largest station in the British Isles.

Next to Waterloo the most interesting station on the line is Clapham Junction, one of the busiest railway spots in the whole world. The ordinary booked trains passing through it every 24 hours vary from 1100 in winter to 1400 on busy days in summer, and for $\frac{3}{4}$ of a mile on the eastern side of the junction it has been found necessary to provide 13 separate lines to accommodate the immense traffic.

LONDON AND SOUTH WESTERN RAILWAY SERVANTS' ORPHANAGE, WOKING

CHAPTER XX

LONDON, BRIGHTON, AND SOUTH COAST RAILWAY

It was only natural that railway promoters should fix upon a line between London and Brighton as offering fair scope for their energies. The first proposal in 1825 was altogether too ambitious for the period, since it involved the construction of a line from London to Brighton, thence to Shoreham, Portsmouth, and Southampton, and onwards to Salisbury, Warminster, and the Bristol coal-fields. The Surrey, Sussex, Hants, Wilts, and Somerset Railway, however, did not lay a line even as long as its name.

In 1836 there were no less than six schemes promoted, Stephenson, Rennie, and Vignoles being the respective engineers for three of them. The Parliamentary battle that ensued resulted in the adoption of Rennie's "direct line." But a railway from London to Greenwich, and another from Greenwich to Croydon, had already been authorised; and a line to Dover had only been sanctioned upon the condition that it should be by way of continuing the Croydon line. Parliament, in view of the detestation of railways in many quarters, was determined to keep the "nuisance" within the narrowest limits possible; and decided that the London and Brighton Railway must utilise the metals of the Greenwich, Croydon, and Dover railways as far as Redhill.

Parliament thus having complicated matters, and recognising that the construction of the 12 miles of line between Norwood (the junction with the Croydon Railway) and Redhill might lead to friction, decided that the London and Brighton Railway should build the line, and then sell the southern half to the South Eastern Railway, as the London and Dover came to be styled. In due course the South Eastern Railway paid £300,000 to the London and Brighton; and both companies held equal rights over the section. Under this arrangement the Brighton trains called only at Redhill on the South Eastern metals, and the Dover trains at Croydon on the London and Brighton.

The first portion of the London and Brighton line to be opened for traffic was the 6 miles branch between Brighton and Shoreham; but on September 21st, 1841, the first train with the directors and their friends arrived at the Brighton terminus for the return journey to London, to the accompaniment of all the musical

PLATE X.

THE "SOUTHERN BELLE."

instruments in the town, the pealing of bells, and the cheers of enthusiastic crowds. There was nothing in the rolling-stock to indicate that the Company would some day run the most luxurious trains in the world. The third-class carriages, in particular, were of the poorest description, quite uncovered, and some even without seats.

Although John Rennie nominally was the engineer of the London and Brighton Railway, it was John U. Rastrick who really constructed it. A notable example of his work is shown in the Ouse Valley Viaduct, which is one of the finest engineering achievements in the country. The photograph depicts the noble proportions

OUSE VALLEY VIADUCT
(London, Brighton, and South Coast Railway)

of the thirty-six arches, along the top of which a train is passing; but a second view of the viaduct is as interesting as it is unique, presenting a remarkable vista of oval spaces that are built in the middle of the piers; at once a great saving in material, while giving lightness and strength to the whole structure. It must be remembered that lightness in a bridge or viaduct is often absolutely essential, in order that the foundations may support the weight.

An interesting experiment was made by the Croydon Company in the year 1845 by the laying down of a single line of atmospheric railway. The following description is taken from the *Locomotive Magazine*:—

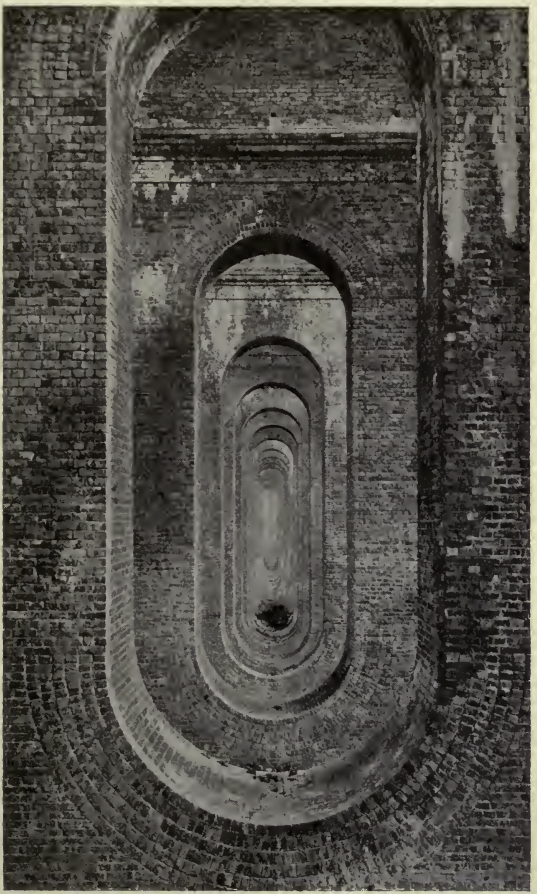
"A large tube was laid down in the centre of a line of rails. This tube had an opening at the top, which was closed by a valve formed of a leather strap covered with short plates of iron above and below. The strap being broader than the plates, it pressed against the top of the pipe by a succession of long rods, screwed down with hook bolts, and thus forming a hinge. On the side on which the valve opened was a groove, which was filled with a composition of wax and tallow. When the valve was raised there was space enough for a bent plate of iron to pass into the tube. To the leading carriage of every train a piston was attached by a bent plate; on the piston rod were four wheels, two before and two behind the bent plate, so that when the piston was in the pipe these wheels raised the valve and prevented it from touching the bent plate. In this manner a communication was made between the piston in the pipe and the leading carriage. Engines, working large air pumps, were stationed at intervals along the line, by means of which the pipe was exhausted of its air. When this was done, the pressure of the atmosphere on the back of the piston was the power to draw the train. The size of the tubes on the London and Croydon Railway was 15-in., internal diameter, and at a trial trip with a train of twelve carriages the remarkable rate of 75 miles an hour was said to have been attained."

After being in use for twelve months the atmospheric line was discarded. The system, however, had many prominent exponents, amongst them Brunel, who laid down an atmospheric track between Teignmouth and Newton Abbot. A speed of 70 miles an hour was regularly attained, and it looked as if steam locomotives were doomed. But when it was found that the rapid deterioration of the parts, which maintained a vacuum in the piston tube, would cost £1600 per mile every year for renewals, the atmospheric railway passed out of the realm of practical railway work.

The London and Brighton management was soon busy developing the coast-lines. In November, 1845, Worthing welcomed its first railway passengers, and in the following June Chichester, Lewes, and Hastings were linked up with the system. The Parliamentary session of 1846 witnessed the amalgamation of the Brighton and Croydon companies under the present title—London, Brighton, and South Coast Railway; a year later the line reached Portsmouth, thus completing the three great arteries of the system. In the meantime a branch from Croydon to Epsom had been constructed, and the Company found itself in possession of 140 miles of line at a total cost of about £2,500,000.

In another chapter is mentioned the London and Brighton's opposition to the South Western running into Portsmouth. The former Company did not take kindly to defeat in the law courts, and promptly cut down rates and fares. The South Western retaliated, and soon passengers were being conveyed from Portsmouth to London and back for 3s. 6d. When each company had lost about £80,000 they settled down amicably, the South Western taking two-thirds of the London–Portsmouth traffic receipts, and the Brighton Company one-third.

In the autumn of 1861 "travelling porters" were introduced on the Brighton line, a feature already in vogue on the Great Western Railway. A "travelling porter" rode on a seat at the back of the tender, facing the train, and well placed to inform the engine man if any circumstance called for the stopping of the train.



IEW THROUGH THE ARCHES—OUSE VALLEY VIADUCT
(London, Brighton, and South Coast Railway)

Matters progressed with gratifying smoothness for some years, until a new line, the London, Chatham, and Dover, introduced a fly into the London, Brighton, and South Coast Railway's ointment. To compete with the new route to Dover, the South Eastern, in 1868, constructed a shorter line via Sevenoaks, and diverted much traffic that hitherto had gone via Redhill. This resulted in the London, Brighton, and South Coast Railway using the metals between Purley and Redhill considerably more than the South Eastern, and a few years later the latter obtained an arbitration award of £12,000 per annum from the London, Brighton, and South Coast Railway in atonement. The London and Brighton, therefore, sought powers to build a line of its own from Purley to join its metals south of Redhill; this work came into use in April, 1900, and the majority of the London, Brighton, and South Coast express trains pass that way.

When we come to consider the early locomotives of the London, Brighton, and South Coast Railway we are presented with a difficulty. Up to March, 1844, the Company possessed at least a score of its own locomotives, most, if not all, of them with 5-ft. 6-in. driving wheels, cylinders generally 14-in. by 18-in., and the heaviest in working order about 15 tons. Between March, 1844, and January, 1846, the rolling-stock of the Croydon, South Eastern, and Brighton companies was used by the three in common. Even after the Croydon was absorbed, the Brighton and the South Eastern shared the locomotives between them; the former having the letter B painted on the buffer beams, so that as an engine approached, a station staff could recognise to which company it belonged. Until its own works were completed at Ashford in 1847, the South Eastern used the London, Brighton, and South Coast Railway's workshops at New Cross, which a few years later gave place to the present locomotive works at Brighton.

From 1847 to 1870 the locomotive superintendent was Mr. J. C. Craven. When he retired, the Company owned 233 engines, among which were no less than 70 different types, and representing the work of quite a score of firms. Two engines were put to rather severe tests. At London Bridge No. 4 overran the turn-table, and fell, wheels uppermost, over the viaduct into Bermondsey Street. It suffered little damage, however, and was drawn through the streets and placed on the rails at Bricklayers' Arms Station. This experience was at least a proof of good workmanship on the part of Messrs. Bury, Curtis, and Kennedy, who constructed the engine. No. 10, on March 17th, 1853, exploded at Brighton terminus, killing three men. "The barrel was completely destroyed and the tubes scattered, whilst the smokebox fell forward on to the buffer beam, the tank was driven back into a carriage, the piston rods were bent up against the cylinders, and the crank axle was broken into three pieces and the wheels forced off. A portion of the firebox was blown up through the station roof and descended through another part of the roof on to a carriage." This engine was built by Messrs J. and G. Rennie; but as the boiler's safe limit was 100 lbs. per sq. in., and the driver had pressed it to nearly 300 lbs., the builders could disclaim all responsibility.

The engines used on the line included examples of all the best-known types that were employed by other companies, including "Jenny Linds," Crampton's patent, and the inevitable "Sharpies." No. 82, one of the last-named, came to grief through a shepherd-boy wilfully placing a sleeper across the metals. The engine and tender left the line, forced a passage through the parapet wall of an arch, and fell a distance of 25-ft. into the road beneath, dragging the second and third-class carriages after them. The men on the foot-plate and three passengers were killed. The boy was acquitted at the ensuing trial, but, strangely enough, a year later to a day, he was struck by lightning and killed instantly, only a short distance from the scene of the railway accident.

In March, 1871, Mr. William Stroudley came from the Highland Railway as locomotive, carriage, and wagon superintendent of the London, Brighton, and South Coast Railway; and he proved himself one of the Cyclopean knights of locomotive engineering who have left their mark on British railway practice. The whole chapter would not suffice for even a brief account of the Stroudley locomotives; and therefore attention will be directed to two types that became famous, not only on the line of their birth, but throughout the whole railway world.

The first small six wheels coupled tanks appeared in October, 1872, and during the next eight years fifty of them were in running. Owing to their small and smart appearance, and sprightliness in getting away with a train, they became known as "Terriers," as already stated in earlier pages. They were intended specially for service between Victoria and London Bridge, and between New Cross and Liverpool Street. The traffic was then small and not equal to working expenses, and the light iron rails of the permanent-way were in bad order. For this reason the "Terriers" only measured 26-ft. ½-in. over the buffers, with a mean weight of 24 tons 7 cwt. The following were the leading dimensions: cylinders, 13-in. by 20-in.; wheels, 4-ft. diameter; boiler, 7-ft. 10-in. long by 3-ft. 5⅛-in. outside the middle ring; 121 tubes, 1¾-in. diameter and 8-ft. 4¼-in. long; heating surface, 518 sq. ft., of which the tubes contributed 463 sq. ft. and the firebox 55 sq. ft. The tanks held 500 gallons and the bunker had 27 cubic ft. of coal space. No. 40, "Brighton," went to the Paris Exhibition in 1878. For many years afterwards the little engine had "Gold Medal, Paris Exhibition, 1878," in gilt letters on the tank sides, as shown in the illustration on page 70. This, of course, made the "Brighton" an object of interest, perhaps equalled only by the fact that at one time the fireman was a negro. That the "Terriers" were an undoubted success was proved by the fact that some of them were working well into the twentieth century, drawing a dozen closely packed coaches from station to station, often less than a mile apart, which renders good running no easy matter.

The next notable class that appeared were single express engines with 6-ft. 6-in. drivers. Known as Class "G," these engines did excellent service for a score of years and more, often running some of the most important express trains, until they were displaced by the bogie express locomotives of 1895. The "Stephenson," which represented the London, Brighton, and South Coast Railway at the Stephenson Centenary at Newcastle in 1881, was one of the "G" class.

The system having grown and its passenger service steadily increased, calling for trains more numerous, heavier, and speedier, Mr. Stroudley set himself to the task of providing engines to meet the demands. The result was the famous "Gladstone," the first of the "B" class, novel in design, and as perfect and successful as the experience of a life's work could devise. Although the first engine was not completed until 1882, its design really originated in the 0-4-2 suburban tank engines of 1873, which had coupled wheels 5-ft. 6-in. diameter, and cylinders 17-in. by 24-in. This class proving its efficiency, Mr. Stroudley, in 1876, adopted their leading dimensions for main-line mixed traffic engines, the two classes differing only in the proportions of the firebox and boiler. Two years later came lineal descendants with coupled wheels 6-ft. 6-in. diameter, and cylinders 17½-in. by 26-in.

The epoch-marking "Gladstone" has some of its leading dimensions detailed on page 45. For the first time in locomotive history the cylinders were cast in one piece. The new type was greeted with doleful prophecies in many quarters. Mr. Stroudley claimed for his production that front-coupled wheels permitted a larger firebox than rear-coupled; the greatest weight was well forward, and made for efficient adhesion; the independent trailing wheels, being less weighted, evinced no tendency to push the foremost wheels over a rail when traversing curves, and thus reduced oscillation; and in addition to these various advantages, wheels of large diameter are less easily derailed, and at points and crossings cause less disturbance by their passage at higher velocity than is the case with smaller wheels. In actual practice Mr. Stroudley's claims were fully vindicated, as was the case wherever the design was adopted, which makes it difficult to assign adequate reasons for the comparative scarcity of the 0-4-2 type nowadays.

The nineteenth engine of the "B" class, of which eventually thirty-six were built, was No. 189, "Edward Blount," and its date March, 1889. It was exhibited at the Paris Exposition in the same year and gained a gold medal. It remained in France after the close of the Exhibition in order to run trials on the Paris, Lyons, and Mediterranean Railway in competition with the South Eastern's engine No. 240. While making arrangements for the tests Mr. Stroudley contracted a severe cold, developing into acute asthma, from which he died in Paris on December 20th, 1889. The last eleven of the "Gladstones" were under construction at the time of the decease of their designer.

For the moment it will be convenient to jump to the year 1908, when we find the "Edward Blount" drawing the Victoria to Eastbourne express, at which time it had been fitted with Hammond's apparatus for heating the air prior to its combustion in the firebox. The smokebox is divided into two compartments by means of a horizontal partition placed above the tube ends, and the lower chamber communicates with two "pockets" on either side of the smokebox exterior, which contains a number of air tubes open to the atmosphere at their front ends. At the other end they lead into pipes, which conduct the air down under the fire-plate, and thus supply oxygen to the fire. The waste gases from the furnace pass through the lower chamber inside the

NO. 198, "EDWARD BLOUNT"

Fitted with patent hot-air apparatus, drawing the Victoria and Eastbourne express (London, Brighton, and South Coast Railway)

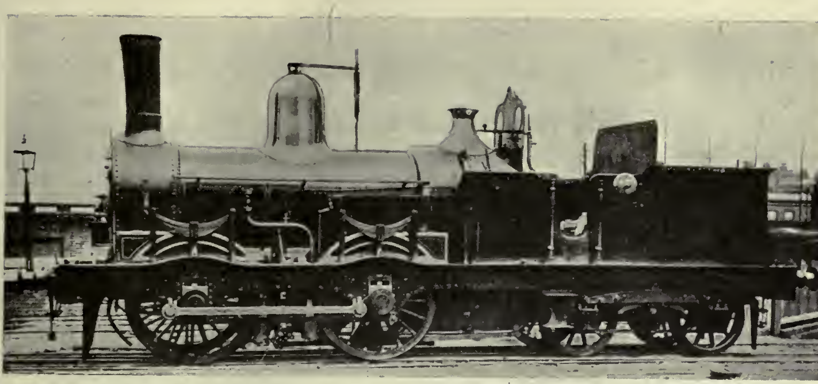
smokebox, thence around the air tubes in the "pockets" and into the upper part of the smokebox, where the blast pipe orifice is situated. In their passage through the "pockets" these gases heat the air on its way to delivery under the fire-grate. As shown in the photograph, the Hammond apparatus gives an engine a decidedly squat appearance.

Mr. Robert J. Billinton, who succeeded Mr. Stroudley, was not new to the Brighton works, having been chief draughtsman there before he went to the Derby works to hold a similar position. Of the eighteen locomotives which the new superintendent found under construction, one was a large six wheels coupled radial tank engine; cylinders, $18\frac{1}{4}$-in. by 26-in.; coupled wheels, 4-ft. 6-in. diameter, and radial trailing pair, 4-ft.; total wheel-base, 21-ft. 3-in., the overhang at the trailing end being 4-ft. 7-in.; standard boiler 10-ft. 2-in. long, and diameters 4-ft. 1-in., 4-ft. 2-in., and 4-ft. 3-in.; 262 tubes, $1\frac{1}{2}$-in. diameter and 10-ft. $8\frac{3}{4}$-in. long; total heating surface, 1174 sq. ft.; area of fire-grate, 17 sq. ft. The side and bunker tanks had a capacity of 1416 gallons; bunker capacity, $2\frac{1}{4}$ tons of coal. A powerful steam brake acted on the coupled wheels instead of the Westinghouse brake, which is favoured on the London, Brighton, and South Coast Railway. Weight of engine, 51 tons 14 cwt. The engine was numbered 158 and named "West Brighton." The dimensions are detailed because of developments in later years.

The first notable additions to the locomotive stock of Mr. Billinton's own design were passenger tank engines having four wheels coupled and a trailing bogie. They were calculated to be useful for all classes of passenger work, whether fast main-line or local; and between May, 1892, and November, 1896, thirty-six of them were built and put into service.

In the years 1893, 1894, and 1900–1–2, the Vulcan Foundry Co., of Warrington, constructed for the London, Brighton, and South Coast Railway 55 standard six-coupled goods known as class "C 2." The wheels were 5-ft. in diameter; heating surface, 1212 sq. ft.; weight of engine in working order, 38 tons 12 cwt. The six tender wheels were 4-ft. in diameter; tank capacity, 2420 gallons; coal storage, 4 tons; weight of tender in full working order, 32 tons 13 cwt. These engines were fitted with the Westinghouse brake for use in hauling heavy passenger trains, which they did quite smoothly at 55 miles an hour.

During the years 1894–5 there were built at the Brighton works fourteen six wheels coupled radial tank engines of the "West Brighton" type. They differed but little from the first of the class. The tubes were of brass, twenty less in number but $\frac{1}{8}$-in. larger in diameter, and afforded 24 sq. ft. more heating surface. The capacity of the water storage was 38 gallons less. These engines, fitted with the Westinghouse automatic brake, were used so frequently on passenger trains that it was decided to build all future engines of this type with 6-in. larger wheels; between the end of 1897 and the early part of 1902 no less than 69 of them were turned out of the Brighton shops. Of course, the original intention was to use engines of the "West Brighton" type for goods traffic, and they were coloured olive-green accordingly, but the last forty-five were given the standard garb of the passenger locomotive stock: gamboge with green edging, lined out with red, black, and white; in both cases the buffer beams were red with black and white lines. The goods engines were olive-green, lined out



1. EARLY TANK ENGINE (0–4–4). 2. NO. 595, BOGIE TANK ENGINE (4–4–2)
3. NO. 37, "ATLANTIC" TYPE EXPRESS LOCOMOTIVE
(London, Brighton, and South Coast Railway)

with two red lines, and buffer beams red with black and white lines.

In June, 1895, appeared the first four-coupled bogie express engines, a type that was quite new to the London, Brighton, and South Coast Railway, although familiar on various other lines. Twenty-four of this type were built; half a dozen of them being fitted with the Automatic Vacuum brake for working "foreign" trains that pass over the Company's system; and a couple of them were fitted to burn liquid fuel.

More powerful four-coupled bogie express engines were soon called for, and the "Sirdar" came from the Brighton shops in January, 1902, the forerunner of thirty-two of similar design and dimensions: cylinders, 19-in. by 26-in.; driving wheels, 6-ft. 9-in. diameter; boiler, 10-ft. 11-in., and diameter of biggest ring, 4-ft. 10-in.; total heating surface, 1635 sq. ft.; working pressure, 180 lbs. per sq. in. Total weight of engine and tender in working order, with 3000 gallons of water and 6 tons of coal, 77 tons 7 cwt. No. 45, the "Bessborough," had Drummond's water tubes in the firebox; No. 52, the "Siemens," was fitted with Holden's liquid fuel apparatus. No. 54, "Empress," on February 2nd, 1901, was selected for the honour of hauling, from Fareham to Victoria, the special train conveying the body of the late Queen Victoria *en route* for Windsor; while on November 2nd the same engine was employed in the joyful mission of drawing the Prince and Princess of Wales from Portsmouth to Victoria at the conclusion of their great Imperial tour. On December 21st of the same year, No. 42, "His Majesty," found itself in Lime Street station, Liverpool, having worked a theatrical special over the London and North Western Railway—a rare experience for a London, Brighton, and South Coast engine to travel so far from home. On the same date No. 70, "Holyrood," hauled the Pullman Limited from Victoria to Brighton, 51 miles, in 53½ minutes, a fair example of the capabilities of the class. Of the whole thirty-three engines in the class only eight were built at Brighton, the remainder being constructed by Messrs. Sharp, Stewart and Co. Of the engines specifically named above, all were Brighton engines except "Holyrood."

Mr. Billinton died in November, 1904, and was succeeded by Mr. D. Earle Marsh, who came from the Great Northern works at Doncaster. It was only fitting that he should introduce to the London, Brighton, and South Coast Railway engines of the "Atlantic" type; and speedily five fine locomotives were built by Messrs. Kitson and Co. to his designs. Bearing a strong resemblance to the No. 251 class on the Great Northern Railway, comparison of the dimensions of the two classes shows that practically they differ only in the cylinders and boiler pressure. No engines of such size and power had hitherto been seen on the London, Brighton, and South Coast Railway, as shown by the following particulars:

cylinders, 18½-in. by 26-in.; coupled wheels, 6-ft. 7½-in. diameter; boiler, 16-ft. 3⅞-in. long, diameter, 5-ft. 6-in.; 246 tubes; total heating surface, 2459 sq. ft.; grate area, 31 sq. ft.; working pressure, 200 lbs. per sq. in.; water capacity, 3500 gallons; coal,

A PULLMAN CAR DRAWING-ROOM
(London, Brighton, and South Coast Railway)

4 tons. Weight of engine and tender in working order, 106 tons 10 cwt. The colours of the locomotives were changed at this period; the passenger engines being painted umber with gold or yellow lines; and the goods engines black with red lines. The numbers appearing on the buffer beams are in gold.

We illustrate locomotive No. 37, one of the first London, Brighton, and South Coast engines of the "Atlantic" type, and No. 595, bogie tank (4–4–2), which is a modification of a similar type used on the Great Northern Railway, and possesses the adhesive weight and power demanded by modern traffic conditions. It is interesting to compare these up-to-date locomotives with No. 231, which was considered a remarkably fine engine when it appeared in 1866.

Coming to the passenger stock affords us an opportunity of considering the acme of comfort in travel for which Pullman cars are synonymous all the world over. Only five companies in the kingdom use these cars, of which an exterior view is illustrated on page 127; there are only 49 of the cars, of which 31 are found on the London, Brighton, and South Coast Railway, 11 on the South Eastern, 3 on the South Western, and a couple each on the Metropolitan and the Highland railways. The Midland Railway introduced the American vehicles in 1874, but discarded them for British carriages, well designed and decorated, and beautifully upholstered, but falling considerably short of the renowned Pullmans. On the London, Brighton, and South Coast Railway the "Southern Belle," a world-famous train that runs twice daily, and the "Eastbourne Limited," running on Sundays only, are made up solely of British-built Pullmans, the others being used singly, or several together, attached to ordinary stock. The "Southern Belle" is shown on Coloured Plate X.

The cars that are favoured in this country are the parlour or drawing-room car, buffet car, with accommodation for serving light refreshments, and the dining or breakfast car.

The full "Southern Belle" train, which has been termed "a chain of vestibuled luxury," consists of seven cars, the "Grosvenor" (buffet car), and the "Cleopatra," "Bessborough," "Princess Helen," "Belgravia," "Alberta," and "Verona" (parlour cars). It claims to be the most luxurious train in the world, and the title is not denied by people who have travelled in many different countries. The seven Pullman cars, which form the "Southern Belle," rival each other in charm and attractiveness. The "Cleopatra" car has smooth panelling of Indian satinwood, inlaid with grey sycamore and delicate tulip-wood. The domed ceiling of purest white is decorated with beautiful mouldings. The chairs and lounges are upholstered in velvet tapestries, different shades of blue with a delicate tracery of gold, while the soft carpet of deep rose colour gives a lovely glow to the whole compartment.

No two cars are alike, each exhibiting a wonderful variety of panelling and woodwork, a revelation of the colour harmonies producible by using different woods. One car, for instance, is decorated with a rare quality of striped mahogany, used with kingwood and satinwood, giving a wonderfully rich effect. Another is fitted with "plum-pudding" mahogany, so called because of its curious markings. This is banded with a striped wood of a purple colour. In another car there is an entire change in the colour scheme. It is panelled with pear-tree wood inlaid with holly in the "Pergolesi" style, decorated with beautiful inlaid work of festoons, draperies, and flowers, the general effect being of ivory on the rich brown wood. In this car, which is the "Belgravia," the sofas and chairs are upholstered in a fine blue *piqué* velvet. The blinds are in rich damask of the same colour, and the pile carpets of deep rose.

SALOON BRAKE COACH
(London, Brighton, and South Coast Railway)

In other cars the cosy chairs are tapestried in delicate greens, or pale gold-browns, in harmony with the general tones of these beautiful little rooms on wheels.

Then, coming to the "Alberta" and "Verona" parlour cars, one finds the style of the French Renaissance, so chaste in its dignity and classical decoration. Here the wood is of the finest wainscot oak, beautifully figured and inlaid with decorative panels, mouldings, pilasters, and friezes of holly-wood, giving the effect of bas-relief. The ceilings, wall brackets, door mouldings and other details have all been specially designed to retain the characteristics of the Renaissance style.

Among the details which instantly attract the eye are the standard electric lamps which are upon the little tables in each compartment. They remind one of the gold-chased candlesticks which once illumined the beauty of fair ladies at the Court of Versailles. Not less charming are the wall-brackets in finely chased ormolu, with moulded crystal globes of flower-shape.

The London, Brighton, and South Coast Railway possesses other handsome coaching stock of which the most notable are some vestibuled carriages which were put into service in the summer of 1907.

The parlour saloon dynamo brake consists of a saloon compartment 22-ft. 9-in. long, entered through side doors in the vestibule end. The vehicle has a brake compartment, containing dynamo and accommodation for accumulators to supply electricity for use in the saloon itself, and also in the Pullman cars on the train. The furniture in the saloon compartment is composed of 10 movable wicker chairs and 6 fixed seats, all upholstered in Kashmere rep, and the floor is covered with special Klondyke carpet. The wood finish is in polished walnut and sycamore panels. The vestibule has a polished walnut dado and polished wainscot oak uppers, the roof being whitewood white-enamelled. This coach is lighted from the dynamo in the guard's van, with two-light electroliers and single roof lights ; it is also fitted with lights along the cant rail moulding, the whole being under the control of the guard.

The parlour saloon consists of 2 saloon compartments, divided by a high partition in the centre. The furniture in each compartment consists of 4 movable wicker chairs and 6 fixed seats, two compartments being upholstered in rep, and 2 for smokers in green buffalo hide. The interior decoration of saloons and vestibules is similar to that of the carriage first described, and the coach is fitted with central electroliers.

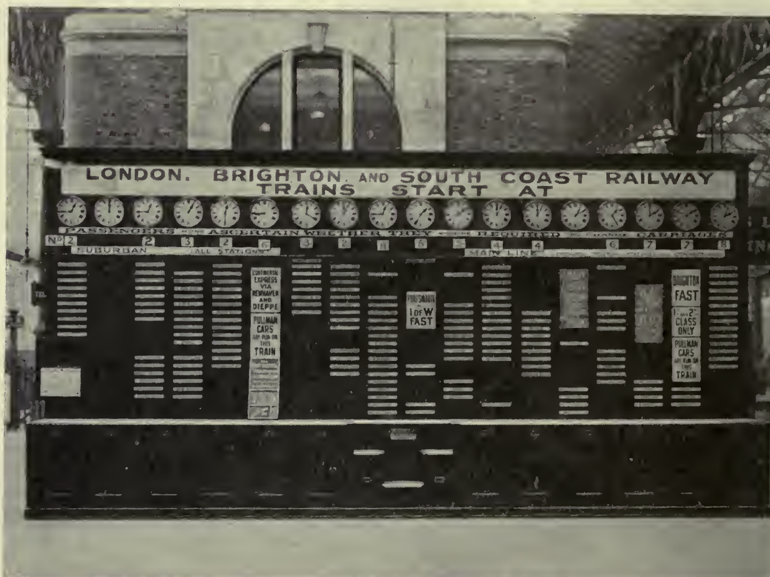
The corridor coach contains six compartments to carry six passengers each, with a corridor down the side. The coach is entered by side doors at each vestibule end. Three compartments are upholstered in green buffalo hide for smokers and three in moquette. The interior decoration consists of millboard panels in roof and sides, decorated with riband lincrusta, the wood finish being of polished walnut and sycamore panels. The compartments are entered by sliding doors with upper panels of glass. The corridor is finished similar to the vestibules in the other carriages. This coach has electric light in single roof lights and brackets, also special lights controlled by the passengers.

Although the Brighton line was not the first to inaugurate specially luxurious carriages, it has carried out the idea to a greater extent than others. It claims also to be the pioneer in several other matters. At the junction of the old Croydon and Greenwich railways there was "an octagonal lighthouse with powerful parabolic reflectors, from which signals by coloured lights were given to approaching trains." From this system fixed signals were but a natural step. The semaphore signals first came into use on the Croydon Railway in 1842, and were speedily adopted upon the London, Brighton, and South Coast Railway, at whose Bricklayers' Arms Station a few years later signals were interlocked for the first time. In the year 1875 Mr. Stroudley fitted to all passenger trains the means of communicating electrically with the guard, instead of the unsatisfactory communication cord; and London, Brighton, and South Coast railway carriages were the earliest to be lighted by electricity.

The total mileage of the London, Brighton, and South Coast Railway is only 483 miles, but it is a perfect network of metals in the restricted area it serves; and no other line in the kingdom so small can compare with it, either in importance or popularity. For the main lines bull-headed section rails, 96 lbs. per yard, are used. There are various 2 and 3 mile sections with gradients varying from 1 in 50 to 1 in 80. The tunnels at Clayton and Oxted are 2266 yards long. The early tunnels at first were lighted by gas, until carriage illumination rendered it unnecessary, and some of the tunnels were lined with iron to save passengers in open vehicles from the water that otherwise would drop from the roof.

The London, Brighton, and South Coast Railway makes no pretensions to the highest speeds, the fastest train occupying 60 minutes for the 50½ miles to Brighton; to Eastbourne, 66 miles, the fastest timing is 1 hour 30 minutes; and to Portsmouth Harbour, 86¼ miles, 2 hours 6 minutes. The longest non-stop run is from Clapham Junction to Fratton, 81½ miles, in 112 minutes. Apart from its services between London and the seaside resorts lying between Hastings and Southsea, the Company has an immense London suburban traffic, in addition to serving numerous beauty spots in its own territory and several racecourses, of which that at Epsom is most famous. During the year 1910 over 53,000,000 passengers (exclusive of season-ticket holders) were carried, entailing the trains running about 9¼ million miles; the goods trains in the conveyance of about 1½ million tons of merchandise and 3 million tons of minerals ran less than 2 million miles. The receipts from passengers, parcels, and mails are nearly three times as much as from goods and minerals. The locomotives number 535; coaching vehicles of all kinds, 3060; goods vehicles, 13,108.

The gathering of people from all parts of the world into London for the Coronation in 1911 caused the running of many special trains on all our chief lines. "To-day's crowd," wrote Mr. Augustine Birrell, "represented more terrifically than ever did crowd before the triumphs of steam." Nobody grasped this more than the railway officials responsible for the conveyance of 100,000 children and their teachers, who were the King's guests at the Crystal Palace on June 30th. The special traffic arrangements necessitated 96 special trains, each accommodating between 900 and 1000 passengers, who arrived and departed from the 4 stations, Crystal Palace (high and low levels), Sydenham Hill, and Penge. The Brighton Company handled 56 of the specials, and the South Eastern the remainder. Most of the trains were from and to stations on the systems of those two companies, but 37 came from various



TRAIN INDICATOR—VICTORIA STATION
(London, Brighton, and South Coast Railway)

other lines. On the Brighton system the 56 specials discharged their passengers between 10.30 a.m. and 2.20 p.m., averaging a train every 4 minutes. Having to find siding accommodation for the trains during the day complicated the traffic immensely. To overcome the difficulty, running lines in the neighbourhood of the Palace were utilised as sidings, and about a score of stations in the district was closed to the general public for the greater part of the day. Altogether, the handling of the King's young guests rendered it one of the most remarkable feats of special traffic working ever known on British railways.

The largest station on the London, Brighton, and South Coast

Railway is Victoria. Until 1899 it covered an area of 8½ acres, containing 8 platforms each about 600 ft. in length. The new Victoria terminus, completed in 1908, covers about 16 acres, with 9 platforms, 4 of which are 1500-ft. long, the total length of the platform faces being 2¼ miles, with accommodation for 18 trains. Under a lofty roof are to be found every possible modern convenience to assist the departure or arrival of passengers without delay or confusion. A striking feature in the circulating area leading to the platforms is a huge train indicator, its numerous clock faces and names of calling stations below saving a passenger from asking direction from the officials. Indicators of various kinds are found at other termini, but this one claims to be the largest.

London Bridge Station covers about 8 acres of land. It contains 6 platforms, averaging 650-ft. in length, which serve 11 lines of rails. Among the stations out of London, Brighton Central Station is the largest, having been improved at various periods until its accommodation now comprises 7 platforms and 13 passenger lines of rails.

CHAPTER XXI

SOUTH EASTERN AND CHATHAM RAILWAY

On the first day of the twentieth century the South Eastern and the London, Chatham, and Dover railways united to work under a managing committee consisting of directors of the two companies; Parliament duly sanctioned the arrangement, and the two lines have been worked since as one concern.

The South Eastern Railway was incorporated in 1836 to construct a line from London to Dover; and in the last chapter was described how Parliament hampered both the South Eastern and the London and Brighton in their endeavours to reach the coast. The line to Dover was opened as far as Tonbridge in May, 1842, by which time a branch from that town to Tunbridge Wells was under construction. By the end of the year the trains ran to Ashford; some months later the line to Folkestone was opened; and in the following year Dover was in railed communication with Bricklayers' Arms Station, which the Company styled its "West End" terminus, although it was situated in the Old Kent Road. This station, which is now the chief goods depôt of the line, figures notably in the history of railway signalling, as told on page 159.

Sir William Cubitt was the engineer of the South Eastern line. He was a great believer in straight runs, and assured the Gauge Commissioners, when giving evidence before them, that no speed was dangerous to the public in a straight line. Between Redhill and Ashford he laid 48 miles of line, straight and practically level; but beyond that point he needed all his engineering skill. At Folkestone there is a viaduct of 20 arches more than 100-ft. high, followed by the Martello Tunnel, 530 yards long. Warren Cutting entailed delving through the chalk for a distance of 2 miles, leading to Abbot's Cliff Tunnel, 1933 yards in length. From this tunnel to where the line pierced Shakespeare Cliff, the metals ran under the cliffs close to the sea, from which it was protected by a strong wall of masonry 2 miles long. Here it was necessary to remove a projection of the Round Down Cliff, in order to ensure a direct passage.

This work entailed the removal of two million tons of chalk. Three different galleries, and three separate shafts connected with them, were constructed in the cliff; and in three chambers at the bottom 18,000 lbs. of gunpowder were tamped up ready for firing by means of electric wires 1000-ft. long, being the first occasion of electricity being employed for such a purpose. On January 26th, 1843, an immense crowd gathered together at a safe distance to witness the operations.

The final signal was given. "The next minute," said the *Times* correspondent, "was one of silent and breathless and impatient expectation. Exactly at 26 minutes past 2 o'clock a low, faint, indistinct, indescribable, moaning, subterraneous rumble was heard, and immediately afterwards the bottom of the cliff began to belly out, and then, almost simultaneously, about 500-ft. in breadth

LONDON EXPRESS ENTERING SHAKESPEARE CLIFF TUNNEL, NEAR DOVER
(South Eastern and Chatham Railway)

of the summit began gradually, but rapidly, to sink. There was no roaring explosion, no bursting out of fire, no violent and crashing splitting of rocks and, comparatively speaking, very little smoke; for a proceeding of mighty and irrepressible force, it had little or nothing of the appearance of force. The rock seemed as if it had exchanged its solid for a fluid nature, for it glided like a stream into the sea, which was at a distance of about 100 yards from its base."

Omitting mention of the numerous extensions of the system that followed in due course, reference must be made to two lines that were absorbed by the South Eastern. The London and Greenwich Railway had been decided upon before the incorporation of the larger company, but it was not opened throughout its length of 3¾ miles until December, 1838. This line, carried upon 878 brick arches between London and Greenwich, was eventually leased to the South Eastern for 999 years.

One portion of the present-day South Eastern system was still older, viz. the Canterbury and Whitstable line, which was opened on May 3rd, 1830. It may appear strange that so small a town as Whitstable, at that time relatively of no commercial importance, should have led the way in the matter of southern railway communication. Briefly, it arose through a projected scheme to widen the river Stour, and virtually make Canterbury a seaport. But Mr. William James, who was interested in the Stockton and Darlington Railway, appeared upon the scene with a proposal to construct a harbour at Whitstable, from whence there should be a railway to Canterbury, which would prove more reliable and a speedier means of conveyance than a waterway.

John Dixon, one of George Stephenson's assistants, surveyed the line, and a route was selected, fairly level, and nowhere demanding heavy earthworks. The promoters of the railway, however, insisted upon having the novelty of a tunnel; and thus Stephenson was forced to take another route over undulating and steep country, simply to pierce Tyler Hill with the first railway tunnel opened in the world.

It proved to be a dear whim, for the consequent steep gradients entailed working the greater part of the 6-mile line by stationary engines. From Canterbury for nearly 2 miles the railway ascended by gradients ranging between 1 in 41 and 1 in 56 to the summit of Tyler Hill; the tunnel, 828 yards in length, and with one section of smaller bore than became usual, had the latter gradient. At the top of the climb from Canterbury stood a couple of 25 h.p. stationary engines for hauling trains up the incline. For 1⅛ mile the track was level as far as Clowes Wood summit, where were two more stationary engines for working the traffic on gradients of 1 in 28 and 1 in 31 to Bogshole, a mile distant. This spot was well named, for in wet weather the spongy ground often subsided, and brought traffic to a standstill. For 1 mile 300 yds. the line was again level until it reached the Church Street incline with a fall of 1 in 57 for nearly half a mile, then 1 in 50 for about a quarter of a mile, the remaining half-mile into Whitstable being practically flat.

When the question of gauge came to be settled, George Stephenson insisted upon 4-ft. 8½-in. He had already been approached concerning the Leicester and Swannington Railway, and his great faith in the triumph of the iron road over all other means of transport led him to prophesy the joining together of whatever railways were constructed in the kingdom.

The locomotive for use on the opening of the line was the "Invicta," the twentieth engine built at Stephensons' Forth Street works, Newcastle. It had four coupled wheels 4-ft. in diameter, driven by two outside inclined cylinders 10-in. by 18-in., which were placed at the forward end, a method adopted since almost universally. The boiler had twenty-five tubes of 3-in. diameter, and a rectangular firebox. The heating surface was 192 sq. ft., working pressure 40 lbs., and total weight of engine $6\frac{1}{4}$ tons.

Naturally, the opening of the second public railway in England created the greatest interest, and was the occasion of great local rejoicing. The carriages behind the engine numbered a score, containing nearly 300 passengers. "The motion of the carriages," said the *Kent Herald* of May 6th, 1830, "is particularly easy and agreeable, and at first starting the quiet power with which the vast mass was set in motion dispelled every fear in the passengers. The entrance into the tunnel was very impressive—the total darkness—the accelerated speed—the rumbling of the cars—the loud cheering of the whole party echoing through the vault, combined to form a *situation* almost terrific—certainly novel and striking. Perfect confidence in the safety of the whole apparatus, however, seemed to prevail, and the company emerged from the dismal tunnel in high spirits. The journey altogether was a delightful one. The only drawback on the pleasure of the occasion was the great delay attending the shifting of the machinery and its application to various detachments of the long procession."

Although the "Invicta" was intended only to work the traffic at the Whitstable end of the line, it was soon found that its powers were insufficient to negotiate the Church Street bank, where another stationary engine had to be erected, leaving the little locomotive to work the South Street level mile. Eventually the engine was abandoned in favour of horses, until arrangements were completed for working even the South Street section by a rope.

In 1844 the South Eastern took over the Canterbury and Whitstable Railway on lease, and purchased it in 1853. The old Birkinshaw wrought-iron, fish-bellied rails, in 15-ft lengths and 28 lbs. to the yard, oak sleepers 3-ft. apart, and the sheaves on which the ropes ran, were taken up by the new owners, in order to lay the permanent-way to coincide with other parts of the system; but the small-bore tunnel remains to this day, necessitating the use of smaller rolling-stock.

With signalling arrangements far from perfect, the increase of traffic at London Bridge station, into which four companies were running independently, was causing absolute confusion. In 1844 a joint working committee endeavoured to improve matters, but solution lay in another direction, for the South Eastern acquired the London and Greenwich line on lease, as before stated, and the London and Croydon was taken over by what was freshly styled the London, Brighton, and South Coast Railway.

A notable event in the history of the South Eastern Railway was its extension from London Bridge to Cannon Street and Charing Cross, opened in 1866 and 1864 respectively. The additional

$2\frac{3}{8}$ miles of line cost about 4 millions sterling, or £1000 a yard, certainly an immense sum, but giving the South Eastern a great advantage over other southern lines. The late Dr. Samuel Smiles was then secretary to the Company, and was one of the originators of the scheme. In May, 1868, the South Eastern opened a new direct line to Tonbridge via Sevenoaks, in order to compete with its rival, the London, Chatham, and Dover Railway.

At this point we must consider the inception of the East Kent Railway, which obtained an Act to construct a railway from Strood to Canterbury, which was opened throughout in July, 1860. Further powers enabled the line to be extended in one direction to Dover, and in the other to St. Mary Cray. From the latter town

LONDON EXPRESS PASSING THE WARREN, BETWEEN DOVER AND FOLKESTONE
(South Eastern and Chatham Railway)

there was the Mid-Kent line to Bromley, from which there was the Farnborough extension of the West End of London and Crystal Palace Railway to Battersea, and giving access to Victoria Station by the Pimlico Railway. By obtaining running powers over these various lines the East Kent Railway gained entrance into London in November, 1861, but more than a year earlier had changed its name to the London, Chatham, and Dover Railway. To complete its main line the Company constructed a line from Kent House to Herne Hill, and thence on to Ludgate Hill and Holborn.

Now we may view the present-day system of the South Eastern and Chatham Railway. The lines owned, leased, and rented at the end of 1910 totalled 646 miles. The steepest gradient on the South Eastern section is 1 in 28, between Canterbury and Whitstable, but there are many long gradients as severe as 1 in 140. On the Chatham section the steepest gradient is 1 in 75 for about 2 miles near Ramsgate, but the most trying gradient is 1 in 100 for 5 miles between Strood and Sole Street; but really, the Chatham and Dover line for 50 out of the 70½ miles between London and Dover provide about as difficult running as one can conceive, not more than a score of miles being easier than 1 in 200.

The tunnelling operations between Folkestone and Dover have been mentioned. Other tunnels on the South Eastern section are Sevenoaks (3541 yards), Polhill (2609 yards), and Bletchingley (1324 yards). This last was cut through the Weald clay, instead of chalk, at a cost of £80 a yard. Saltwood Tunnel was shorter (950 yards), but it cost nearly £120 a yard, because of striking running water, bringing with it large volumes of sand. Cubitt conquered the difficulty, after much consideration, by stuffing straw behind his wooden barricades, which allowed the water to drain through but kept the sand in check. On the Chatham section the chief tunnels are Shepherd's Well (2365 yards), near Dover, and one, 1¼ miles long, under Sydenham Hill.

It was stated in the previous chapter that the South Eastern and the London and Brighton worked their locomotives as general stock under a joint committee for several years. An early locomotive, No. 136, "Folkestone," was one of a batch of ten delivered to the South Eastern Railway in 1851 by Messrs. Robert Stephenson and Co. They were designed by Mr. T. R. Crampton. The "Folkestone" was a 4-2-0, with driving wheels 6-ft. diameter behind the firebox, the front wheels being 3-ft. 6-in. diameter. The cylinders, placed under the smokebox, were 15-in. by 22-in., and worked on a crank-shaft, from which, by outside cranks and coupling-rods, the motion was transmitted to the drivers. The "Folkestone" often ran from Redhill to Tonbridge, 46 miles, in 40 minutes, and at some parts of the journey the speed averaged 78 miles an hour. This engine was shown at the Great Exhibition of 1851, alongside the South Eastern's new eight-wheeled carriage, which was jointed in the middle to assist it in taking curves.

As the South Eastern at one time went in largely for Crampton's engines, we may consider the most famous locomotive of this design. On page 40 reference was made to Messrs. Bury's second locomotive, built in 1831. It was a four-coupled goods, and was named the "Liverpool." In 1848 the same firm built another "Liverpool" under Crampton's patent. This famous engine was an eight-wheeler, but with only a single pair of drivers 8-ft. diameter, the other wheels being 4-ft. diameter. The cylinders were 18-in. by 24-in.; total heating surface, 2290 sq. ft. Weight of engine in working order, 35 tons, of which 12 tons were on the driving wheels; weight of tender, 21 tons. With a light load the "Liverpool" attained a speed of 78 miles an hour, and upon one occasion it hauled

40 carriages from London to Wolverton, a load sufficient for three ordinary engines, and yet it ran to time. In general working, however, these engines proved unsatisfactory, and particularly were too heavy for the light rails of that day; and in due course they were converted to the ordinary type with wheels upon the driving axles.

When the South Eastern railway works at Ashford were opened in 1847 James J. Cudworth was the locomotive superintendent. In 1853 the Company's first engine of its own building was put on the rails; it was a four-coupled passenger locomotive, and one of a batch of eleven. Its cylinders were 15-in. by 20-in.; coupled wheels, 5-ft. 6-in. diameter; heating surface, 1123 sq. ft.; weight, 26 tons. These were followed by 6-ft. singles; and in 1857 some coal-burners

AN OLD "CRAMPTON"
(South Eastern and Chatham Railway)

appeared. Until 1855 all engines had used coke as fuel, James Beattie's "Canute," on the London and South Western, being the first engine to burn coal. Cudworth patented a firebox with a sloping grate and a division in the middle, which necessitated two fire-doors, side by side. The idea was that if each were fired alternately, the smoke emitted from one side of the box would be consumed by the heated products of the other. Oil fuel engines of the "Holden" type were also tried on this railway. Some large goods engines may be passed over, except to note that a couple of them had Mansell wooden wheels, mentioned elsewhere. Of some 7-ft. singles, mention may be made of No. 81, "Flying Fox," which was painted blue, and worked the royal trains. These locomotives were known as the "Dover Mail" engines, first built in 1861, and used on the boat trains, which, prior to the opening of the Sevenoaks line, ran from London Bridge to Dover, 87¼ miles, without stopping.

1. "INVICTA" (1830)
(Canterbury and Whitstable Railway)

2. NO. 504, EXPRESS PASSENGER LOCOMOTIVE
(South Eastern and Chatham Railway)

When Mr. Cudworth resigned he was followed by Mr. (afterwards Sir) A. M. Watkin, who ruled at Ashford until 1878, when he was succeeded by Mr. James Stirling. The new superintendent worked wonders with the South Eastern locomotive stud, ruthlessly scrapping many engines of his predecessors, converting others, and building new locomotives of more power and weight to meet the growing requirements of the traffic. One of his engines, No. 240, gained a gold medal at the Paris Exhibition of 1889. It was a 4 – 4 – 0 ; cylinders 19-in. by 26-in. ; driving and trailing wheels, 7-ft. diameter, and bogie wheels, 3-ft. 9-in. diameter. Total weight of engine 42½ tons, and tender 30½ tons. With this engine we may compare No. 440, a four-coupled bogie express locomotive that appeared in 1898, designed by Mr. Stirling, but built by Messrs. Neilson, Reid and Co., of Glasgow. The following were the leading dimensions : cylinders, 19-in. by 26-in., and placed at an inclination of 1 in 30 ; driving wheels 7-ft. diameter, and the front of the engine carried on a bogie with four wheels, 3-ft. 9-in. diameter ; boiler, 10-ft. 4½-in. long, and 4-ft. 8⅛-in. outside the largest ring ; firebox, 5-ft. 9-in. long ; 215 tubes of 1⅝-in. diameter ; total heating surface, 1087 sq. ft. The tender, on six wheels, 4-ft. diameter, carried 3 tons of coal and 3000 gallons of water. Total length of engine and tender over buffers, 52-ft. 8-in. When loaded the weight on the bogie was 15 tons, on driving wheels 16 tons 8 cwt., on trailers 14 tons 13 cwt. Total weight of engine and tender, 80 tons 3 cwt.

The first engines employed on the London, Chatham, and Dover Railway were several which the contractors had used for ballasting purposes, and half a dozen lent by the Great Northern. For twenty years the Company's locomotives were built by outside firms ; they were of various kinds, and much the same as those built for other railways. The " Swale," a six wheels coupled tender goods engine of 1860, had inside cylinders and inside frames. It was sometimes used for passenger traffic, and once distinguished itself by conveying the late Duke of Cambridge from Chatham to London, accomplishing the journey of 35 miles in 3 hours.

Mr. William Martley was appointed locomotive superintendent in 1860. To cope with the growing traffic, he bought six engines from the Dutch-Rhenish Railway. They were, however, British-built by Messrs. Sharp, Stewart and Co., of Manchester, and were generally of the standard type constructed by that firm during the fifties. A couple of years later the stock was increased by two dozen " Crampton " engines, which were among the first bogie locomotives constructed in this country for express work. It was not until 1869 that Mr. Martley built his first engine at the Company's own Longhedge works at Battersea. It was a four wheels coupled passenger engine with 6-ft. drivers, which the superintendent named " Enigma," because work upon it was so often stopped for want of funds that he marvelled how it was ever completed.

In 1873 Mr. Martley designed four handsome four wheels coupled express passenger locomotives, for working the continental boat trains between London and Dover. They were constructed by Messrs. Sharp, Stewart and Co., and were named respectively, "Europe," "Asia," "Africa," and "America." The chief dimensions of these engines were: cylinders, 17-in. by 24-in.; coupled wheels, 6-ft. 6-in. diameter; pair of leading wheels, 4-ft. 6-in. diameter; heating surface, 1180 sq. ft. Weight of engine in working order, 36¾ tons. At the time of their construction these engines were considered a very powerful type, and until nearly the end of the century they took a prominent part in the express passenger workings of the line.

Mr. Martley died in 1874, and was succeeded by Mr. William Kirtley, nephew of Matthew Kirtley, the locomotive superintendent of the Midland Railway. The greater part of Mr. Kirtley's duties at Longhedge works for a long time consisted of rebuilding and conversions. The first engines to his own designs were eighteen four wheels coupled trailing bogie, side tank engines, for suburban traffic. These were followed a couple of years later by four wheels coupled bogie express locomotives for the Dover boat trains. Their performances were very creditable, for they ran the distance of 78½ miles with 150 tons behind the tender in 1 hour 50 minutes on the down journey, and a few minutes longer on the up journey, owing to the heavy pull of 1 in 132 for 6 miles from Dover to Shepherd's Well, and up Sole Street bank, 5 miles of 1 in 100. In 1881 and 1884 more bogie express engines of the same type were added to the Company's stock. In 1891 Mr. Kirtley designed another series of six four wheels coupled bogie express engines, which were built by the Vulcan Foundry Co., Ltd., the last type of express passenger engine up to the time of the amalgamation with the South Eastern.

Mr. H. S. Wainwright became locomotive, carriage, and wagon superintendent of the united South Eastern and Chatham systems on January 1st, 1899. For an example of his work we may note some fine passenger locomotives (4 – 4 – 0) which came out in 1906. No. 273, when it appeared, was acknowledged to be the finest-looking engine that had ever appeared at the head of a South Eastern train. It had cylinders 19¼-in. by 26-in., and coupled wheels 6-ft. 6-in. diameter. The boiler, with a Belpaire firebox, afforded the following heating surface: firebox, 136 sq. ft.; tubes, 1396 sq. ft.; total, 1532 sq. ft.; grate area 21·15 sq. ft., and working pressure 180 lbs. per sq. in. It was fitted with Stone's patent fuel economiser and also a spark arrester. The capacity of the tender was 4 tons of coal and 3450 gallons of water. Weight of engine, 52¼ tons; tender, 39 tons 2 cwt. Length of engine and tender over buffers, 55-ft. 1⅝-in., and total weight, 91 tons 7 cwt. No. 516, another example of this class, was the only locomotive shown at the Franco-British Exhibition of 1908. Appended is a photograph of No. 504, an exactly similar engine.

At the end of 1910 the locomotives of the two companies numbered 736. They are coloured dark green. The coaching stock comprises over 4000 passenger vehicles of various kinds, coloured dark maroon. Of goods vehicles there are 11,400. Excluding season-ticket holders the passengers in 1910 numbered 57,922,725, for whose conveyance the trains ran 12,412,000 miles, or five times the mileage of the goods and mineral trains.

The popularity of the Pullman car on other lines induced the directors of the South Eastern and Chatham Railway to introduce this luxurious mode of travel on their system. The Pullman Company, therefore, built six cars to run in the continental boat trains; and from March 21st, 1910, one parlour and one buffet car ran daily in the express services between London and Dover. Great care and attention were given to the designing of these cars, which are replete with every comfort. It must be noted that they are entirely British built, the whole of the construction having been carried out in the works of the Birmingham Carriage and Wagon Company, at Smethwick. The following are the leading dimensions: length over buffers, 60-ft.; centres of bogies apart, 39-ft. 9-in.; extreme width, 8-ft. 7-in.; height from rail to top of roof, 12-ft. 6½-in.

The bodies and under frames are built in one, generally on the lines of "Pullman" construction, but specially designed and improved upon to suit these cars. The entrance vestibules and end portions of the corridors are panelled in mahogany, the floor being covered with special rubber tiling. The carriages are fitted with "Laycock's" patent combined arrangement of centre coupled and adjustable side buffers, and Pullman vestibules, so that they may be coupled up with other stock fitted with either the automatic coupler, or the ordinary side buffers and draw-gear. The bogies are of the "American" side compensating type. An improved system of steam heating is employed, this being arranged in sections so that each may be cut off when not required. The automatic vacuum brake has a system of passenger communication working with it. The exteriors of the cars are finished a light "lake" colour, and tastefully lined with gold; the roofs are painted white, and the under frames and bogies black.

The parlour cars are divided into two large saloons, each capable of comfortably seating eight passengers, and two smaller saloons arranged to seat four each; and in the case of the latter, they can be reserved and cut off entirely from the rest of the car for travellers requiring extra privacy. Each car is designed in a different style, wall panellings of different woods giving a distinctive character. The parlour cars are named "Corunna" (page 127), "Savona," and "Sorrento."

I. PULLMAN BUFFET-CAR "VALENCIA." 2. PULLMAN PARLOUR-CAR "SAVONA"
(South Eastern and Chatham Railway)

The buffet cars, named respectively "Valencia," "Florence," and "Clementina," are divided into one large and one small saloon, similar to the parlour cars. They also have another large saloon to seat eight passengers, which contains a commodious buffet counter. Behind each counter is a pantry fitted with gas-stove, hot and cold water, and every convenience for the supply of refreshments. The covings and ceilings are formed of fibrous plaster decorated with enriched mouldings, simple ornaments on the flat portions, and with cups in which the electric ceiling lamps are ensconced. The finishing colour is light cream. While the woodwork of the several compartments varies in general appearance, some of the decorative features are the same in all, viz. the electric-light fittings, ceiling lights, wall brackets, and table standards of brass gilded by the mercurial process; door handles, basket racks, ventilators, and other fittings of chased and gilded brass, specially designed and modelled to harmonise, and the blinds, which are of a very rich green damask with a flower design.

The "Corunna" parlour car is panelled with fine wainscot oak, richly inlaid with holly-wood softly shaded in the style of the "Renaissance." The deep velvet pile carpet is crimson in colour, and the chairs are covered with "Renaissance" velvet of a colour to harmonise. The "Florence" buffet car has finishings of rich mahogany with panels of Spanish curled veneer, quartered and inlaid with satinwood marquetry on the panels, friezes, and pilasters in the Georgian style. It has a carpet of rich green velvet pile, and the arm-chairs are covered in green morocco.

The "Savona" parlour car is treated with finely marked satinwood, with quartered panels, inlaid with a green and red floral decoration in the style of Louis XVI. The carpet is red velvet pile, and the arm-chairs are upholstered in a red velvet of fleur-de-lys design. The "Valencia" buffet car is panelled with mahogany, of fiddle-back pattern and of a rich rosy colour, quartered and richly inlaid with satinwood floral decorations in the style of Louis XVI. The carpet is rich green velvet pile, and the chairs covered in green morocco.

The "Sorrento" parlour car has wood of finely mottled pear tree, rosy in hue, inlaid with holly, which is delicately shaded in an "Adamesque" style. The carpet is rich blue velvet pile, and the chairs are upholstered in blue velvet to match. The "Clementina" buffet car is of mahogany with *satiné* quartered panels inlaid with satinwood and green decorations in the Louis XVI style. The carpet is red velvet pile, and the chairs are covered in red morocco. Five new cars have been added recently to the Company's stock.

These Pullman cars of the South Eastern and Chatham, as well as those of the London, Brighton, and South Coast Railway, have been described in considerable detail, because they represent not only the *trains de luxe* of the British Isles, but in their perfection of appointment and convenience are surpassed by none in the whole railway world.

On the South Eastern section the distance from London to Folkestone is 71 miles, and the fastest train takes 89 minutes; to Dover, 76½ miles, in 99 minutes; to Hastings, 62 miles, in 98 minutes. On the Chatham section, the distance to Dover is 78½ miles, and fastest train 99 minutes; Canterbury, the shortest route from London, 62 miles, in 94 minutes; Margate, 74 miles, in 92 minutes, etc.

The South Eastern carries the Continental, Indian, and Austra-

POST OFFICE SORTING VAN
(South Eastern and Chatham Railway)

lian mails between London (Charing Cross, Cannon Street, Victoria, and Holborn) and Dover and Calais; but the quickest service between London and Paris is via Folkestone and Boulogne, which occupies 6¾ hours. The foreign mail, especially for the East, is well worth the watching, whether at its start from London or its transference to the mail packets at Dover.

No line is better served than the South Eastern and Chatham Railway in regard to large London stations. In greater London there are over 660 miles of railway with more than 600 stations; and the share of the South Eastern and Chatham Railway comprises quite 120 miles of line with 120 stations, which accounts for the great revenue that the Company receives from season tickets.

CHAPTER XXII

MISCELLANEOUS ENGLISH AND WELSH RAILWAYS

In the preceding chapters, devoted specifically to the chief English railways, we have dealt with more than 14,000 out of the 16,045 miles of line that comprise the total railway mileage of England and Wales. The remaining lines, totalling about 1760 miles, are owned by something approaching 200 different companies, whose separate mileages range from the 226 miles of the North Staffordshire Railway to the less than one quarter mile of the Felixstowe Dock and Railway Company; but many of these smaller lines are leased or worked by the larger companies.

In reality, not a few of these minor lines are tramroads rather than railways in the ordinary acceptance of the term; on the majority of them steam locomotives work the traffic; on some of them electric traction has been adopted; Liverpool has an overhead railway; Snowdon is railed to its summit; and one short railway at least is still worked by horses.

Passing reference was made on page 145 to the varied railway gauges in use in the United Kingdom, and (excluding the 5-ft. 3-in. gauge of Ireland) it is in this batch of very mixed lines that we find these departures from the British standard gauge. In this chapter attention will be drawn to several small, but nevertheless important railway systems, generally normal in character, but whose business is often out of all proportion to their mileage; and will conclude with a rapid survey of a number of lines that present unusual features either in construction or general practice, as well as sometimes throwing interesting sidelights on past railway history.

The LONDON, TILBURY, AND SOUTHEND RAILWAY comprises less than 100 miles of line, on which the receipts from all sources amount to £632,000. This sum is not a huge amount compared to the takings of some of the larger companies, but it works out at about £7,000 per mile per annum compared, for instance, to about £5000 per mile on the Great Western. Again, the London, Tilbury, and Southend receipts for goods, minerals, and livestock are little more than one-fourth of the income derived from passengers, parcels, and mails, which foreshadows a remarkable density of passenger traffic. The passenger train mileage is nearly

PLATE XI.

LOCOMOTIVE DECORATED IN HONOUR OF THE CORONATION OF KING GEORGE & QUEEN MARY, JUNE 22nd, 1911.
(London, Tilbury & Southend Railway.)

six times that of the goods and mineral trains. During the year 1910 the passengers exceeded 32,000,000, exclusive of season-ticket holders, which works out at 330,000 persons per mile per annum compared to 80,000 per annum on the Great Eastern Railway.

The Eastern Counties and London and Blackwall Railway Companies promoted the London, Tilbury, and Southend Railway. For twenty-one years after its opening, in 1854, the line was worked by Messrs. Peto, Brassey, and Betts, the contractors, who guaranteed the owners 6 per cent on the share capital, in addition to paying the debenture interest. Since 1875, however, the London, Tilbury, and Southend Railway has worked the line, which in the main consists

HEAVY MORNING BUSINESS TRAIN
(London, Tilbury, and Southend Railway)

of two routes to Southend and Shoeburyness, 36 miles via Upminster and 42 miles via Tilbury. The commencement of the line is really at Gas Factory Junction, on the London and Blackwall Railway, but the London, Tilbury, and Southend Railway has perpetual running powers over the $2\frac{3}{4}$ miles of line into Fenchurch Street station, which latter is the London terminus of the system. By arrangement with the Great Eastern and Midland Railways special trains are run through to Liverpool Street, and boat trains between St. Pancras and Tilbury Docks. In the near future the London, Tilbury, and Southend Railway will probably be absorbed by the Midland Railway.

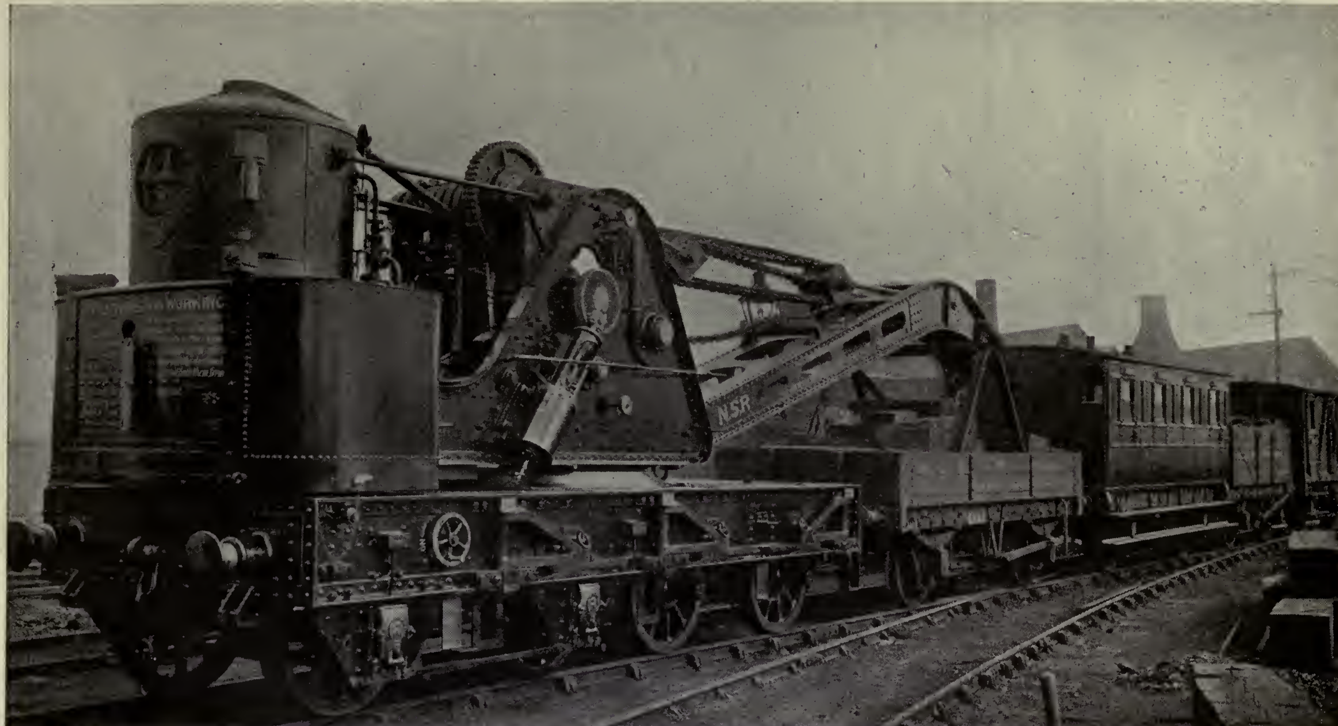
The longest non-stop run on the system is between Fenchurch Street and Westcliff, 35 miles, in 47 minutes. The rolling-stock consists of 82 locomotives, which, with the exception of a few condensing engines (black), are painted green; the 500 coaching vehicles are varnished teak; the goods vehicles number about 1900. The locomotive works are at Plaistow, London, E. The standard passenger locomotives are of the tank type (4 – 4 – 2), with outside cylinders 19-in. by 26-in., and 6-ft. 6-in. coupled wheels. The best known of these engines is No. 80, "Thundersley," one of a quartette, built in 1909 by Messrs. Robert Stephenson and Co., Ltd. This locomotive was exhibited at the Imperial International Exhibition in the same year, and was awarded a gold medal. When shown at the White City it was painted lavender colour, but was afterwards repainted the standard green.

For the auspicious day, June 22nd, 1911, the "Thundersley" was decorated in honour of the Coronation of King George V. The scheme of decoration is shown in Coloured Plate XI. The locomotive was painted the railway company's standard green, the painting and varnishing having been given an "exhibition" finish, the tank sides and bunker being lined out with gold, relieved by a blue edging, and decorated gold corners, while the frames were in crimson-lake. The chimney cap and safety-valve column were nickel-plated, and the lagging bands were of polished brass with bright steel edges. The cylinder cases were of planished steel decorated with a raised bright steel moulding with the royal coat-of-arms in relief. The tyres, draw gear, and side chains were finished bright, and the splashers of the bogie and trailing wheels were outlined with brass beading, as also the brake hangers, which were polished. On the bogie platform, between the life-size busts of King George and Queen Mary, was a small fountain worked automatically by water from the side tanks. Other details included an aluminium rail and royal coat-of-arms over each side tank.

On Coronation Day No. 80 worked a train from Fenchurch Street, and the return from Shoeburyness; and on the following day ran the Orient Line Special from St. Pancras to Tilbury.

Stoke-upon-Trent is the centre of the 226 miles of line owned by the North Staffordshire Railway. On the south it has four loose ends terminating at Market Drayton, Norton Bridge, Colwich, and Burton. At the last named the Midland Railway is tapped; from Norton Bridge there is access by 6¼ miles of London and North Western Railway line to Stafford, which is almost as convenient a junction for nearly everywhere as is Crewe, to which the North Staffordshire runs on its own territory. From Macclesfield, which is the northern outpost of the system, there is direct communication with Manchester, again via London and North Western Railway metals.

The North Staffordshire Railway has quite an extensive mileage, if could be included the "foreign" lines over which it works. The following are only some instances: passenger and goods train from Crewe to Chester, and then passenger only to Llandudno; passenger and goods to Manchester, but goods only to Liverpool;



BREAK-DOWN TRAIN
(North Staffordshire Railway)

in these cases the trains work over London and North Western Railway lines. By arrangement with the Great Northern and Midland Railways the North Staffordshire obtains access for passenger trains to Derby, Trent Junction, and Nottingham, and for goods only by London and North Western Railway to Rugby, and by Midland to Leicester and Wellingborough. It thus comes about that the longest journey made by a North Staffordshire passenger train is from Derby to Llandudno, a run of 118½ miles, of which 6½ miles are on Midland metals, 67½ on North Western, and only 44½ miles on its own line.

The North Staffordshire Railway originated in three small lines, of which the "Potteries" line was one. Nearly forty years ago this railway was in the market, but it still maintains its independence, although surrounded by various railway giants. There is a baker's dozen of tunnels on the system. Goldenhill Tunnel is only 500 yards long, but it is nearly 40-ft. wide and contains three sets of metals. The Harecastle Tunnel (1763 yards long) is one of three parallel tunnels that pierce Harecastle Hill. The first one was constructed for the Trent and Mersey Canal in the latter part of the eighteenth century; the roof is only 5-ft. 10-in. above the water-line, and consequently the boatmen have to "leg" the boats along the subterranean channel, which means that they lie on their backs and propel the craft by pushing the roof or side of the tunnel with their feet. A second canal tunnel, built in 1825, has an ordinary towing path, and horses haul the boats in the usual way. In 1848 a railway tunnel was constructed only 7 yards above the level of the two water channels.

Serving the North Staffordshire coalfield and the Potteries, minerals bulk largely in the traffic, viz. 5,575,000 tons as against 1,607,000 tons of general merchandise; the passengers number between 7 and 8 millions; the total train mileage is 3,033,000 miles, of which rather more than half is concerned with the passenger traffic. The total receipts from all sources amount to a little over £1,000,000. The locomotive, carriage, and wagon works are at Stoke-on-Trent, where the Company constructs some of its engines. The locomotives number 175; they are painted crimson-lake, which is also the colour of the 430 passenger vehicles, not unlike those of the Midland. There are 6400 goods vehicles of various kinds.

The system controlled by the Cheshire Lines Committee comprises 142 miles of line, roughly from Manchester to Liverpool and Southport in one direction, and to Chester in another. This railway is the joint property of the Great Northern, Great Central, and Midland Railways, each company nominating a third of the directors, who form a committee of nine. The title "Cheshire Lines" is rather deceptive, for most of the metals are laid in Lancashire, which county yields the greater portion of the revenue, much of it being obtained by keen competition with the Lancashire and Yorkshire and London and North Western railways. It was on this line that hourly express trains between Manchester and Liverpool were first introduced, and their regularity and punctuality are most marked, non-stop trains accomplishing the journey of a little over 34 miles in 40 minutes, or 45 minutes with a stop at Warrington.

Commencing at its head-quarters at Barrow, the main line of the FURNESS RAILWAY extends for 28½ miles in a south-westerly direction to Carnforth, where it connects with the London and North Western and Midland systems. Between Furness Abbey, with its fine monastic ruin, and Ulverston the route is through the

A "BURY" LOCOMOTIVE, NO. 4, SISTER ENGINE TO "COPPER NOB"
(Furness Railway)

iron-mining district, which yields the red hematite that gave rise to the monster blast furnaces in Barrow and district. Northwards the line passes through Millom, where is probably the richest iron mines in the world, and is continued on for a distance of 45 miles to Whitehaven, where more red hematite abounds, as well as rich seams of coals that are mined far under the sea. It was the mineral wealth of Cumberland that originally led to the incorporation of the railway. Thus it is that the 120 Indian red locomotives of the company are largely engaged in transporting 3,662,000 tons of minerals, or more tons than there are passengers carried in a year in the 350 coaching vehicles, in their striking colouring of ultramarine-blue with white upper panels. The goods, mineral, and livestock traffic accounts for nearly four-fifths of the total evenue.

By means of two branch lines the Furness Railway serves one of the most charming corners of England, namely, to Windermere and Coniston Lake; while from Ravenglass the Eskdale Light Railway (3-ft. gauge) runs very nearly to weird Wastwater.

At Barrow Central Station the Furness Railway Company has erected on a pedestal a Bury locomotive, No. 3, which was built in 1846. This engine was one of four, which had cylinders 14-in. by 24-in., and four-coupled wheels 4-ft. 9-in. in diameter; heating surface 940 sq. ft.; working pressure 110 lbs. per sq. in. The engine and tender in working order weighed 32 tons. No. 3 was in active service until the end of 1908, and then served a term in shunting at Barrow Docks, where its brightly polished large-domed copper firebox gained for it the nickname of "Copper Nob." The photograph shows No. 4, sister to the relic at the Central Station.

In quite another direction the Company has done something to preserve the memory of George Romney, who for some years lived at High Cocken. The house has been restored, and in a small museum is a collection of coloured engravings, etc., of some of the famous artist's most prominent works. Often railway companies are considered to be iconoclastic to a degree, rather than sentimental, and possibly the action of the Furness Railway Company may be considered the exception proving the rule.

The Hull and Barnsley Railway was not opened for traffic until July, 1885, together with Alexandra Dock, without which the line practically would have had no excuse for its existence. The company, which assumed its present title in 1905, owns 77½ miles of line, and even including lines worked, or worked over, the total does not exceed 118 miles. One has only to inspect the annual receipts to conclude that this railway is intensely utilitarian. Out of a total income of £715,000 less than £28,000 is derived from the carriage of passengers, parcels, and mails, whereas goods, minerals, and livestock bring in considerably more than half a million sterling. The passengers number about 574,000 in trains that run 430,000 miles; the coal traffic amounts to well over 4,000,000 tons, and other minerals and goods to another 970,000 tons. The business of the line is concerned largely with South Yorkshire "black diamonds," but there has been no marked auriferous yield to the shareholders. During the first eight years of the Company's existence dividends were declared only twice, and both together amounted to less than two per cent; in 1910 it was 3⅝ per cent, the highest in the Company's history.

The Hull and Barnsley Railway rolling-stock comprises 150 locomotives, 80 passenger carriages, and over 4000 assorted goods vehicles. A vast proportion of the mineral traffic is carried in wagons belonging to the colliers and coal merchants generally, which is the rule on all our great coalfields. Of the whole locomotive stock, the mineral engine stands out prominently, especially the eight-coupled class. These engines have cylinders 19-in. by 26-in., and wheels 4-ft. 6-in. in diameter, with a total wheel-base of

16½-ft. The boiler barrel is 14-ft. long, 5-ft. 6-in. in diameter, and contains 229 copper tubes; total heating surface 1859 sq. ft.; working pressure 200 lbs. per sq. in. Weight of engine 61 tons 11 cwt.; weight of tender 39 tons 18 cwt. There are also 0 – 6 – 0 goods engines with wheels 5-ft. in diameter, and 4 – 4 – 0 passenger

HULL TO SHEFFIELD EXPRESS

(Hull and Barnsley Railway)

engines with 6-ft. 6-in. coupled wheels; the tenders for each of these classes weigh 40 tons 8 cwt. when carrying 5 tons of coal and 3300 gallons of water. Most of the Hull and Barnsley locomotives are domeless; they are painted invisible green (practically black) picked out with blue and fine-lined vermilion.

The CAMBRIAN RAILWAYS comprise about 230 miles of line, and Moat Lane Junction is a good central point from which to survey the whole system. Southwards there are 56 miles of line to Talyllyn Junction via Rhayader, from whence Birmingham draws its supply of water. North-east by way of Montgomery and Oswestry we can reach Whitchurch after a journey of 52¼ miles, or we can branch off to Llangynog, passing through at least nine stations with fearsome-looking names, of which Llanrhaiadr-yn-Mochnant is an example. In passing, it may be mentioned that Llanfair, in Anglesey, on the Irish mail route, is a judicious abbreviation on the part of the London and North Western, possibly out of consideration for purely English-speaking passengers, and perhaps with an eye to a saving in printing and in station signboards. The correct native designation of the village is Llanfairpwllgogerychwyrndrobwllllandisiliogogogoch. Westwards, from Moat Lane via Machynlleth, we can reach Aberystwyth, or, skirting the coast northwards, arrive at Pwllheli with many famous seaside resorts between.

The Cambrian Railways are the result of amalgamations of various lines, not one of which was opened before 1859. The geographical position of the system leads one to expect that the grading is far from easy; between Pantydwr and St. Harmons the line is 941-ft. above sea-level; and among the steepest gradients is 1 in 30 for a mile between Welshpool and Golfa (2-ft. 6-in. gauge), and 1 in 43 for nearly as long near Abermule on the Kerry Branch.

The locomotive carriage and wagon works are at Oswestry, but only repairs and rebuilding are carried on. The 90 locomotives in service are painted black with yellow and red lines, while the 240 passenger vehicles are bronze-green with yellow lines. Some years ago the Company abolished second-class carriages, but have reintroduced them. The goods vehicles number less than 2500. The passenger trains run over 1 million miles, carrying about 3 million passengers, a good proportion of whom are summer tourists *en route* to or from the coast resorts. The goods trains travel nearly half a million miles in transporting 519,000 tons of minerals and 200,000 tons of merchandise.

The TAFF VALE RAILWAY originated with a line from Merthyr Tydvil to Cardiff, which was constructed by Brunel and opened in 1840, since when the system has grown into 124 miles of line. Taking the four northern outposts of the system, Merthyr, Aberdare, Maerdy, and Blaenau Rhondda, we find separate lines traversing as many valleys, all savouring of coal and converging upon Pontypridd, from whence there is a line to Aberthaw and another to Cardiff. From the latter, by using a short stretch of Great Western metals, another Taff Vale section is gained that runs via Penarth to Cadoxton, which gives access to the Barry Railway.

That the Taff Vale line is a difficult one to work is evidenced by gradients of 1 in 40 at half a dozen different places; but at Blaenclydach there is a half-mile ascent of 1 in 13 on a mineral line, in working which locomotives have to be assisted by a wire rope worked by a stationary engine. Three special locomotives $\left(\frac{0-6-0}{T}\right)$ are employed upon this incline. The cylinders are $17\frac{1}{2}$-in. by 26-in.; wheels 5-ft. 3-in. in diameter. The firebox and roof slope backwards so that the water is level over the top of the firebox. They are fitted with two drawbars for attaching the wire rope in such a manner that the rope is kept below the axles of the wagons, which follow the engine down the incline, or are pushed up in front of it. In addition to the ordinary equipment there are cast-iron "sleigh" brakes to act upon the rails. The dome is on the firebox and the regulator within it to ensure dry steam on the incline. Weight of engine 44 tons 15 cwts.

Serving numerous thickly populated colliery districts, the passengers total about 9½ millions, but for every passenger the company transports nearly 2 tons of minerals, chiefly coal. To express the traffic in similar terms, we may assume the average weight per passenger to be 10 stones; and thus we find that for every ton of humanity the company carries at least 30 tons of goods and minerals.

How the Taff Vale Railway deals with its enormous coal traffic at Penarth Dock is described on page 234; and how its mineral receipts overshadow the income from passengers is tabulated on page 233. Nevertheless, the transport of nearly 10 million passengers on a small system is no light business. At Cardiff station (Queen Street) 300 trains pass in and out daily, but at Pontypridd the number is 500. The locomotive works are at Cathays, near Cardiff,

STANDARD MINERAL ENGINE
(Taff Vale Railway)

but no engines are now constructed there. The Company owns nearly 200 locomotives, which are painted black, lined out with red, white, and yellow. Heavy six-coupled trailing radial tank engines ($\frac{0-6-2}{T}$) are the best examples of the locomotives which accomplish the heavy work that is unceasingly carried on. The passenger stock numbers about 260 vehicles, which have dark chocolate bodies with white upper panels. The goods and mineral wagons total 2540, almost lost amid the immense number of privately owned wagons that throng the 285 miles of metals, if we reduce the line to single track and include the sidings.

The Rhymney Railway, 61 miles long, is another notable Welsh bearer of burdens. Its goods and mineral mileage is nearly seven times that of the 376,000 miles run by the passenger trains; the passengers exceed 3½ millions, as against 9 million tons of goods and minerals. Roughly the Company carries 57,000 passengers and 147,000 tons of minerals per mile of its track, compared to the 43,000 passengers and 30,000 tons of goods and minerals per mile per annum on the London and North Western Railway. Thus in 1910 the Rhymney ordinary shareholders received 9½ per cent dividend, which is larger than the North Western has ever paid, except in the first year of its existence, amply bearing out previous statements that passenger traffic is not the most lucrative department of the work of a railway.

An extension of the line from Caerphilly to Cardiff necessitated the construction of a tunnel less than a mile in length, but which caused five years' strenuous labour to overcome the large volumes of water, mud, and running sand. The water proved to be not an unmixed evil, for the tunnel now supplies about 60 million gallons per annum, quite sufficient to meet the requirements of all the Rhymney locomotives stationed at Cardiff. The whole locomotive stock comprises 120 engines of the tank type, most of them powerful machines specially suitable to engage in the heavy hauling which is the feature of the line.

The Taff-Bargoed section is a 9-mile line owned jointly by the Great Western and Rhymney railways. It was opened in 1876, and at once gave the Rhymney Railway access to the ironworks and collieries of Dowlais. From Llancaiach for 7 miles the line rises at a gradient of 1 in 40, up which steep ascent 300,000 tons of iron and iron ore have to be hauled to Dowlais; and as each train can consist of not more than ten wagons, the working is not only laborious, but expensive into the bargain.

In 1908 it was decided to promote a Bill in Parliament for the complete amalgamation of the Taff Vale, Rhymney, and Cardiff railways; it was, however, withdrawn, the Barry Railway Company in particular strongly opposing the proposal. The BARRY RAILWAY, which is another great coal-carrying concern with 138 locomotives, naturally would be affected adversely by the proposed combination. On this line in the course of a year 2,748,000 passengers are carried in trains that travel 500,000 miles; but the goods and mineral trains travel 1,159,000 miles in transporting loads that amount to 5,000,000 tons.

The CARDIFF RAILWAY, mentioned in the foregoing paragraph, is intimately connected with the position of Cardiff as the first port in the world for the shipment of coal. Although the Company's track is less than 5 miles in length, the sidings amount to 112 miles of single track. The London and North Western, Great Western, Midland, Rhymney, and Taff Vale Railways all have communication with the docks; and it is calculated that within 1 square mile from the water's edge there are no less than 120 miles of line.

So far we have been traversing standard gauge lines, but now we betake ourselves to the very by-ways of Bradshaw, and, indeed, some of the railways about to be described briefly do not figure in the tome that has grown to such bulky proportions since its first issue at the end of 1841.

The FESTINIOG RAILWAY was incorporated in 1832 for the purpose of constructing a line from Blaenau Festiniog, wherefrom

TAKING THE STAFF AT TAN-Y-BWLCH STATION
Train drawn by a "Fairlie" locomotive
(Festiniog Railway)

to transport slate from the quarries to the coast at Portmadoc. The line easily lent itself to a gradient by which the loaded wagons could descend by gravitation, while the empties were hauled back to the quarries by horses. This method answered satisfactorily, but when it was desired to introduce steam traction for passenger traffic, not only was there the grading to face, but the numerous sharp curves appeared to be so many danger spots. The value of a leading bogie in locomotives needs no pointing, and therein lay the solution of the difficulty on the Festiniog line. The engines and carriages were furnished with bogies, back and front, and thus a train swings round the curves with the utmost freedom and safety. During the whole of the year this single line railway, with its miniature gauge of 1-ft. 11½-in., meets the needs of the local mineral and passenger traffic, the latter in summer being swelled by great numbers of holiday excursionists.

It has been stated elsewhere that the Burry Port and Gwendraeth Valley Railway has tried engines of the "Fairlie" type, but on the Festiniog Railway double-bogie tanks are in regular use. These engines are used in various out-of-the-way parts of the world for light traffic on specially heavy grades. The distinctive feature of a "Fairlie" is the very flexible wheel-base. Upon the carriage are mounted two boilers each with its own chimney and ordinary fittings. One firebox serves both boilers. Each bogie is worked by a different pair of cylinders, which take their steam from the separate boilers; and thus to all intents and purposes the machine is a "double" locomotive.

The North Wales Narrow Gauge Railway originally ran from Dinas Junction to Snowdon (Rhyd-ddu) station, but has been extended through Beddgelert to Portmadoc, a distance of 18 miles. In the work of extension there was much severe tunnelling work to avoid spoiling the natural beauties of the Pass of Aberglaslyn. The gauge is 1-ft. 11½-in. Among the locomotives employed are several of the single Fairlie type, such as the "Gowrie," built by the Hunslet Engine Co. in 1908. This engine is carried on two bogie frames—the leading bogie having six-coupled wheels with the cylinders and motion attached, whilst the other is an ordinary four-wheeled carrying bogie. The cylinders are 9½-in. by 14-in.; coupled wheels, 2-ft. 4-in. diameter; trailing bogie wheels, 1-ft. 10-in. diameter. The tanks have a capacity of 400 gallons. Total weight of engine, 18½ tons. Further reference will be made to Fairlie engines at a later stage in the foreign section.

The Padarn Railway is a privately owned line that presents sufficiently interesting features to give it a claim to inclusion in this chapter. At the north-east end of the Llanberis lakes there is a mountain reputed to consist of solid slate for a distance of 4 miles north, with a width of 1½ miles, and a depth of 2000-ft. When the slate was first worked at Dinorwic Quarries is uncertain, positively longer than two centuries ago, and at the present time 3000 men and boys are engaged. The mountain-side is cut into numerous terraces, each level having a portable narrow gauge (1-ft. 11½-in.) railway with its own locomotive. These little engines, which are four-coupled saddle-tanks weighing 6 tons, shunt the small slate trucks to the inclined planes that lead from the various levels to the railway, which extends from the foot of the quarries to Port Dinorwic, 7 miles away.

The Padarn Railway (4-ft. gauge) was constructed in 1824, and steam traction was employed four years later. The present permanent-way is laid with rails 80 lbs. to the yard; and the track receives as careful attention as if it were a main line on an important railway. The locomotives employed are six-wheeled, six-coupled side tanks with cylinders 12½-in. by 20-in.; wheels 3-ft. 6-in. diameter; total wheel-base, 10-ft.; boiler barrel, 8-ft. long by 3-ft. 4½-in. diameter, and containing 119 brass tubes; total heating surface, 507 sq. ft. Weight of engine in working order, 25 tons. The wagons are built to carry four of the small slate trucks, which

TRAIN OF SLATE TRUCKS ON 4-ft. GAUGE LINE
(Padarn Railway)

are run on to the larger ones without breaking bulk, a saving of time, and minimising risk of breakage of slates. The rolling-stock of the line includes a train of 23 carriages, each seating 60 men, for conveying the quarrymen to and from their work, many of them living as far away as the island of Anglesey.

The 4-foot gauge railway comes to an end at the top of a ¼-mile-long declivity, 1 in 4, which leads down to the wharves at the port. This slope is laid with the same narrow gauge rails as at the quarries, down which the full slate trucks are worked, and the empty ones up, by means of an endless chain cable. The work is done by gravity, the full trucks in descending pulling up the empties.

A particularly interesting fact about this little mineral line is the preservation of an old four-coupled tender locomotive in a museum attached to the quarries. The "Fire Queen," as it was named, was built at the Northfleet Iron Works, Kent, for the 4-ft. gauge line, in 1848, at a cost, it is said, of £1500. It was in service until 1886, about which time a sister engine, called "Jenny Lind," was broken up. The "Fire Queen" was built without framing, the axle guards being riveted brackets fastened to the boiler shell, the leading axle guards riveted just behind the smoke-box, and the trailing wheel guards riveted to the front plate of the fire-box. The four-coupled driving wheels of 4-ft. 6-in. diameter, being no less than 12-ft. ½-in. apart from centre to centre, causes one not to wonder that bent coupling rods were a frequent source of trouble. The boiler barrel is lagged with wooden strips painted green.

The SNOWDON MOUNTAIN TRAMROAD possesses the distinction of being the best example of a mountain-climbing railway to be found in the British Islands. If there is a fascination in speed, there is also something specially attractive in ascending to a great height, as witness the popularity of the Eiffel Tower and its successors, and such contrivances as the famous Great Wheel at Earl's Court. However pleasurable and exciting it may be to be raised to a height of 1000 feet in an iron tower, it is outvied by the ascent to a natural height four times as great, a ride above the clouds amid scenes of romantic, if not awful grandeur. Snaefell railway (electric) is not so high, or steep, as Snowdon.

In the Alpine regions there have been for many years past a considerable number of mountain railways, by means of which tourists are able to ascend various popular and lofty peaks without the expense of guides, and without the enormous risks attendant upon mountaineering on foot. Our own Snowdon, although only 3650-ft. high, can boast of a formidable death roll, one of the last victims being a mountain guide, who, losing his way in the darkness, fell into a crevasse, where his body was not discovered until some weeks afterwards.

Possessing so promising a field for a mountain railway, it was only to be expected that a track would be railed to the summit of Snowdon. Sir Douglas Fox, the eminent engineer, was instructed to examine the various systems of mountain railways on the Continent, and then to prepare plans of a scheme best fitted to the Welsh project; and eventually the Snowdon Mountain Tramroad was constructed and opened in 1895. The route selected was not one of the five or six different paths by which the ascent of the mountain was usually accomplished, but took a new course which secured the easiest gradients, while affording great diversity of view. The steepest gradient is 1 in 5½, and the sharpest curve is 264-ft. radius, as against inclines of 1 in 2 and much sharper curves on some of the Swiss lines.

The Abt system of mountain railways is considered the most efficient yet invented, and this method was adopted on the Snowdon tramroad. We are indebted to Mr. J. R. Owen (Secretary and Traffic Manager) for the following account of the track and rolling stock :

"The track has been formed on a firm and solid bed, and well metalled the whole distance. The course is fairly direct. The gauge is 2-ft. 7½-in., the steel rails are firmly joined with long and heavy fish plates, and fastened down with bolts and clip-plates to rolled

LOCOMOTIVE "SNOWDON" AND CARRIAGE
(Snowdon Mountain Tramroad)

steel sleepers, which are well embedded in the metalling at intervals of 3-ft. all the way. Any slipping or breaking would seem almost impossible. The road is also anchored at intervals into massive concrete blocks to overcome the tendency to slide down hill. The steel rails serve the purpose of bearing the weight and guiding the course of the train ; but its propulsion is by quite a separate arrangement. In the centre, between the rails, is fixed a double rackwork of solid steel plates, which, again, are firmly bolted at close intervals to the steel chairs. This rackwork, with its deep and wide alternating teeth, is of a strength calculated at several times the amount of strain which will come upon it ; and the weight of the engine and train on the rails adds to the general rigidity of the mechanism. The engine is always below the car.

"In some respects the engines resemble ordinary locomotives, except that they are a little smaller, but in proportion they appear much more massive and powerful. This superabundance of power, however, is not for the purposes of speed (which at the most can only be about five miles an hour), but in order to secure a firm and lengthy grip and amply to control the movement. Each engine is built somewhat on the kangaroo fashion, the funnel end being lower, but when on an incline the boiler assumes a horizontal position. Underneath, on very powerful axles, is the propelling gear, which consists of four separate solid steel pinion-wheels of great strength and thickness. Each of these four wheels has three broad teeth deeply indented in the rack continuously, and anyone having the merest knowledge of mechanism must see at once that it would require an enormous force to pull one of these engines out of place when firmly fixed on the rails. They work very smoothly and almost noiselessly, and with the application of the ordinary brake can be brought to a stand instantly within the space of a few feet. In addition to this there is the extra precaution of a steam brake, whereby the entire power of the engine can be applied to stop its movement, bringing it to a dead stand on the steepest incline within three or four feet distance. In all, there are five brakes to each engine. The carriages are strongly built on iron girders, and are carried on two four-wheel bogies. Each carriage has seven compartments, with seats to suit the gradient, calculated to accommodate fifty-six passengers. At the end of each coach is a separate brake of great power under the immediate control of the guard. The carriages are roofed, but instead of glass windows there are strong waterproof curtains, as on continental mountain railways."

The Swansea and Mumbles Railway claims to be the oldest railway in the kingdom, for it was in June, 1804, that an Act was obtained for constructing a "Railway or Tramroad" from Swansea into the parish of Oystermouth. It may well be imagined that the original permanent-way was of a very crude character. The flanged rails were of angle iron in 3-ft. lengths, which were spiked directly to stone sleepers in the absence of chairs. In later times transverse wooden sleepers and chairs came into use, and nowadays the rails are in 33-ft. lengths, weighing 85 lbs. to the yard. It was a remarkable fact that the promoters of the line had in view the utilisation of steam traction, although it was not until three score and ten years later that steam displaced the horses that hitherto had worked the traffic.

The abolition of horse traction came about through the Swansea Tramway Company securing running powers over the line in 1870, sought chiefly with the view of sharing in the holiday traffic to the

"Mumbles," which had grown into an exceedingly popular seaside resort. The Tramway Company used engines of the closed-in type, which travelled at an average rate of ten miles an hour; and consequently the three horse-drawn vehicles that traversed the line between the steam trams had to move at a good rate in order to compete with their rivals.

The line was built for most of its length alongside the public road, and consequently the tram engines carried a bell for warning purposes. Eventually the Swansea Improvements and Tramway Company gained complete control of the line; horses were discarded; a portion of the line was abandoned in favour of a new route on the seashore; and saddle-tank locomotives of ordinary design replaced the engines of the enclosed type. The carriages, of which there are first and second classes, are of the tramcar variety, some with seats on the top. Passengers can enter or alight only on one side, on account of the line still traversing the edge of the public road for about half of its course.

OLD TANDEM HORSE TRAIN
(Swansea and Mumbles Railway)

From the foregoing description one must not jump to the conclution that the arrangements on the Oystermouth Railway are still rather primitive; unusual certainly, but a system that transports 40,000 passengers on a Bank Holiday, or that can run a train of 18 cars containing 1800 persons, appears to have a justifiable claim to modernity.

The REDRUTH AND CHACEWATER RAILWAY was opened in January, 1825, to carry coal from Devoran Harbour Quay to the copper mines in the neighbourhood of Redruth, where William Murdock had made the first steam locomotive in this country nearly thirty years earlier. The line was never used for passenger traffic, and is of interest chiefly for the fact that the permanent-way is practically in its original state. The cast-iron rails, in 10-ft. lengths, resting in chairs on stone sleepers, were laid to a gauge of 4-ft., probably the only line of such a gauge in the kingdom, except the Padarn Railway, already mentioned. The traffic was worked by horse-power until 1854, when Messrs. Neilson and Co. supplied two six-wheeled engines with four-coupled leading and driving wheels 3-ft. 6-in. in diameter, and a pair of trailing wheels 2-ft. 6-in. in diameter. One of these locomotives has been rebuilt twice in the small railway workshops at Devoran. The Company also owns a very interesting old engine, "The Miner," which is probably the last locomotive, with a domed haycock firebox, working in this country.

The West Somerset Mineral Railway was constructed some fifty-four years ago from the iron-ore mines on the top of the Brendon Hills in West Somersetshire to the port of Watchet. The mines became very extensive, and hundreds of miners and their families formed the flourishing little town of Brendon, with its 600 inhabitants, a church, two chapels, shops, an inn, a brass band, a railway station, and excursions to Bristol and London. In the course of time iron-ore could be imported cheaper from Spain than mined in the Brendon Hills. The mines were closed, and the little town was deserted, most of the buildings pulled down and the bricks and stone sold. In 1907, however, the mines were reopened, and the railway came into use again. The photograph shows the steep descent from the mines, and also the locomotive decked out with flags upon the

REOPENING OF THE WEST SOMERSET MINERAL RAILWAY
Old Metropolitan locomotive, No. 37, decorated for the occasion

day of reopening, July 17th, 1907. This engine was No. 37, which had been bought from the Metropolitan Railway when steam was abolished for electric traction.

The photograph shows that the engine was still fitted with condensing apparatus as seen by the large conducting pipes above the tank ; a similar pipe is shown in the photograph of the Great Northern tank engine No. 116, on page 71. Condensing engines have modified blast arrangements to prevent the emission of steam from the chimney, when working in tunnels and on underground lines. Such engines can work in the ordinary manner in the open, but when necessary flap-valves can close the exit up the blast pipe, at the same time the steam being allowed to pass by side branch pipes to the water tanks in which it is condensed.

Returning to the old mineral line, which is standard gauge, there still are standing some interesting signals, such as were standard on many of our railways until the introduction of the semaphore. The signal consists of a tall mast with a round disc at the top to show " all right " and a cross-bar below to indicate danger. Standing at a great height, the signal could be seen from a considerable distance, and there could be no mistake as to the definition of the disc and crossbar in either position, except in very windy weather, when general unsteadiness rendered it ofttimes unreliable. The line was again closed in 1910.

There are numerous other small standard as well as miniature gauge lines that would afford interesting matter. The Easingwold Railway, with its 2½ miles of line, one locomotive, and three passenger carriages, is the smallest standard-gauge passenger line. Of miniature railways the Ravenglass and Eskdale, 7¼ miles long and of 3-ft. gauge, in Cumberland ; the Corris, 11 miles long, and the Tal-y-llyn, 6⅝ miles long, both in Wales and of 3-ft. 6½-in. gauge ; and the Isle of Man Railway, 46 miles of 3-ft. 6-in. gauge, are noted for the picturesque scenery traversed by them, which causes them to be patronised largely by tourists in the summer months.

" Light Railways," as implied in their name, are light in construction and correspondingly light in cost, rendering it possible for districts with scattered populations to be served, where heavier and costlier lines could not possibly have been laid with any hope of profitable return to the shareholders. There are numerous light railways in the United Kingdom, new ones are continually added, and the older ones are constantly being extended. They are of various gauges, the majority, perhaps, 4-ft. 8½-in, but also 3-ft. 6-in., 3-ft., and 1-ft. 11½-in. Some are worked by steam, others by electricity, but as they exhibit little that is new beyond the points already mentioned, one example of a steam light railway must suffice, leaving electric ones to fall into a later chapter.

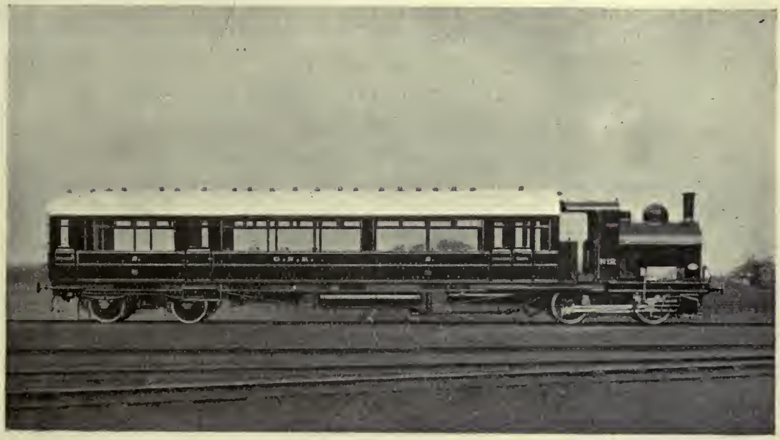
The Mid-Suffolk Light Railway is selected for consideration because its initial letters remind one of the old M.S.L.R., whose identity was swallowed up by the Great Central Railway in 1896. This Central Suffolk line was the outcome of a movement, initiated by a committee of farmers and landowners in 1900, to open up one of the most inaccessible portions of the county. The line was opened in September, 1904. It commences at Haughley, an important junction on the Great Eastern Railway, where the light railway has a connection for through traffic, one of the advantages of adopting the standard gauge. From Haughley the line extends eastwards for 21 miles to the village of Cratfield; the rails some day may be carried to Halesworth, five miles farther on. The profile of the route lent itself to the cheap construction that is so essential in railways of this class. In the whole 21 miles only one deep cutting was necessary, and there the one bridge over the line had to be built. There are 31 level crossings, 12 of which are provided with cattle-guards of oak arris rails placed on edge, spanning shallow pits (over which no cattle have ever been known to pass) on either side of the roadways on a level with the metals; the remaining level crossings are protected by gates.

The rolling-stock at the end of 1911 consisted of 3 locomotives, 7 passenger vehicles, and 39 goods wagons, cattle trucks, horse-boxes, etc. The locomotives were built by Messrs. Hudswell, Clarke, and Co., Ltd., of the Railway Foundry, Leeds. Their weight is 24½ tons empty and 30 tons loaded; wheel-base, 12-ft. There is a slight difference in the cylinders of the three engines—No. 1 has 14-in. by 20-in. stroke, while Nos. 2 and 3 have 13-in. diameter by 20-in. stroke. The driving wheels are 3-ft. 4-in. diameter spaced equally. There is a fuel space of 50 cubic feet capacity, and the tanks carry 650 gallons of water.

These engines have fulfilled all the requirements very satisfactorily. They are painted crimson-lake, with the initials "M.S.L.R." in gilt letters on the side tanks, and the panels lined out with yellow and vermilion. They have copper-topped chimneys and brass dome covers and safety valve casings.

Rail Motor-Cars are a twentieth-century innovation that have been adopted in many parts of the country upon sections of the great railways chiefly, where the traffic does not call for a train of several vehicles drawn by an ordinary locomotive. Sir Charles Owens, then General Manager of the London and South Western Railway, was the first to realise the material economies that could be effected by running a motor and single coach; and in 1902 Mr. Dugald Drummond set to work to devise a rail motor. The line from Fratton to East Southsea—jointly owned by the London and South Western and London, Brighton, and South Coast railways—was selected for the experiment. The new car was produced and approved, and commenced regular working in June, 1903. Although a combination engine and carriage had been running on a branch line of the Great Southern and Western Railway, Ireland, no vehicle of the London and South Western type, combining on one frame the motor and a passenger car of moderate seating capacity, had hitherto been seen on British rails.

This new steam motor-car was 50-ft. in length and ran on two four-wheeled bogies. As a locomotive it was a single-driver, the leading pair of wheels being driven direct by a pair of 7-in. by 10-in. cylinders. The boiler was of vertical type, and was fitted with vertical and cross tubes. The car could be driven from either



RAIL MOTOR-CAR (NO. 2)
(Great Northern Railway)

end. Seating accommodation was provided for 10 first-class and 32 third-class passengers, and there was a luggage compartment capable of holding 1 ton of baggage. The car was calculated to get up a speed of 30 miles an hour in 30 seconds. The illustration shows a Great Northern rail motor, generally similar, except for its horizontal boiler.

Of the various types of car with which British railway companies have experimented, it is claimed in many quarters that the most economical results combined with best running are given by the car fitted with the plain locomotive boiler. It is an advantage for the engine to be able to be removed from the carriage portion, so that when repairs are needed the car is still available for service ; and the most modern designs include a separable locomotive, or what is practically a miniature tank engine. In some cases an ordinary tank is placed between a couple of passenger cars with a driver's compartment at each end of the train, from which there is gear operating the engine in the centre.

Internal combustion engines (gasolene, petrol, or oil) have also been employed for rail motor-cars. The axles support a frame upon which the whole of the machinery is assembled. Being thus quite isolated from the superimposed body of the coach, the noise and vibration from the engine is scarcely noticeable by the passengers.

Sufficient has been said to show the possibilities of rail motors in providing cheap and rapid transit for light traffic, that in many cases could not be worked at a profit by locomotives and carriages of the ordinary type. Some companies have gone in extensively for steam rail motor services ; the Great Western trains of this class in 1910 travelled over 3,000,000 miles.

Electric traction naturally lends itself well to this kind of traffic, and the subject will claim further attention in later pages.

CHAPTER XXIII

SCOTTISH RAILWAYS

SCOTLAND possesses only five important and independent railways. The total length of line is 3844 miles, or little over one-fifth of the railway mileage of England and Wales; and the Caledonian and North British Railways between them account for nearly two-thirds of the whole of the Scottish metals. Excluding the busy industrial centres in the south and along the east coast, the greater part of Scotland is too sparsely populated to yield much railway traffic. The whole of Scotland's passengers in a year do not amount to more than those which the Great Eastern carries alone; and the goods and mineral trains in the whole of North Britain only travel about as many miles as the similar trains on the Great Western Railway. Viewed more generally, the total Scottish receipts from all traffic are exceeded by the receipts of the London and North Western, the Great Western, or the Midland. Upon the other hand must be noted the fact that the population of Scotland is less than that of London; and therefore the transport of over 100,000,000 passengers (exclusive of 90,000 season-ticket holders) and 66,000,000 tons of merchandise and minerals is a business that bulks largely in the energies and interests of our people over the border.

We have already dealt with much concerning the competition for traffic along the great routes from England into Scotland, and conversely the routes out of it. For some reasons it would have been convenient to have followed the London and North Western Railway by its close ally the Caledonian, and similarly to have allowed the North British to have come next in review to the North Eastern on the East Coast route, or next to the Midland because of the North British traffic via Carlisle; but on the whole it was considered better to treat the railways in something like territorial groups.

CALEDONIAN RAILWAY

The first public passenger railway in Scotland was the Monkland and Kirkintilloch line, which commenced business in 1826, four years earlier than the Liverpool and Manchester Railway; and five years later the Glasgow, Garnkirk, and Coatbridge Railway opened its 8½ miles of line for goods and passenger traffic.

Early in the 'thirties the question of continuous railway communication between Scotland and England was seriously discussed. There was a proposal to link up Newcastle-on-Tyne with Edinburgh and Glasgow. Little or no progress was made with the scheme, and Joseph Locke, engineer of the Grand Junction Railway of England, surveyed a West Coast Route to connect Preston with Edinburgh and Glasgow via Lancaster and Carlisle, and from thence via Beattock bank, which, by gradients averaging 1 in 75, rises over 600-ft. in about 8 miles. While Locke recognised the difficulty of engines accomplishing such a climb, really he was more perturbed concerning the descent, for in those days the braking apparatus left much to be desired.

In the meantime the promotion of various other lines in the south of Scotland, especially the Glasgow, Ayr, and Kilmarnock Railway, complicated matters; and when the Caledonian Railway

LONDON EXPRESS LEAVING GLASGOW CENTRAL STATION
(Caledonian Railway)

Company was formed, and desired a Bill authorising the construction of a line from Carlisle to Edinburgh and Glasgow, via Beattock and Annandale, the Glasgow interests favoured a line through Nithsdale. So fierce was the controversy that the Government appointed Commissioners to inquire and report upon the matter, because at that time it was believed that there would never be more than one railway between England and Scotland, and therefore it was advisable to fix upon the most advantageous route, apart altogether from local rivalries. In the end the Caledonian Railway secured Royal Assent in July, 1845. In less than three months the first sod of the new line was cut at Lockerbie. "Tom" Brassey was one of the contractors; 10,000 navvies were at work the next year, and double the number the year following. The line was opened from Carlisle to Beattock in September, 1847, and to Edinburgh and Glasgow in February, 1848.

Before the Caledonian line was opened, the new company had commenced to absorb smaller undertakings, one of them being the Garnkirk line already mentioned; and with the acquisition of the

Wishaw and Coltness Railway, the mileage of the Caledonian was 144 miles in the year of its opening. The present-day map speaks volumes for later extensions. By 1867 the Company possessed a continuous route, not only from Carlisle to Glasgow and Edinburgh, but onwards to Perth, Arbroath, Montrose, and Aberdeen, which remains the northernmost outpost of the system. On the west the Company's metals now extend to Ardrossan, Wemyss Bay, Oban, and Ballachulish on Loch Leven. All told, the mileage of the Caledonian Railway (1040 miles) ranks seventh among British lines.

It was only natural that the construction of a railway traversing long stretches of "Caledonia, stern and wild, land of the mountain

ALLOA SWING BRIDGE (OPEN)
(Caledonian Railway)

and the flood," should have presented many engineering difficulties. There are numerous viaducts, but the tunnels are fewer and shorter than one would have expected; the longest, between Greenock and Gourock, is 2100 yards in length; Moncrieffe Tunnel is only about half as long, and the next at Bishopton is less than a quarter of a mile from end to end. There are notable bridges over the Clyde at Glasgow, over the Forth near Alloa, and again at Stirling; the Tay is bridged at Perth and the Dee at Aberdeen. It may be remarked that the Caledonian Railway bridges over the Forth and Tay, although fine structures, cannot compare for size with those which cross the estuaries of the same rivers on the East Coast Route. The central portion of the Alloa bridge is a particularly fine example of a swing span.

The permanent-way of the Caledonian Railway is up to the same high standard as the great lines of Southern Britain. When the Garnkirk Railway, the oldest portion of the system, was opened in 1831, fish-bellied iron rails were carried by cast iron chairs that weighed only 8 lbs. each, which were strong enough to support the early engines, of which the standard type weighed 8 tons. At a later period locomotives exceeding 47-ft. in length and over 60 tons in weight called for rails 75 lbs. per yard; but nowadays rails 90 lbs. per yard and chairs of 46 lbs. are necessary to carry locomotives 65-ft. over the buffers and 130 tons in weight.

When the Caledonian was engaged in numerous amalgamations, particularly in the years 1865-6, it became possessed of some freakish locomotives. One of them bore the name "Lucifer," and acted thoroughly up to its name in the emission of live sparks that were a sore plague to the excursionists, who had to ride in open, seatless, coal wagons, when holiday times made special demands upon the rolling-stock.

In view of the Beattock bank, the Caledonian Railway from the first built its own locomotives. Mr. Robert Sinclair, who was the Company's first locomotive superintendent, constructed six-wheeled singles with driving wheels 6-ft. in diameter. The cylinders were 15-in. by 20-in., heating surface 770 sq. ft., working pressure 90 lbs. per sq. in.; engine and tender in working order weighed 28 tons. At the end of ten years the Sinclair singles had 7-ft. drivers.

The next superintendent was Benjamin Connor, who went in for 8-ft. 2-in. drivers. His engines were as greatly admired as Stirling's 8-footers on the Great Northern; and the Khedive of Egypt purchased a replica of one of them that was shown at the London International Exhibition in 1862.

Mr. Dugald Drummond (now of the London and South Western Railway), who became locomotive superintendent in 1882, found that the increased loads demanded more powerful engines, especially for work on Beattock bank. The principal additions that Mr. Drummond made to the Caledonian stock were of the four-coupled type with 6-ft. 6-in. drivers, of which the "Eglinton" of 1887 was a good example; but he also designed No. 123, a 4-2-2 with 7-ft. drivers; cylinders, 18-in. by 26-in.; working pressure, 150 lbs.; weight of engine and tender, 75 tons 7 cwt. This locomotive, which is illustrated on page 47, was one of the racers of 1888.

In 1895 Mr. J. F. M'Intosh became head of the Caledonian locomotive works at St. Rollox, Glasgow. On August 22nd the West Coast express accomplished a record run for this country, namely, from Euston to Aberdeen, 541 miles, in 512 minutes, and in the last section the Caledonian engine maintained a speed exceeding 71 miles an hour. Early in the following year Mr. M'Intosh turned out his famous No. 721, the first of the "Dunalastair" class, in time for the East and West Coast racing competition of that year.

Compared with the previous four-coupled express engines on this railway, it showed several notable differences. The boiler was nearly 2 in. more in diameter, and the firebox was larger. The tubes were increased to 265, affording a heating surface of 1285 sq. ft., making, with the 119 sq. ft. of the firebox, a total heating surface of 1404 sq. ft. The cylinders were 18¼-in. by 26-in., and the working pressure 160 lbs. per sq. in. In working order the engine weighed 47 tons and the tender 39 tons. The water capacity of the latter was 3570 gallons. The " Dunalastairs " made a mark elsewhere than in their own territory, for the Belgian Goverment adopted this type of locomotive for use on the State railways.

The second " Dunalastairs " showed still further improvement in size and power. The heating surface was increased to 1500 sq. ft.

NO. 721 "DUNALASTAIR"
(Caledonian Railway)

and the boiler pressure to 175 lbs. Engine and tender complete weighed 94 tons.

The next notable passenger express engines to appear were 4–6–0's. The earlier 49 class may be passed over in order to consider No. 903, the " Cardean," one of a batch of five new locomotives that came out in 1906, and which were the biggest and most powerful locomotives ever placed upon British metals up to that time, as shown by the following leading dimensions : cylinders, 20-in. by 26-in. ; coupled wheels, 6-ft. 6-in., and bogie wheels 3-ft. 6-in. diameter ; total wheel base, 28-ft. 8-in. ; boiler barrel, 17-ft. 7⅞-in. long by 5-ft. mean diameter ; heating surface, 2400 sq. ft. ; grate area, 26 sq. ft. ; boiler pressure, 200 lbs. ; weight on coupled wheels, 54 tons 10 cwt. The capacity of the tender was, water 5000 gallons and coal 6 tons. Engine in working order weighed 73 tons, tender 57 tons. Total weight of engine and tender in working order 130 tons.

One of the latest important Caledonian engines is No. 139, a 4–4–0. Following the general design and dimensions of the

No. 140 class, the application of the Schmidt superheater involved a number of changes in details. The more important of these, apart from the superheater itself, are an increase of the cylinder diameter from 19-in. to 20-in., the use of piston valves, a decrease of the working boiler pressure from 180 lbs. to 165 lbs. per sq. in., and the application of mechanical lubrication to the cylinders and valves.

The superheater system has a damper in the smoke-box automatically controlled by a small cylinder and piston receiving steam on the opening of the regulator, a back-balance weight closing the damper when steam is shut off. The working superheat temperature is 670 deg., and should this be exceeded, as shown by a pyrometer gauge, the damper can be closed from the foot-plate.

The engine has the following leading dimensions: cylinders, 20-in. by 26-in.; diameter of wheels: bogie, 3-ft. 6-in., coupled, 6-ft. 6-in.; boiler: length of barrel, 11-ft. 2-in., diameter, 5-ft.; height of centre above rails, 8-ft. 3-in.; containing 163 fire tubes 11-ft. 6-in. long by $1\frac{3}{4}$-in. diameter and 24 of 5-in. diameter, these latter containing $1\frac{1}{4}$-in. superheater tubes; heating surface: fire-box, 145 sq. ft., ordinary flue tubes, 859 sq. ft., large flue tubes, 361 sq. ft., superheater tubes, 330 sq. ft. (total, 1695 sq. ft.); grate area, 21 sq. ft.; working pressure of boiler, 165 lbs. per sq. in. The tender has a capacity for 4600 gallons of water and 7 tons of coal, but with expected economies of 33 per cent in water and 25 per cent in coal by the use of the superheater this capacity counts for more than appears. The total weight of engine and tender is 115 tons.

To realise the capabilities of the best Caledonian express engines, one has only to think of the everyday West Coast expresses and the postal trains. The best runs are from Carlisle to Perth, $150\frac{3}{4}$ miles, in 3 hours, at a speed of $50\frac{1}{4}$ miles per hour; to Edinburgh, $100\frac{3}{4}$ miles, in 2 hours, or $50\frac{1}{3}$ miles an hour, and to Glasgow, $102\frac{1}{4}$ miles, in 125 minutes, or $49\frac{1}{5}$ miles an hour. The longest non-stop run is from Carlisle to Perth, but as the trains generally stop at Beattock for water, or to attach or detach a pilot, the non-stop is thereby cut down to 111 miles, or $101\frac{1}{4}$ miles.

The West Coast Route has figured sufficiently here and elsewhere, and for a moment we may survey the Grampian corridor express, leaving Glasgow (Buchanan Street) at 10 a.m. and Edinburgh at 9.30, the two portions joining at Perth, where the restaurant-car is added. The journey is then continued to Aberdeen, which is reached at 1.51. This is not fast running, but it is a heavy train and the gradients are not the easiest in the kingdom, for Dunblane bank is 1 in 73, and it requires good locomotives to haul such a weight up so steep an incline.

Lighter express trains between Glasgow and Aberdeen accomplish the distance in $3\frac{1}{4}$ hours. The fastest daily run on the

1. NO. 139, SUPERHEATED EXPRESS LOCOMOTIVE. 2. NO. 903, "CARDEAN," EXPRESS LOCOMOTIVE
(Caledonian Railway)

system is between Forfar and Perth, but the distance is only 32½ miles and the time 33 minutes.

The Caledonian passenger engines are coloured blue; the goods and mineral engines black. Of the latter it need only be said that they fully meet all the requirements of the line. The total number of locomotives is 927. The passenger coaching stock numbers nearly 3000 vehicles of various kinds; the main-line carriages have the bodies painted lake with white upper panels; branch line carriages lake. There is no second-class on the line. The largest passenger vehicles are 68-ft. bogie carriages used in the Glasgow and Edinburgh direct service.

The goods vehicles number over 58,000, and present a great contrast to those used in the earlier years of the line, when 50 tons

30-TON MERCHANDISE WAGON
(Caledonian Railway)

was a good load for a train. There are over 400 30-ton bogie merchandise wagons, but a few years ago the Company built a 50-ton wagon; it proved to be useful, but, being in advance of the times, none of similar size have followed it.

We may conclude our review of this great railway with a few miscellaneous facts and figures. Its passenger trains travel 9½ million miles in carrying over 38 million passengers, plus season-ticket holders; and in transporting goods and minerals the trains run 6½ million miles. The Company provides recreation-rooms for the employés at convenient centres; addresses and lectures are given upon railway subjects, and in certain grades employés are examined periodically so as to maintain the highest possible efficiency. The largest passenger station on the system is Glasgow Central, with 13 platforms and 13 roads; the total length of the platform faces is 8800 ft. This station is one of the finest and best equipped in Great Britain.

North British Railway

The North British Railway was incorporated in 1844 for the construction of a line from Edinburgh to Berwick with a branch to Haddington, and the line was opened in June, 1846. From that year there were continual extensions, and gradually fifty separate small companies were absorbed, amongst them the Edinburgh and Dalkeith, in 1845, and the Monkland and Kirkintilloch, in 1865. The latter comprised the oldest metals in Scotland.

The present-day North British Railway map may be viewed conveniently from Edinburgh, the head-quarters of the system. Southwards there is a line to Berwick, part of the East Coast Route to England. By the Waverley Route, via Hawick to Carlisle, shared by the Midland, the North British connects with the London and North Western and Midland systems; and in this connection it may be mentioned that the Scottish company extends over the English border to the extent of 120 miles of line, reaching Morpeth and Hexham among other places. Between the Firths of Forth and Tay on the east, and Glasgow on the west, there is a network of North British metals that there is no space to detail; on the east coast the line goes northwards beyond Kinnaber Junction; while

EDINBURGH-DUNDEE TRAIN LEAVING THE TAY BRIDGE, DRAWN BY NO. 898, "SIR WALTER SCOTT" (4-4-0)
(North British Railway)

along the west coast there is unbroken connection as far north as Mallaig. The total mileage of the North British Railway, including joint, leased, and worked lines, is $1377\frac{1}{2}$ miles.

Of various important engineering works the Forth and Tay bridges take foremost rank. These two works are referred to on page 142, but their importance justifies additional details. A bridge across the estuary of the Forth had been mooted very many years before the task was undertaken. Various schemes were discussed for both bridges and tunnels, and Parliamentary powers were obtained at different times. The old Edinburgh, Perth, and Dundee Railway employed a steam ferry across the five miles of water between Granton and Burntisland, which in later years was worked by the North British Railway. Notwithstanding all efforts to fit the ferry with every conceivable appliance to expedite the transport of traffic, the inconvenience and delays to passengers, and the time expended and damage to goods in the transport over the water of as many as 17,000 wagons a month, were causing much of the North British business to be diverted to the Caledonian route; and thus in 1873 the Forth Bridge Railway Company was incorporated to build a bridge at the narrow neck of Queensferry.

Sir Thomas Bouch designed a structure of steel on the suspension principle. Work was commenced, and one small brickwork pier was erected on Inchgarvie Island; but on the evening of December 28th, 1879, occurred the terrible Tay Bridge disaster, which destroyed all faith in a suspension bridge for railway traffic. The Forth Bridge Company promptly cancelled the contracts for the construction of the bridge, preferring to pay heavy damages to the various contractors, and await the report of a House of Commons Select Committee that was appointed to inquire and report on the collapse of the Tay Bridge.

The Forth Bridge, as it stands to-day, was decided upon as related in chapter VI. For more than twenty-one years it has withstood severe storms and the constantly increasing traffic. When it was opened about 130 trains crossed the bridge daily, whereas the number is now nearer 200. Not only have the trains increased in weight, but the engines in particular now weigh $119\frac{3}{4}$ tons compared to 73 tons a score of years ago; yet the heaviest expresses cross the structure at 40 miles an hour on rails that weigh 125 lbs. per yard.

The interest on the capital expended on the bridge is guaranteed by the North British, Midland, North Eastern, and Great Northern Railways, but it is worked and maintained by the North British alone. The structure engages the constant attention of a staff of about fifty men. The exposed steelwork has an area of 135 acres, one-third of which is painted each year, calling for nearly 20 tons of paint.

The opening of the Forth Bridge on March 4th, 1890, put the seal on the partnership of the three railways concerned in the East Coast Route, giving them an advantage of 20 miles over their West Coast rivals, to say nothing of the improvement in the connections between Edinburgh and the kingdom of Fife, in which the North British practically monopolises the railway traffic.

The first Tay Bridge, which was completed in September, 1877, and collapsed in December, 1879, consisted of eighty-five spans, of which thirteen were over the Fairway, two of them of 227-ft.

TAY BRIDGE
(North British Railway)

span and the remainder of 245-ft. The new bridge, a lattice-girder structure containing 25,000 tons of metal, was designed by W. H. Barlow. It was erected a little above the ruins of Bouch's ill-fated structure at a cost of £640,000. It is 3593 yards long, consisting of eighty-seven spans, four of 245-ft. each over the channel of the river, with a clear headway of 77-ft. above high-water mark. Neither in its proportions nor architectural distinction can it be compared to the Forth Bridge, but it has proved both its strength and utility for twenty-four years, and there is little fear that it will meet with the fate of its predecessor.

On the North British system there are many steep gradients, such as the Commonhead Incline with 1 in 23 for ¼ mile, and other sections almost equally severe. Between Hardengreen and Tyne-head there is a rise of 1 in 70 for 7 miles, and there are many other inclines varying in severity and length that necessitate powerful engines for running heavy trains. The tunnels are not numerous, and the longest, the Haymarket Tunnel, Edinburgh, which is double for four lines of rails, is only 1009 yards in length. The main-line permanent-way is laid with bull-head section rails 92 lbs. per yard with chairs of 45 lbs.

In the early 'sixties the East Coast express trains were hauled by North British engines with 6-ft. drivers, and very much of the "Jenny Lind" type. The locomotive works were then at St. Margaret's, Edinburgh, but were afterwards transferred to Cowlairs, the locomotive head-quarters of the Edinburgh and Glasgow Railway, which was absorbed in 1865. The Cowlairs shops have been ruled by various notable locomotive engineers, e.g. Mr. S. W. Johnson, late of the Midland, and Mr. Dugald Drummond, of the London and South Western; Mr. William Stroudley was works manager at Cowlairs before he went as locomotive superintendent of the Highland Railway in 1865, from whence he migrated to the London, Brighton, and South Coast Railway in 1871.

In the 'seventies Mr. Dugald Drummond built some 4-4-0 passenger express engines with 6-ft. 6-in. coupled wheels to work on the Waverley Route. They rendered capital service until the introduction of dining-cars increased the weight of the trains, when the engines were rebuilt with nearly 300 additional sq. ft. of heating surface, and the working pressure raised from 150 to 175 lbs. per sq. in. In the 'eighties Mr. Matthew Holmes constructed 7-ft. four-coupled locomotives with cylinders 18-in. by 26-in. One of these engines, No. 592, gained a gold medal at the Edinburgh Exhibition of 1886; another, No. 602, hauled the first passenger train across the Forth Bridge.

As on other great railways, North British locomotives have continually increased in size and power. No. 868, "Aberdonian," crossing the Forth Bridge on its way to Aberdeen, is depicted in Coloured Plate IV.

This locomotive was one of fourteen new Atlantics built in 1906 by the North British Locomotive Co., Ltd., Glasgow, for work on the East Coast and Waverley routes, and on the Aberdeen main line. They were designed by Mr. W. P. Reid, who succeeded Mr. M. Holmes in 1904. Leading dimensions of these noteworthy engines: cylinders 20-in. by 28-in.; diameter of coupled wheels 6-ft. 9-in., bogie wheels 3-ft. 6-in., and trailers 4-ft. 3-in.; height of boiler centre from rails 8-ft. 11-in.; heating surface: firebox 184·8 sq. ft.; 257 tubes of 2-in. diameter, 2071·4 sq. ft.; total heating surface, 2256·2 sq. ft.; grate area, 28·5 sq. ft.; working pressure, 200 lbs. per sq. in. Weight of engine in working order, 74 tons 8 cwt., of which 40 tons were on the coupled wheels; weight of tender with

EXPRESS PASSENGER LOCOMOTIVE, NO. 902, "HIGHLAND CHIEF
(North British Railway)

7 tons of coal and 4240 gallons of water, 45 tons 8 cwt.; total weight of engine and tender, 119 tons 16 cwt.

In 1909 appeared a notable class of 4 – 4 – 0 express locomotives to run between Edinburgh and Perth, also built by the North British Locomotive Co. No. 895, "Rob Roy," 896, "Dandie Dinmont," and 898, "Sir Walter Scott," were among the earliest of these engines delivered to the Company. They had cylinders 19-in. by 26-in.; coupled wheels, 6-ft. 6-in. diameter; 258 steel tubes; working pressure, 190 lbs. per sq. in.; heating surface, 1618·12 sq. ft. Weight of engine in working order, 54 tons 16 cwt.; tender, with 7 tons of coal and 4235 gallons of water, 46 tons.

In 1911 Messrs. Robert Stephenson and Co., Ltd., Darlington, constructed six 4 – 4 – 2 express locomotives for the North British Railway, practically identical with the "Aberdonian." A photograph of one of them, No. 902, "Highland Chief," shows an engine that appears to suggest the very last word in finish, size, and power.

The North British Railway owns 1025 locomotives, which are coloured dark gamboge. The 3420 coaching vehicles, coloured dark red, are engaged in the carriage of 36,550,000 passengers, for which the trains run 9,000,000 miles. There is no second-class. The Westinghouse automatic brake is fitted to all passenger train vehicles. The longest first- and third-class carriages are 58-ft. 4-in. in length, but the composite dining-cars measure 66-ft. The goods and mineral wagons, of which the largest are over 66-ft. long, number 66,320; the merchandise and minerals carried amount to 28,584,000 tons, in the transport of which the trains run 8,743,000 miles..

The North British Railway provides the only routes from Edinburgh to many important towns, among which are Berwick, 57½ miles, fastest train 70 minutes; Hawick, 52¾ miles, in 75 minutes; St. Andrews, 56 miles, in 100 minutes; Helensburgh, 67½ miles, in 114 minutes, etc. It also possesses the shortest routes between the Scottish capital and Carlisle, 98¼ miles in 131 minutes; Perth via Forth Bridge, 47¾ miles, in 65 minutes; Dundee, 59¼ miles, in 80 minutes; Montrose, 90 miles, in 134 minutes; Aberdeen, 130½ miles, in 192 minutes, etc. The longest non-stop runs are from Edinburgh to Carlisle, Berwick, Perth, and Dundee, with times as above. The largest passenger station on the system is Waverley, Edinburgh, covering 23 acres, half of which is roofed, and containing eighteen platforms.

A brief account of the North British Railway would not be complete without mention of the fact that perhaps the only horse-worked British railway in existence is an English section of the Company's system from Drumburgh to Port Carlisle. The passenger traffic on this line is so very small that it does not justify the expense of running a locomotive, or even a rail motor, and hence the retention of this relic of the days of the "Dandies." The top of the car is fitted with a rail for the safe carriage of passengers' luggage, which is still further reminiscent of the old coaching days.

Glasgow and South Western Railway

The nineteenth century was only eight years old when Parliamentary consent was obtained to construct a tramroad from the Duke of Portland's collieries, near Kilmarnock, to the coast at Troon. William Jessop laid down the 9½ miles line, using cast-iron edge rails spiked down to stone blocks. For six years after the opening, in 1811, the traffic was worked by horses; but though it

GLASGOW TO LONDON EXPRESS BETWEEN GRETNA AND CARLISLE
(Glasgow and South Western Railway)

was a colliery line, it claims also to be really the first passenger line, for in the evenings, and always at holiday times, the weavers of Kilmarnock used the line for trips to the seaside.

In 1817 the Duke of Portland bought an engine from George Stephenson, which had been constructed at Killingworth. With its wheels connected by chain gearing, it was undoubtedly a good hauler, but it jolted terribly, and smashed Jessop's rails right and left. It is often stated that the engine was discarded, whereas the iron wheels were replaced by wooden ones, and for thirty years it hauled minerals, goods, and passengers. The line is now part of the Glasgow and South Western Railway.

In 1837, the year of Queen Victoria's accession to the throne, an Act was passed for the construction of the Glasgow, Paisley, Kilmarnock, and Ayr Railway, which was opened from Glasgow to Ayr, 40 miles long, in October, 1840. Ten years later this concern amalgamated with the Glasgow, Dumfries, and Carlisle line under the title of the Glasgow and South Western Railway; but the line southwards had been constructed only as far as Gretna, 8½ miles short of Carlisle; and, in fact, this last section was never completed, the Company running into Carlisle over the Caledonian metals.

The Glasgow and South Western main line is from Glasgow (St. Enoch's Station) to Gretna, 107 miles; a second important section of nearly 100 miles is from Glasgow, via Paisley, Ayr, Girvan, and Barrhill, to a junction with the Portpatrick and Wigtownshire Joint Railways, which gives access to Stranraer and Portpatrick; the remaining metals consist of various cross-country sections, and loose ends running to Greenock, Largs, Kirkcudbright, etc.

The total length of line is 577 miles. The steepest gradient is 1 in 55 for 3¾ miles falling towards Girvan; there is no tunnel a mile long. The locomotives, which are coloured green, number 400; there are 1350 coaching vehicles painted crimson-lake; and the goods and mineral wagons total nearly 18,000. The passengers number 16,611,000 (exclusive of season-ticket holders), carried in trains that travel 4,510,000 miles during the year. The merchandise amounts to 1,800,000 tons and minerals 6,851,000 tons, transported in trains that run 2,784,000 miles.

To gain a good conception of the main line we may journey by the 4.2 p.m. train from Carlisle to Glasgow, which is the 9.30 a.m. ex St. Pancras. Drawn by one of Mr. James Manson's 4–6–0's, we shall pass through the heart of the Burns country, interesting alike for its associations and its beauties, one of which is a view from the Ballochmyle Viaduct, bridging a chasm at a great height above the River Ayr.

Leaving Carlisle, varying gradients are encountered in the 17½ miles to Annan, and several climbs of 1 in 200 in the succeeding section to Dumfries (33 miles), which is reached and left in 40 minutes. The next 17½ miles to Carronbridge include a 6-mile ascent of 1 in 200, which reduces the speed to a fraction below 41 miles an hour, and a similar distance of 1 in 148 and 150 at less than 39 miles an hour. A rise of 1 in 180 to Sanquhar is followed by 10¾ miles almost level to New Cumnock. From that point some fast running is possible, e.g. 5¼ miles to Old Cumnock occupy 5¼ minutes. Down to Mauchline the speed varies from 65 to 70 miles an hour, in the 4 miles fall of 1 in 100 it frequently rises to 80 miles an hour for a couple of miles, drawing up at Kilmarnock in 67 minutes for the 58¼ miles from Dumfries. Out of Kilmarnock it is good running to reach Kilmaurs, 2¼ miles out, in a few seconds over 5 minutes. On through Dunlop and Caldwell to Lugton is mostly severe collar-work, followed by a terrific fall of 4 miles to

Barrhead, near which 70 miles an hour is common. Thence onwards the 7½ miles to Glasgow (St. Enoch Station) are generally down-hill, but on moderate gradients; and the whole distance of 115½ miles from Carlisle is completed in 153 minutes, or at an average speed of 45.3 miles an hour.

The locomotives of the Glasgow and South Western call for no special comment until Mr. James Stirling built some 7-ft. four-coupled express engines for use after the Midland gained access to Scotland, via Settle and Carlisle. Mr. Stirling was succeeded by Mr. Hugh Smellie, who reduced the driving wheels by 3-in. and abandoned the bogie for a two-wheeled truck. Later he reduced the drivers to 6-ft. and restored the bogie.

The present chief mechanical engineer is Mr. James Manson, one of whose 4–6–0's is shown in the photograph hauling the Glasgow to London express. The leading dimensions are: cylinders, 20-in. by 26-in.; coupled wheels, 6-ft. 6-in. diameter; heating surface, 1852 sq. ft.; fire-grate, 24½ sq. ft.; working pressure, 180 lbs. per sq. in. Weight of engine in working order, 67 tons 2 cwt.; weight of tender with 4100 gallons of water, 50 tons 6 cwt. Total weight of engine and tender, 117 tons 8 cwt.

The Company's locomotive works are at Kilmarnock. In 1896 the directors decided to house a large number of their employés as comfortably as possible. The result was the establishment of the model village of Corkerhill, which is now tenanted by some 750 people. Cheapness is the prevailing note in this unique railway village. A three-room-and-kitchen house can be rented at about 5s. per week, while unoccupied land owned by the Company for future extensions has been handed over to the villagers for cultivation. "Of course, when you have a town clerk who gives his services gratis, a fire brigade that costs nothing, and only an occasional visit of a policeman, you can save money. Each tenant can obtain a season-ticket to take him, his wife, or any number of his household to and from Glasgow at a cost of 5s. a year; hot baths at a charge of 1d. each (take your own soap and towel), children half-price; well-stocked library and reading-room for a shilling a year; and another shilling provides unlimited recreation. Thrift among the young is encouraged by a savings bank, and forethought among the old by a rent club and a doctor's club. In the former the members pay a penny per week, and when one is off work through sickness the rent is paid for him."

The Portpatrick and Wigtownshire Joint Railways, with a length of 82 miles of line of which only 2 miles are double track, link Stranraer to Castle Douglas on the Dumfries and Kirkcudbright section of the Glasgow and South Western. From Stranraer to Larne, in Antrim, is only 39 miles, being the shortest sea route from Great Britain to Ireland. The locomotives to work the traffic are supplied jointly by the Glasgow and South Western and Caledonian Railways, charging for their use on a mileage basis. For working the branch line between Newton Stewart and Whithorn, the same two companies furnish the locomotives alternately for periods of three years. Although the engines are changed, the same drivers and firemen work them, the only difference to the men being that for three years they are on the wages list of one company, and for the next three years on the list of the other.

Great North of Scotland Railway

Incorporated in 1846 with the intention of linking Aberdeen and Inverness, the Great North of Scotland Railway got only towards its projected goal from Aberdeen as far as Elgin, which was far short of the original programme. The first sod was cut near Oyne in 1852, but it was not until September, 1854, that 40 miles of single line were open between Kittybrewster and Huntly. In the section between Inverurie and the coast a portion of the line followed the course of the Aberdeenshire Canal, which proved very serviceable for the transport of a great deal of material for the construction of the line.

Amalgamations with various local ventures and extensions from time to time have given the system a total length of 336 miles. The main line is from Aberdeen to Elgin, throwing off separate arms on the north to Peterhead and Fraserburgh, and to Banff, from whence the line skirts the coast to Lossiemouth. From Craigellachie there is a branch to Boat of Garten, and from Aberdeen another to Ballater. Notwithstanding the rugged character of much of the country, the longest tunnel on the system has a length of only 270 yards. The grading is severe in places, the steepest being 1 in 50 for $1\frac{1}{2}$ miles near Rothes. This northern line adopted the telegraph largely from the first, being in front of most Scottish railways in that respect.

The quickest trains are between Aberdeen and Elgin (non-stop as far as Huntly, $40\frac{3}{4}$ miles), and from thence to Inverness by the Highland Railway. The Company also runs through services between Elgin and Glasgow via the Caledonian, and to Edinburgh via the North British metals.

The locomotive works are at Inverurie, where the present chief is Mr. William Pickersgill. He learnt his business at Stratford, leaving the service of the Great Eastern for that of the Great North in 1894. Mr. James Manson was superintendent from 1883 to 1890. The engines are built generally by outside firms, but in 1909–10, however, the Company's own shops turned out four express locomotives (4 – 4 – 0). They were of standard type with a slight modification in some of the details and dimensions:

cylinders, 18-in. by 26-in.; coupled wheels, 6-ft. 1-in. diameter; total heating surface, 1207 sq. ft.; tender capacity, 5 tons of coal and 3000 gallons of water. Total weight of engine and tender, 82 tons. These engines are fitted with an automatic tablet-exchanging apparatus for single-line working. A tablet case is given up and another one taken while the train is in motion, on

THE UP KING'S MESSENGER TRAIN IN DINNET STATION. THE ONLY SUNDAY TRAIN ON THE LINE
(Great North of Scotland Railway)

practically the same principle as mail bags are caught up or delivered. This apparatus is not confined to the Great North of Scotland Railway, but is used in many parts of the United Kingdom with very satisfactory results.

An illustration is given of one of the Great North's 0–6–0 tank engines at the head of a branch-line train in St. Comb's station. A very noticeable feature is the "cow-catcher," so common in American practice, but which, in the British Isles, is used only in some parts of Scotland and Ireland, where half-wild cattle are liable to stray on to the line. On the Leek and Manifold Valley Light Railway (2-ft. 6-in. gauge), in North Staffordshire, and the Tralee and Dingle Light Railway (3-ft. gauge), in Ireland, the locomotives carry big headlights at night after the American fashion, because of the windings of the respective lines.

On the Great North of Scotland Railway there are 115 locomotives in a livery of green picked out with red. The coaching vehicles number 789, and never included any second-class; they are painted white from top to waist and crimson-lake below.

0–6–0 TANK ENGINE FITTED WITH "COW CATCHER"
(Great North of Scotland Railway)

There are nearly two-score road motor vehicles for passengers and parcels, and particularly for tourists in the summer season. The goods and mineral wagons, etc., number about 3700. The passengers carried in a year total nearly 3½ millions, not reckoning season-ticket holders; the passenger trains run more than 1½ million miles. The goods and mineral business is concerned largely with the transport of fish from the ports served by the line, whisky from numerous distilleries, and always granite, for which the Great North territory is famed.

Highland Railway

The Highland Railway commenced with the Inverness and Nairn line, 15 miles long, upon which the first train was run on November 5th, 1855. Other lines followed, and the inevitable amalgamations took place, until in 1863 the present title of the system came into being. Commencing at Stanley, $7\frac{1}{4}$ miles north of Perth, the line extends to Wick and Thurso in the north, while east and west its metals stretch from Keith, near Elgin, to Kyle of Lochalsh. The Company owns 485 miles of line, of which about 450 miles are single track. This most northerly of British railways, traversing many wild districts, was not constructed without many bridges and viaducts, the chief being on the direct line between Aviemore and Inverness. The locomotives belonging to the Company number 146; the engines and rolling-stock are coloured green. The coaching

NO. 144, "BLAIR CASTLE" (4-6-0), HAULING EXPRESS TRAIN, INVERNESS TO PERTH

(Highland Railway)

vehicles only number 463, but they include two Pullman cars, the only carriages of the kind in Scotland. During the course of a year over 2 million passengers are carried on the Highland Railway, and in their transport the passenger trains run about $1\frac{3}{4}$ million miles.

The locomotive and carriage works are at Inverness, where Mr. Peter Drummond superintends the erection of engines to meet the special requirements of a difficult line. The steepest gradient is 1 in 50 for about 4 miles near Dingwall. There is a long stretch of very difficult grading from Blair Athol to Newtonmore, during which the line crosses the Grampian Mountains. Just beyond Dalnaspidal the highest summit level (1484-ft.) is reached, from whence there is a steep descent to Dalwhinnie. This hard section of about $23\frac{1}{2}$ miles is accomplished in a few minutes over the hour, which is a capital performance even for such good locomotives as the "Castle" class of 4-6-0's, which made their appearance in 1900. Six-wheels coupled engines were first used on the line in 1894. They were built by Messrs. Sharp, Stewart, and Co., and at the time were not only the first of the type in Great Britain, but were among the most powerful main-line locomotives in the country.

The "Blair Castle," which is shown hauling the express from

SNOW PLOUGH BLOCKED IN A DRIFT
(Highland Railway)

Inverness to Perth, is one of a dozen similar engines built by Messrs. Dübs and Co., of Glasgow. These engines have cylinders $19\frac{1}{2}$-in. by 26-in.; coupled wheels, 5-ft. 9-in. diameter; total heating surface, 2064 sq. ft.; weight in running order, 58 tons 17 cwt. The tender, carried on two four-wheeled bogies, has a tank capacity of 3350 gallons and a coal space of 260 cubic feet; weight in running order, 38 tons 2 cwt. These fine locomotives haul the trains up the long banks of 1 in 70, which are numerous on the line.

During a great portion of every winter the Highland Railway has to wage a continual warfare against snow. Ordinary downfalls do not interrupt the services of the line to any great extent, because the snow-ploughs are traversing the metals during even slight storms. But in Inverness and Sutherlandshire, notwithstanding all precautions, a prolonged snowstorm will cover long stretches of line to the depth of a dozen feet, with drifts of 25 to 30-ft. in various sections. Where the profile of the line is likely to encourage drifts snow fences are erected. The simplest kind consists of walls of old sleepers reared up on end; but a more scientific fence takes the form of a sloping plane towards the line, which, in cuttings particularly, has the effect of assisting the wind to carry the drifting snow and disperse it more widely. Some sections of the Caledonian system in the Western Highlands suffer complete dislocation in winter. At least one cutting, a mile or so long, has been covered in with corrugated iron, which is an adoption of an American method, largely in vogue on the railway lines that cross the Rocky Mountains.

Carmyllie Light Railway

The Elliot Junction and Carmyllie Light Railway was the first line in Scotland opened for passenger traffic under the Light Railways Act of 1896. Originally it was a private undertaking for the conveyance of freestone from the famous Carmyllie quarries to the Dundee and Arbroath Railway; but in the course of time both the Caledonian and North British railways acquired interests in the line. Many endeavours were made to induce the companies to run a passenger service, but the anticipated traffic did not warrant the cost of installation of signalling and other appliances to conform with the requirements of the Board of Trade. Upon the Light Railway Act becoming law, agitation was renewed, and on February 1st, 1900, the line was opened for passenger traffic with a service of four trains each way daily.

This line is described chiefly on account of its gradients and the method of working safety points. "Light" railway in name, it is one of the heaviest in the country to work. At Elliot Junction the safety points, facing towards Carmyllie, are for the protection of the main line of the Dundee and Arbroath Joint Railway, and lie for a safety siding. Before any train can proceed either toward Carmyllie or Elliot, it has to be brought to a standstill clear of these points. The engine driver carries the train staff, which he hands to the guard, who, by means of the "Annett's key" attached to the staff, unlocks the frame, which allows the points to be opened for the train to proceed. After the train has passed the points, the guard withdraws the staff, which automatically relocks the points for the siding, and thus prevents a second train coming on to the line. Between Cuthlie and Denhead is a grade of 1 in $35\frac{1}{4}$, the steepest to be found on any passenger line in Scotland. Denhead station stands on an incline of 1 in 45, and there are several climbs a little worse, and more that are little better in the 3 miles' grinding pull to Carmyllie passenger station, which is 5 miles from Elliot. As with the Dundee and Arbroath Joint Railway, the Caledonian and North British railways supply the locomotive and carriage plant on this light railway in alternate years. The type of engine used by the North British is a four-coupled bogie tank, with driving wheels 5-ft. diameter and bogie wheels (solid) 2-ft. 6-in. diameter ; the cylinders are 16-in. by 22-in. ; heating surface, 647·5 sq. ft. The tanks carry 600 gallons of water.

CHAPTER XXIV

IRISH RAILWAYS

THE first Act for a railway in Ireland was passed in 1831, authorising the construction of a line from Dublin to Kingstown, which was opened for public traffic in 1834. Two years later the Ulster Railway (Belfast to Armagh) and the Dublin and Drogheda Railway were sanctioned. In order to ascertain the best means of building up a useful national system of railways, the Government appointed commissioners to consider the subject as a whole, rather than to allow lines to come into existence merely as the outcome of scattered local effort. In 1838 a really valuable report was issued, but the Government never acted upon its suggestions, leaving private companies to act upon them, or not, as they thought fit. As stated in an earlier chapter (page 145) the Irish standard gauge is 5-ft. 3-in.

Railways did not develop in Ireland at the same rapid rate as in the sister isle ; by 1845 only 65 miles of line had been constructed, but in the next ten or twelve years nearly a thousand miles were laid down ; twenty years later (1875) the mileage was more than doubled ; in 1895 the total length of line was 3173 miles, and at the end of 1910, 3391 miles.

Considering the undoubted disadvantages under which Ireland labours, the railways have developed to a greater extent than at one time seemed probable. The country is poor compared to either England or Scotland ; it has practically no mineral wealth and few manufactures ; and further, the population since 1841 has decreased by nearly 50 per cent, while that of Great Britain has increased by more than 100 per cent.

First we will view the railway energies of Ireland as a whole. The total length of line mentioned above includes more than 500 miles of 3-ft. gauge line. Non-standard railways in Ireland exclusively use the 3-ft. gauge, which is unusual in Great Britain, there being only 9 miles of it in England and Wales and none in Scotland. Even including the whole of the sidings, Irish railway metals total up no more than 4587 miles, significantly bearing out the statement that the country is concerned but little with goods and mineral traffic. During the year 1909 the passengers numbered under 30 millions (excluding season-ticket holders), and the passenger trains travelled nearly 12 million miles. The general merchandise carried amounted to 4,014,000 tons, and the minerals to little more than half the weight; and the goods, mineral, and mixed trains ran 6,540,000 miles. The gross receipts from all sources of traffic amounted to £4,335,368, of which more than a half was derived from passengers. Ireland has a Clearing House of its own, to which some English and Scotch lines are parties. The total capital of all the Irish railways stands at little more than £46,000,000, which is exceeded by the separate capitals of twelve companies in Great Britain, and the whole of the Irish gross receipts are exceeded by ten companies in England and two in Scotland.

Great Southern and Western Railway

The Great Southern and Western Railway commenced with the authorisation of a line from Dublin to Cashel in 1844, with assent for an extension to Cork in the following year. The system grew by various additions, and absorptions by purchase or amalgamation of fourteen small companies. Of the lines thus absorbed the principal were: the Killarney Junction Railway from Mallow to Killarney, sanctioned in 1846, and taken over on its completion in 1854; the Cork, Youghal, and Queenstown Railway amalgamated in 1866, and giving complete access to the mail traffic; the Irish South Eastern Railway (Callow to Kilkenny), authorised in 1846 and incorporated with the Great Southern and Western in 1863; and the Cork and Limerick Direct Railway from Charleville to Limerick, absorbed in 1871. In 1898 the Fishguard and Rosslare Railways and Harbours Act authorised the construction of a new line from Waterford to Rosslare, 38½ miles long. This was opened in August, 1906, but in the meantime (1900) had come two absorp-

DOWN KILLARNEY TOURIST EXPRESS NEAR CLONDALKIN
(Great Southern and Western Railway)

tions that added considerably to the importance of the Great Southern and Western, viz. the Waterford, Limerick, and Western Railway (350 miles), and the Waterford and Central Ireland Railway (65 miles). Other additions may be omitted, but altogether the Great Southern and Western Railway now has a total length of over 1120 miles. This, the longest railway in the country, traverses some of the most beautiful and famous parts of Ireland, notably the lake district of Kerry; but the Company's claim to importance rests more upon it controlling the direct route from Dublin to Queenstown in connection with the American mails and passenger traffic.

The territory served by the Great Southern and Western Railway comprises the southern half of Leinster, the whole of Munster, and part of Connaught; from east to west the system includes places as far apart as Dublin and Valentia Harbour (235 miles), via Mallow and Farranfore; from north to south places as widely separated as Sligo and Queenstown (197¾ miles), via Limerick, Charleville, and Mallow.

The main-line permanent-way consists of bull-head rails, 45-ft. long and 85 lbs. per yard, and chairs 50 lbs. each. There are but few tunnels, and the longest, which is at Cork, is only 1342 yards long. The grading is by no means easy, as will be shown a little later; the stiffest climb for passenger trains is 1 in 50 for a couple of miles at Mountain Stage, in County Kerry.

The opening of the Rosslare–Fishguard route coincided with the need for renewing the older locomotive stock of the lines recently amalgamated, and therefore, in 1907, appeared two different classes of express locomotives, built at the Company's works at Inchicore, to the designs of Mr. Robert Coey, the locomotive superintendent. The "321" class were built for working the mail and express trains between Dublin, Cork, and Queenstown, while the "333" class were designed for the Rosslare boat service to haul heavy express trains over a very difficult road.

Principal dimensions of the "321" class: cylinders, 18½-in. by 26-in.; coupled driving wheels, 6-ft. 7-in. in diameter; coned boiler, greatest diameter 5-ft. 6⅝-in.; heating surface, 1511 sq. ft., but in some of the later engines 80 sq. ft. less; boiler pressure, 160 lbs. per sq. in.; weight of engine in working order, 49 tons 15 cwt. In the "333" class the cylinders were ½-in. less diameter; driving wheels, less diameter by 10½-in.; heating surface, 1412 sq. ft.; weight of engine in working order, 51 tons 3 cwt. The locomotives were provided with standard tenders carrying 3300 gallons of water and 4 tons of coal; weight, 35 tons.

The main line between Dublin and Queenstown is not considered difficult except for banks at Cork and Dublin, but, nevertheless, it has hardly a level mile throughout its course. Leaving Cork (Glanmire Station) the gradients are 1 in 78 for ⅛ mile, 1 in

64 for $\frac{1}{3}$ mile, 1 in 714 for $\frac{1}{8}$ mile, 1 in 60 for nearly 2 miles, followed by $\frac{1}{3}$ mile of 1 in 749. At the Dublin end the grade is not so severe, averaging 1 in 80 to Inchicore, followed by a practically uphill stretch to Kildare, 30 miles, some of it 1 in 125.

When the Great Southern and Western amalgamated with the Cork, Youghal, and Queenstown Railway to run the mail trains wholly on its own metals, the timing for the 165$\frac{1}{2}$ miles (Dublin to Cork) was 5 hours 25 minutes. The down day mail now covers the distance in 3 hours 55 minutes, with four intermediate stops—an improvement of 90 minutes, while hauling a much heavier train. The present-day load is seven bogie coaches, two of them dining-

ENGINE OF THE "321" CLASS FOR MAIL AND EXPRESS TRAFFIC DUBLIN TO QUEENSTOWN

(Great Southern and Western Railway)

cars, and a 66-ft. bogie and two six-wheelers, slipped at Kildare, so that the train is heaviest over the hardest part of the road.

The fastest train in Ireland is the Killarney express from Dublin (Kingsbridge Station), which in summer usually consists of two bogies and a six-wheel brake for Cork; the same for Killarney, and two bogies slipped at Limerick Junction for Ennis. The timing for the 185$\frac{1}{2}$ miles is 4 hours 10 minutes, including a stop for water at Ballybrophy (66$\frac{3}{4}$ miles) and at Mallow, where the train is divided. The average speed on the journey is about 50 miles an hour as far as Mallow, and then 40 miles an hour to Killarney. The longest non-stop run on the system is from Mallow to Ballybrophy, 77$\frac{3}{4}$ miles, in 83 minutes.

A few years ago in a record run His Excellency the Lord Lieutenant and his suite were carried from Dublin to Killarney in 3½ hours, including stops of 4 minutes at Thurles and 5 minutes at Mallow for taking in water. Deducting the 4 minutes' stop at Thurles, the average speed to Mallow was 58 miles an hour, afterwards it was just under 50 miles an hour, the remaining distance (40¾ miles) being single line, with five block stations worked on an electric-staff system. At four stations the staffs are exchanged mechanically, without the train slackening speed, by means of a staff-catching apparatus attached to the engine (pages 168 and 480); but at one station, owing to the formation of the line, the staffs have to be exchanged by hand.

The train used in this record run consisted of the engine, No. 301, "Victoria" (4–4–0), a tri-composite bogie brake, royal saloon, and bogie brake van. The "Victoria," a four-wheels coupled bogie locomotive, was built at Inchicore in 1900 by Mr. Coey. The following were the leading dimensions: cylinders, 18-in. by 26-in.; coupled wheels, 6-ft. 7-in. diameter; heating surface, 1220 sq. ft.; total weight of engine and tender in working order, 77 tons 11 cwt. In comparing the record run with the ordinary express services it must be remembered that on the main line the "321" class of locomotives sometimes haul trains of twenty coaches.

The royal saloon is divided into three compartments, viz. a boudoir, a reception saloon, and a smoking-room, communicating with each other. It is furnished with comfortable couches and armchairs, richly upholstered in blue tapestry, with a pile carpet. Irish poplin curtains shade the large plate-glass windows, and the roof lights are of coloured and cut glass. The panelling is very elaborate, being of specially selected walnut and oak. The roof is elevated, and the ceiling covered with white embossed moulding. Handsome wicker brackets, specially constructed for holding flowers, are hung round the compartments. At the end of the saloon is a lavatory, the washhand-stand and basin being of Connemara marble, with silver-plated fittings. A large mirror occupies one side. The whole is lighted by five ornamental electroliers in oxidised silver suspended from the roof, and by portable and fixed bracket lights at the sides and in the passages. The saloon is carried on two four-wheel bogies and weighs 27 tons 17 cwt., the total length over buffers being 54-ft.

The Rosslare boat trains, for which the "333" class of locomotives was built, are usually decidedly heavy between Cork and Waterford, consisting of from 66-ft. side-corridor coaches, weighing 38 tons each, and one 52-ft. long weighing 29 tons. The road is a difficult one for the working of express services. From Cork to Mallow the main line is used, involving the heavy pull out of Cork mentioned earlier. Leaving Mallow the single road is of a switchback nature, but with no really severe gradients until after Lisburn ; after a 4-mile descent, mostly at 1 in 80, 85, to Cappoquin, there is a 1-mile rise of 1 in 80 and 1 in 66. From just beyond Dungarvan to within 5 miles of Waterford there are 22 miles of line about the hardest in Ireland over which express trains are run. The ruling gradient of 1 in 66 is frequent, and there are over sixty separate curves, some of them as sharp as only 10 chains radius. Taking the grading into consideration, and the fact that the staffs are changed by hand, the 50-minute timing between Dungarvan and Waterford (29 miles) is good locomotive work. At Waterford two more bogie

ROSSLARE BOAT TRAIN LEAVING CORK (GLANMIRE STATION)
(Great Southern and Western Railway)

coaches are added to the train, one from Limerick and the other from Dublin. The road is still single, and includes a rise of 1½ miles at 1 in 72 ; and to run 38½ miles to Rosslare in 55 minutes (42½ miles per hour) calls for smart work. On this section a tablet apparatus is installed by which tablets can be exchanged at from 30 to 35 miles per hour. For the whole journey from Cork to Rosslare (135 miles), the timing of 3 hours 50 minutes must be accounted exceptionally good.

The far-western section of the system, from Farranfore to Valentia, is one of the most picturesque in the world. "The railway clings to the side of the mountains at a height of over 100-ft. above the sea, with here a cutting or embankment, and there a mountain gorge, in which a lovely waterfall is almost lost sight of in a labyrinth of foliage." Valentia is the most westerly station in the British Isles. Half a century ago the Duke of Wellington and others selected it as the terminus of a railway for the conveyance of mails and passengers to and from ocean liners, instead of as now at Queenstown. The sections of the line, Headford to Kenmare (19½ miles) and Killorglin to Valentia (27 miles), were opened in 1893, the Government and county ratepayers assisting in paying the cost.

The paid-up capital of the Great Southern and Western Railway at the end of 1910 exceeded £13,500,000; the annual receipts amounted to £1,516,000, and the expenditure to £860,000. The locomotives, coloured black with fine red and white lines, numbered 283; there were 880 coaching and 7300 goods vehicles. During the year 6,263,000 passengers (excluding season-ticket holders) were carried in trains that travelled 3,869,000 miles, while the goods and mineral trains travelled 2,178,000 miles. The receipts from passengers, parcels, and mails are about £750,000; the income from goods, minerals, and live-stock is almost exactly the same.

Great Northern Railway (Ireland)

In some respects the Great Northern Railway (Ireland) is the most important system in the Emerald Isle, for it serves the northern half of Leinster and a great part of Ulster, or that portion of the country which is most industrial and consequently most populous, and thus on the 587 miles of line more passengers are carried than on the Great Southern and Western. This railway forms a connecting link between Dublin, Belfast, and Londonderry, three of the largest and most important towns in Ireland; it is connected with the London and North Western Railway port at Greenore; and as it also includes the North Wall Dublin Extension line, the system taps three routes of communication with Great Britain.

The Company was incorporated under its present title in 1876. The whole system is the result of amalgamations of various railways. Some of these lines are among the oldest in Ireland, such as the Ulster Railway, which was opened partially in 1839 with a 6-ft. 2-in. gauge, afterwards converted to the national gauge, and particularly to coincide with the Dublin and Drogheda line. The latter, which is now also part of the Great Northern, was slow in construction, and Sir Robert Peel's Cabinet voted £120,000 to expedite matters.

Another railway absorbed by the Great Northern was the line from Dundalk to Londonderry via Enniskillen. The rails of this line between the two last-named towns were laid on large iron castings, which served both as sleepers and chairs. When frosty weather disturbed the ballast, the weight of the trains frequently broke the cast-iron supports and called for the relaying of the metals. The engines were four-wheelers, with tanks beneath the boilers; the outside cylinders varied from 9-in. by 18-in. to 11-in. by 22-in.; and the driving wheels were 5-ft. 3-in. in diameter. The passenger vehicles were of similarly primitive style, especially the third-class, in which there were seats all round the carriage, with longitudinal seats in the centre. In some cases the carriages possessed only one door on each side.

Of the engineering works on the line the most important is the Boyne Viaduct, Drogheda. The railway is carried over the river by means of three iron lattice girders at a height of 90-ft. above the water. The centre span is of 265-ft., and the other two of 140-ft. span. The north end of the centre span is supported by a stone pier, the foundations of which go down to about as great a depth below the river as the pier rises above it. The approaches to the river consist of semicircular arches of 60-ft. span; four of them are on the north bank, and ten on the south bank of the river. There are but few tunnels on the system, the longest being between Goraghwood and Loughgilly (1 mile). The steepest gradient on a passenger line is 1 in 57 at Hillsboro', falling towards Knockmore Junction, but its length is only about 140 yards.

The locomotive works of the Great Northern Railway (Ireland) are at Dundalk, opened in 1887. The first engine built there by Mr. J. C. Park was a small 4–4–0 tank, with 4-ft. 6-in. coupled wheels, and weighing in working order 31½ tons. At that time two of the chief express locomotives on the line were single-driver bogie expresses, No. 88, "Victoria," and No. 89, "Albert," which were supplied by Messrs. Beyer, Peacock and Co., Ltd. Their dimensions were: cylinders, 16-in. by 22-in.; driving wheels, 6-ft. 7-in. diameter; boiler, 9-ft. 11¾-in. long, and diameter, 4-ft. ⅝-in. In 1905 these old singles were converted by Mr. Charles Clifford into four-coupled bogie locomotives, with driving wheels, 5-ft. 7-in.; cylinders, 17-in. by 24-in.; boiler, 10-ft. 2-in. long and diameter 4-ft. 7½-in.; total heating surface, 1175·9 sq. ft.; weight of engine and tender in working order, 69 tons 9 cwt.

The increase in the weight of the passenger rolling-stock, coupled with the addition of dining-cars on the fast trains between Dublin and Belfast, necessitated an augmentation of the locomotive power; and therefore Mr. Clifford, the locomotive superintendent, commenced the twentieth century with four new engines (4–4–0) of his own designing, but built by Messrs. Neilson, Reid and Co., of Glasgow. No. 133, "Apollo," the first of the quartette, had the following dimensions: cylinders, 18½-in. diameter by 26-in. stroke; driving wheels, 6-ft. 7-in. diameter; total heating surface, 1361·5 sq. ft.; working pressure, 175 lbs. per sq. in.; weight of engine and tender in working order, 75 tons. In 1905 appeared several new four-wheels coupled bogie express locomotives, built by the North British Locomotive Co., Ltd. They differed from earlier engines of the same type chiefly in boiler dimensions ; total heating surface, 1531 sq. ft. ; weight of engine in working order, 49½ tons, of which 16 tons 19 cwt. rested on the drivers.

The Great Northern Railway (Ireland) constructs its own carriage and wagon stock at Dundalk. The passenger coaches, of which the longest measure 58-ft., are thoroughly efficient vehicles in every respect, fitted with automatic vacuum brake, steam-heated, and lighted by electricity. This line was one of the very first in the

CATTLE TRAIN NEAR DERRY
(Great Northern Railway) (Ireland)

United Kingdom to try the system of each carriage generating its own light.

The largest station on the Company's system is Dublin (Amiens Street). The quickest trains are Dublin to Belfast, 112¾ miles, in 2 hours 35 minutes; Dublin to Derry, 175 miles, in 4 hours; and Belfast to Derry, 100 miles, in 2 hours 34 minutes. The longest non-stop runs are between Dundalk and Portadown, 33¼ miles; Dublin and Drogheda, 32 miles; and Belfast and Portadown, 25 miles.

The work of the system entails the employment of 164 locomotives, painted green and picked out with yellow ; the passenger vehicles, about 650 in number, are varnished oak ; the goods vehicles of all kinds total 5100. The passengers carried in a year number 6,882,000, plus season-ticket holders. The passenger trains run 2,500,000 miles, and the goods trains 1,163,000 miles. The Company has various rail motor-trains, which travel 231,000 miles during a year. The total traffic receipts amount to about £1,050,000, a little more than half being derived from the conveyance of passengers, parcels, and mails.

Midland Great Western Railway

The Midland Great Western Railway dates from 1845 with the projection of a railway from Dublin to Mullingar, followed by a branch line to Longford. Later extensions and amalgamations have given a length of 538 miles to the system, which serves the central districts of the country and a great part of Connaught. Roughly the main line extends across Ireland from Dublin to Galway and Clifden, with branches extending northwards to various important points, such as Kingscourt, Cavan, Sligo, Killala, and Westport.

The business of the Company differs considerably from the two preceding lines, for while its income from passengers amounts to about £280,000 per annum, the transport of goods, minerals, and live-stock brings in £460,000. It has been suggested that Galway would lend itself admirably as a port for direct steamship services between the United Kingdom and America. If anything ever comes of the idea to construct a tunnel between Great Britain and Ireland, at points near Portpatrick and Larne respectively, Galway's commercial outlook would be brightened, for the north of England and Scottish traffic could be run to the far western port, and thus shorten the Atlantic passage considerably. Whether the North Channel tunnel will ever become an accomplished fact it is impossible to say; it would necessitate burrowing under the sea for 25 miles, with approaches of 10 miles, at an estimated cost of about £12,000,000.

The Midland Great Western serves the following important towns, to which are added the distances and quickest trains from Dublin (Broadstone Station): to Mullingar, the longest run without a stop, 50¼ miles, in 72 minutes; to Athlone, 78 miles, in 107 minutes; to Galway, 126½ miles, in 3 hours 10 minutes; to Sligo, 134¼ miles, in 3 hours 55 minutes. Exclusive of season-ticket holders the passengers carried in a year number 1¾ millions; the passenger trains run 1,593,000 miles, and the goods, etc., trains 923,000 miles.

At the beginning of the twentieth century the locomotive and carriage stock was of rather a mediocre character, but with the appointment of Mr. Edward Cusack as locomotive, carriage, and wagon superintendent, a new era commenced at Broadstone works (Dublin). The stock now holds its own in appearance and utility with any in Ireland, and compares favourably with the machines and vehicles to be found upon not a few lines in Great Britain.

Mr. Cusack at once designed and built large express bogie locomotives (4 – 4 – 0), that at that time represented the maximum proportions of engines constructed for the Irish railways, as shown by the following dimensions of No. 129, "Celtic": cylinders, 18-in. by 26-in.; coupled driving wheels, 6-ft. 3-in.; total heating surface, 1363 sq. ft.; working pressure, 175 lbs. per sq. in.; total

CONNEMARA EXPRESS AT CLIFDEN
(Midland Great Western Railway)

weight of engine and tender (5 tons coal and 3000 gallons water), 87 tons. Engines of this class were built to haul the fast through trains between the east and west coasts, which they can work at a speed of 60 miles per hour on the level, or 30 miles per hour over inclines of 1 in 100. One of the latest 4 – 4 – 0's was the "Faugh a Ballagh" of generally similar dimensions, except that the heating surface was less, and the engine and tender weighed only 74 tons in working order.

In anticipation of the visit of the King and Queen to Ireland in 1903, a new royal saloon carriage was built at the Broadstone works. Generally it is considered to be one of the finest specimens of railway-carriage construction and decoration ever built. It measures 50-ft. over all, and consists of entrance-hall, reception-room, dining-room, smoking-room, dressing-room, and kitchen.

The interior is fitted up with every convenience and luxury that modern taste suggests. A feature of the exterior is the large size of the windows and the rounding of the corners.

The Midland Great Western locomotives number 140, and are painted green picked out with black lines; the 600 coaching vehicles are brown, decorated with gold lines; the goods vehicles number 3100.

Northern Counties Committee (Midland Railway)

The Northern Counties (Committee) Railway, so named since 1860, serves the counties of Antrim, Tyrone, and Londonderry. Originating in the Belfast and Ballymena Railway, the first portion

BELFAST TO DERRY EXPRESS
(Belfast and Northern Counties Railway)

of which was opened in April, 1848, nearly a dozen small lines have been amalgamated at different periods, the last of them being the Portstewart Tramway (3-ft. gauge) in 1907. Comprised in the 219 miles of railway, which form the system, there are over 60 miles of narrow-gauge lines (3-ft.). On the standard lines the rails are 83 lbs. per yard; the cast-iron chairs, 57 lbs. each, are probably the heaviest in the kingdom. The steepest gradient over which trains are run is 1 in 39 for about 1½ miles on a narrow-gauge line at Cargan, falling towards Ballymena.

In 1899 the two best bogie express locomotives (4 – 4 – 0) at work on the system, and among the very best in the country, were No. 50, "Jubilee," and No. 55, "Parkmount." They were designed by Mr. B. Malcolm, the locomotive superintendent, and built by Messrs. Beyer, Peacock and Co., of Manchester. They were two-cylinder compound engines on the Worsdell-von-Borries system, with the high-pressure cylinder 18-in. diameter, low-pressure cylinder 26-in., the stroke of each being 24-in.; total heating surface, 1153·6 sq. ft.; working pressure, 175 lbs. per sq. in.; total weight of engine and tender, 77 tons 1 cwt.

The Northern Counties Railway is the only line in Ireland which has used the compound system on its standard locomotives, except for a few engines on the Belfast and County Down Railway. In 1903 Mr. Malcolm designed new two-cylinder compounds, cylindered as before, except for ¼-in. increase in the diameter of the high-pressure cylinder; the coupled wheels were 6-ft. diameter; fitted with Walschaert valve gear and pop safety valves, and tablet-exchanging apparatus for working at full speed over a single line.

The locomotives number about 80; they are painted invisible green, picked out with blue, vermilion, and yellow. About 370 passenger vehicles are coloured lake, picked out with gold and vermilion. The passenger trains run 1,307,000 miles; goods trains, 495,000 miles; total receipts, £386,700, to which the passenger traffic contributes £187,000.

On July 1st, 1903, the Belfast and Northern Counties amalgamated with the Midland Railway, and the line is managed by a committee of six, three directors from each company. Midland passengers from England and Scotland for Ireland, on landing at Larne, can thus join Midland 50-minute express trains to Belfast via Carrickfergus, or proceed by various fast services to Antrim, Ballymena, Coleraine, Portrush (for Giant's Causeway), Ballycastle, and Londonderry.

In dealing with the four preceding railways we have accounted for about 2465 miles of line, leaving only 927 miles owned by many different companies, of which a few typical examples must serve.

The Dublin and South Eastern Railway, with a length of 160 miles, serves various portions of the counties of Dublin, Wicklow, Wexford, and Waterford, which names appeared in the Company's original title in 1846; in 1860 it was changed to Dublin, Wicklow, and Wexford Railway, the present title being assumed on January 1st, 1907. Various small lines have been absorbed, the oldest being the Dublin and Kingstown Railway, the first public railway in Ireland, and certainly the most expensive, for it cost more than £50,000 per mile.

A most important part of the Company's business is concerned with this line between Dublin and the Packet Station, Kingstown, as it forms part of the Royal Mail Route between London and Dublin. From Kingstown there are through carriages to many important stations on the Great Southern and Western, Midland Great Western, and Great Northern railways. The most important train on the system is the day mail from Dublin to Wexford and Waterford, consisting of engine and seven vehicles, 368-ft. long and weighing 204 tons. The timing is 3 hrs. 55 mins., averaging only 25·3 miles per hour, but as there are a dozen stops (one of 5 minutes) the running is, in reality, much better than indicated by the figures given. The grading of the route, too, is difficult, there being numerous climbs of 1 in 75.

TRAIN FOR DUBLIN LEAVING WEXFORD, DRAWN BY LOCOMOTIVE, NO. 57, "RATHNEW"

(Dublin and South Eastern Railway)

For running the "Limited" mail between Bray and Wexford, Mr. R. Cronin, the locomotive superintendent, a few years ago designed four-coupled bogie locomotives that make the double run of 161 miles every day. The leading dimensions were: cylinders, 18-in. by 26-in.; coupled wheels, 6-ft. 1-in. diameter; heating surface, 1193·3 sq. ft.; weight of engine in working order, 45 tons 3 cwt.; weight of tender with $3\frac{1}{2}$ tons of coal and 2600 gallons of water, 30 tons 8 cwt.

The Dublin and South Western Railway receipts from passengers, parcels, and mails amount to £186,000, and from goods less than half that sum. The passengers total over $4\frac{1}{2}$ millions; the passenger trains run nearly 1 million miles, and the goods trains little more than a quarter of the distance. The locomotives number 60; they are painted black with gold lines and red bands. The passenger vehicles, about 400, are coloured crimson-lake with gold lines; the goods vehicles number nearly 1000.

The CORK, BANDON, AND SOUTH COAST RAILWAY originated with 20 miles of line between Cork and Bandon, and the undertaking distinguished itself by failing to return a penny to the ordinary shareholders during the first quarter of a century of its existence. In 1870 a dividend of 2½ per cent was declared, and proved a good augury of future progress. Of various extensions, perhaps one of the most important was from Drimoleague to Bantry, giving the Company a deep-water terminus. The final section cost £30,000, half of which was found by the Government. The total income of the Company is less than £100,000; its trains run 400,000 miles; passengers carried, 488,000, excluding season-ticket holders. The locomotives are 20 in number, 70 passenger and 430 goods vehicles.

In September, 1901, the Company opened an aerial railway between Ballinphellic and Ballinhassig to work the traffic in bricks from the works at the former place to the railway station at the latter. No similar method of conveyance had hitherto been seen in Ireland.

The BELFAST AND COUNTY DOWN RAILWAY comprises 80 miles of line upon which work 30 locomotives (dark green with white lines), 153 passenger carriages (maroon with gold lines), and 660 goods vehicles. The main line is from Belfast to Downpatrick. The Company had great expectations in 1861 from the Newtownards Donaghadee branch line, for the Board of Admiralty favoured a mail packet service between Donaghadee and Portpatrick, and the Government in consequence improved the two harbours at considerable expense, but eventually the mail-service idea was dropped.

Of the various small standard-gauge lines none is more interesting than the WATERFORD AND TRAMORE RAILWAY, quite isolated from the rest of the Irish railway system. The 7½ miles of line were opened in September, 1853. The workshops at the Manor Station, Waterford, are quite a museum of railway relics, which include a Bury tank locomotive that was only taken out of service in 1904. The rolling-stock includes several survivals of the 'fifties. A five-compartment first-class open carriage is still used for excursion traffic, and finds much favour among festive politicians when attending demonstrations at Tramore. We illustrate another antiquated six-wheeled first-class coach, which is still regularly employed. The extension or boot reminds one of a post-chaise; formerly the receptacle contained a folding-bed to enable the end compartment to be used for invalids.

There are about 230 miles of line constructed under the various Light Railways Acts, but for which many parts of Ireland would never have experienced the benefits of the iron road. There are quite a couple of dozen light-railway companies, but brief mention of two of them will suffice.

OLD CARRIAGE STILL IN SERVICE
(Waterford and Tramore Railway)

The CORK AND MUSKERRY LIGHT RAILWAY (3-ft. gauge) commenced with $8\frac{3}{4}$ miles of line from Cork, via Coachford Junction and St. Anne's, to Blarney, opened in 1887; and in due course two branches were constructed, one to Coachford, the other to Donoughmore, making a total length of line of 27 miles. Strangely enough, even near the end of the nineteenth century, the railway was opposed strongly by the farmers of the districts that the railway was to serve; but within a very short time they recognised the advantages offered by the line, as shown by the growing milk and cattle traffic. In summer the tourist traffic is very considerable, especially to Blarney Castle. For $3\frac{3}{4}$ miles the line runs on the public road, $2\frac{1}{2}$ miles of it on a raised siding 9-in. high. The terminus is within the borough boundaries of Cork, where the rails are level with the road and filled in with granite setts. Here the pace allowed is slow, but off the public road the speed is often 25 miles an hour.

The TRALEE AND DINGLE LIGHT RAILWAY (3-ft. gauge) commences in the yard of the Great Southern and Western Railway at Tralee. The 31¼ miles of line traverse a wilder region than the foregoing light railway; for 27 miles it is without a fence, going uphill and downhill, quite close to cottages, where the maximum speed of 12 miles an hour has to be reduced. The summit of the line is at Glonnagalt, to which there is a 4-mile climb of about 1 in 30. This railway was opened in 1891, with locomotives built by the Hunslet Engine Co., Leeds. It has been stated in an earlier chapter that in two respects the Tralee and Dingle engines follow

TRAIN TO BLARNEY CASTLE OUTSIDE CORK
(Cork and Muskerry Railway)

the American practice, in being fitted with cow-catchers and great glaring headlights.

Our rapid review of the Irish railways may conclude with one line that is unique in British practice. Although various forms of *Mono-rail* have failed to prove of practical utility, we possess one real passenger steam railway that works upon a single rail. This eccentric line is to be found in County Kerry, in the west of Ireland. The LISTOWEL AND BALLYBUNION RAILWAY, which was opened for traffic on March 1st, 1888, is laid on the Lartigue system. The 10 miles of single-line track is composed of a double-headed rail, 27 lbs. to the yard, carried on angle-iron trestles about 3-ft. high. The trestles are attached to steel plates, resting in turn on trans-

1. MONO-RAIL ENGINE AND TRAIN. 2. SAND TRUCKS. 3. DRAWBRIDGE CROSSING

(Listowel and Ballybunion Railway)

verse wooden sleepers. On either side of the trestle runs a light guiding rail, about 18-in. below the carrying rail.

It is claimed to be a cheap form of construction for a rough light railway, but there is no gainsaying the fact that sidings, crossing places, etc., present well-defined difficulties. Where the line crosses a public road—that on an ordinary railway would be served by a level crossing—it is necessary to provide a kind of drawbridge at a sufficient height to carry traffic over the elevated rail. At the terminal stations, too, shunting and making up of trains has to be done piecemeal by means of turn-tables, from which the raised tracks radiate, giving the whole station the appearance of a small collection of cattle-pens.

The unusual construction of the permanent-way calls for the employment of locomotives, carriages, and wagons of extraordinary type. The engines are double-barrelled, with a small boiler on each side of the centre rail; they were built by the Hunslet Engine Co., of Leeds. The engine can be operated from either side, the handles operating the gear being in duplicate, and the tender can be used for traction, as it is provided with cylinders, which exhaust up two escape pipes at the rear of the cab. The engine weighs 6½ tons in running order, and the tender 4¼ tons, with 200 gallons of water and 1 ton of coal. The other rolling-stock consists of passenger carriages, cattle vans, and sand trucks, with their lower portions overhanging each side of the rail. The Westinghouse brake is in use on all trains, of which daily there are four each way in summer, and two in winter. The line is worked on the train-staff system. Although the Listowel and Ballybunion Railway has been in existence nearly a quarter of a century, no other similar line has been constructed in this country, nor is one likely to be.

CHAPTER XXV

RAILWAY SHIPS AND DOCKS

A POINT has been made that railway companies never refuse traffic that is offered to them. Going further, it may be asserted that they do not wait for traffic to come to them, but they meet it more than half-way; they foster and encourage traffic where hitherto none has existed. This aspect of railway business is particularly applicable to those companies that have access to the coast; and thus we find railway companies owning their own fleets of steamships, trading in and out of harbours and docks in which they have secured interests, or in some cases have constructed at immense cost for themselves.

It is proposed to note briefly the railway shipping interests in order to gain a general idea of the immense traffic as a whole, together with a few facts concerning specially interesting features. It will be convenient, and a great saving of space, to tabulate a few shipping particulars of the chief railway companies in the order in which they have appeared in the foregoing pages:—

RAILWAY	STEAMSHIPS TURBINE	SCREW	PADDLE	APPROX. GROSS TONNAGE
London and North Western	–	15	–	20,100
Great Western	4	18	2	24,200
Midland	2	4	–	10,600
Great Eastern	3	8	3	19,500
Lancashire and Yorkshire	2	31	2	39,700
Great Central	2	14	–	21,600
London and South Western	2	16	2	15,300
London, Brighton, and South Coast	3	13	1	14,500
South Eastern and Chatham	5	8	4	16,500
London, Tilbury, and Southend	–	4	2	1,400
Furness	–	–	4	1,600
Caledonian	1	–	9	3,500
North British	–	–	7	2,300
Glasgow and South Western	1	–	9	3,900

A glance at the above list will show that with few exceptions the great railways of Great Britain are shipowners; and those that do not appear, such as the North Eastern and Great Northern, are interested in various shipping companies. During comparatively recent years the old familiar paddle steamers on all the important railway steamship services have given place to screw vessels. With the advent of the twentieth century came the turbine engine, which is about half the weight of the ordinary reciprocating engine, and yet capable of higher speed, with a great reduction in vibration; and now there are more than a score of railway turbine steamships.

The London and North Western Railway steamships ply between Holyhead and Ireland. The Anglesey port is one of the chief gateways of Great Britain, and in some respects its importance ranks

LOADING GOODS FROM TRAIN TO STEAMER "SLIEVE GALLION"
(London and North Western Railway)

second only to that of Dover. Holyhead dates its modern history from the building of the Chester and Holyhead Railway, which owned steamships of its own before it became part of the London and North Western.

The mails from Holyhead to Dublin were carried by Admiralty packets until 1849, when the Government solicited tenders from private companies. The Chester and Holyhead Company considered that its financial interests in the mail route gave it a claim to the packet section and declined to tender, with the result that the contract was secured by the Dublin Steam Packet Company. In 1859 the Chester and Holyhead line was absorbed by the North Western, but nevertheless the Dublin Steam Packet Company secured a renewal of the mail contract the following year, and again in 1883.

Meantime, Holyhead had grown out of all recognition by the construction of the Admiralty pier and a magnificent breakwater. The latter, commenced in 1847 and completed in 1873, cost the public funds more than 1¼ million sterling, for although it is rather less than 1½ miles long, it required 7,000,000 tons of stone, which was quarried from the mountain at the head of Holyhead Island. In June, 1880, the then Prince of Wales opened an inner basin, which the North Western had provided at a cost of £750,000.

In 1897 the London and North Western put into service the s.s. *Cambria*, the first of four fine vessels, the others being the *Anglia*, *Scotia*, and *Hibernia*, which still fly the North Western flag at the head of the railway fleet. It was thought that the steamship company would at last fail to secure the renewal of the mail contract, because the railway could claim the better vessels, and also could urge that quite as much Irish capital was invested in its railway-stock as in the Dublin Steam Packet Company. The latter, however, in 1897 secured the mail contract afresh, and will remain in possession of it until March, 1917. Fully alive to its responsibilities, to say nothing of its desire not to be put into the shade by the North Western, the steamship company displaced its paddle boats by four new twin-screw steamers of 24 knots speed. The North Western's four best vessels have a speed of 22 knots; and the eight of them form a fleet second to no similar boats working in and out of any port in the kingdom.

The *Anglia*, *Cambria*, *Scotia*, and *Hibernia* trade between Holyhead and Dublin (North Wall) and Holyhead and Kingstown, and practically are solely passenger boats. They have a length of 338-ft.; breadth, 39-ft.; depth, 16-ft. 6-in.; gross tonnage, nearly 1900; and indicated horse-power, 7000. The photographic illustration of the dining saloon of the *Hibernia* gives a good idea of the manner in which railway companies generally cater for their sea-going passengers.

Euston and Dublin are 334 miles apart; quickest service, 9 hours 15 minutes, e.g. by the Irish night express ex Euston 10.15, arriving at Holyhead 3.30 a.m.; steamer ex Holyhead at 3.55, arriving Dublin (North Wall) at 7.30 a.m. Kingstown is 330 miles from Euston; quickest service, 8 hours 30 minutes.

Seven vessels, of which the *Slieve Bloom* and *Slieve Gallion* (1165 tons) are the largest, are freight boats between Holyhead and Dublin; while four vessels, the *Rathmore* the largest, convey both passengers and goods between Holyhead and Greenore. From London to Greenore the distance is 343 miles; quickest service, 10½ hours.

The loading of the *Slieve Gallion* at Holyhead shows the advantage of merchandise coming by rail directly opposite, and only a few yards removed, from the vessel's hold.

In June, 1909, the White Star Company adopted Holyhead as a port of call for the landing of passengers travelling from United States to England and the Continent in the steamers of their New York–Liverpool service. Geographically Holyhead lies on the direct route, so that steamers calling there need not go more than a mile from their usual channel course. A London and North

SS. "HIBERNIA" FIRST-CLASS DINING SALOON
(London and North Western Railway)

Western Railway Company's tender carries passengers, mails, and luggage to the quay in ten minutes. A good instance of the advantages of Holyhead in the saving of time was shown recently in the landing of the *Cedric's* passengers. The vessel arrived in the harbour at 1.6 p.m. The passengers, nearly 200 in number, with their baggage and a number of bags of mails, were landed, and by 2.30 they were all on their way to London, where they arrived shortly after 7 p.m.—the railway journey of 264 miles being accomplished in less than 5 hours without any intermediate stop. On account of the state of the tide at the bar of the Mersey, the *Cedric* could not get up to the landing-stage before 10 p.m., so that those passengers who landed at Holyhead arrived in London three hours before the vessel got to Liverpool.

Although the White Star Company has ceased to use Holyhead as a port of call, other lines make use of it, all helping to swell the business of the North Western.

At the southern end of the long line of docks, which form the port of Liverpool, the London and North Western Railway owns the Garston Dock, in which are carried out the operations connected with a very heavy traffic. The Old Dock and the North Dock are connected by a channel to enable vessels to pass from one dock to the other. To facilitate the wagon traffic the channel is crossed by a line of rails, which are carried over the waterway by a movable structure, not a swing-bridge, nor yet an ordinary drawbridge, but what best may be termed a "roller" bridge. The main and cross girders are of wrought iron; the flooring is of timber. Hydraulic power is employed for working the bridge, the whole of which is lifted up by rams, and then drawn back on rollers by chains, thus leaving the waterway open. The bridge has a clear span of over 60-ft., but the main girders are about 115-ft. long.

The Great Western Railway vessels are numerous, and with a gross tonnage exceeded only by that of the Lancashire and Yorkshire fleet. The Company is interested in steamship services between Weymouth and the Channel Islands, and between Plymouth and Brest (summer) or Nantes (winter). For its services to Waterford in Ireland the Great Western formerly used the port of New Milford, but in August, 1906, the Fishguard–Rosslare route was opened, which provides the shortest passage between England and Ireland. For this service four new vessels were constructed, namely, the *St. George, St. David, St. Andrew,* and *St. Patrick,* triple-screw turbine steamships with a speed of 22½ knots, which enables the passage of 54 nautical miles to be compassed in 2¾ hours. The *St. Andrew* is depicted on the next page. It has a length of 351-ft.; breadth, 41-ft.; depth, 16-ft. 6-in.; and gross tonnage, 2528. In appearance the vessel resembles a small ocean liner rather than a 54-mile ferry boat, and internally it is as commodious and comfortable as it is handsome without.

On August 30th, 1909, the Cunard Steamship Co. inaugurated Fishguard as an Atlantic port for disembarkation. The turbine steamer *Mauretania* left the Cunard Co.'s pier at New York on August 25th at 10.8 a.m., and the Great Western train from Fishguard, containing the mails to London, drew up in Paddington station at 6.40 on August 30th. This feat entailed some breaking of records both on sea and land. The *Mauretania* crossed the Atlantic, from Ambrose Channel lightship to Daunt's Rock lightship, in 4 days 14 hours 27 minutes, and the Great Western train covered the distance of 261½ miles between Fishguard and Paddington in 4 hours 28½ minutes; the average speed of the vessel at sea was 25·41 knots (29·27 miles per hour), and of the train on land 58·4 miles per hour. Between Swindon and Paddington (77¼ miles) the speed was 67·8 miles per hour. The mail train (two Ocean-Mail vans and a bogie brake) weighed only 55 tons 3 cwt. A passenger train, which followed 42 minutes later, weighed 273 tons 18 cwt. From Fishguard to Cardiff (116¼ miles) it was drawn by two engines at 53·2 miles per hour, and from Cardiff

TURBINE STEAMSHIP "ST. ANDREW"
(Great Western Railway)

to Paddington (145¼ miles) by No. 4021, "King Edward," at 61·3 miles per hour; average running for the whole distance (excluding stop of 2½ minutes at Cardiff), 57·3 miles per hour.

The Midland Railway Company, in 1896, obtained Parliamentary powers for the construction of a deep-water harbour at Heysham, and for passenger steamers in connection therewith. Heysham Harbour is formed by two breakwaters—massive erections of concrete embedded upon rock foundations. At their junction with the shore they are about a mile and a half apart, narrowing to 300-ft. at their outlet to the ocean. They enclose an area of 150 acres, giving an average depth of 17-ft. at the spring tides, with 40-ft. of water immediately outside the entrance. There is a quay 3000-ft. long with three landing-stages at different levels, affording facilities for dealing with express passenger services under any tidal conditions. The harbour is fitted with every modern appliance for dealing with cargoes, either inward or outward; and, in particular, by means of sloping ways cattle, horses, and other livestock can be landed without the use of slings.

ELECTRIC CRANES DISCHARGING TIMBER (PIT PROPS) AT HARTLEPOOL
(North Eastern Railway)

The present Midland fleet comprises only half a dozen steamers. Four of them (*Antrim*, *Donegal*, *Londonderry*, and *Manxman*) are particularly fine vessels. The smallest is the *Donegal* (1996 tons) and the largest the *Manxman* (2173 tons). All four of them are screw steamers, the *Londonderry* (21 knots) and *Manxman* (22 knots) being fitted with turbine engines. The accommodation provided for the passengers is of the highest class, the various apartments being models of artistic decoration and luxurious furnishing. These four vessels trade between Heysham and Belfast, and also to and from Douglas (Isle of Man) in summer. The Midland acquired the boats of the Barrow Steam Navigation

Co., and between Barrow and Belfast there are three sailings weekly for the transport of passengers, goods, and livestock.

Although the North Eastern Railway does not own any steamships directly, it claims to be the largest owner of docks of any railway company in the world. The Company's docks are at Hull, Middlesbrough, Hartlepool, and Newcastle, from which ports there are regular and frequent sailings to and from nearly all European ports, as well as to ports overseas in every part of the world. The North Eastern is the largest carrier of coal and merchandise in the United Kingdom, and much of its traffic is in connection with its dock properties.

The North Eastern Railway riverside quay at Hull is 2500-ft. in length, from 85 to 150-ft. in width, covered throughout and provided with a fully equipped passenger station. Quick-acting electric cranes load fruit, perishables, and other traffic direct to wagons under cover. The fish stage, 3400-ft. long, has a concrete floor, and is covered throughout. Railway sidings are laid alongside, on which 200 wagons can be loaded at one time. During the year 1910 nearly 3,000,000 cwt. of fish were landed at Hull, which is a natural distributing centre to the north, west, and Midlands; a population of 17,000,000 being within easy reach of the port.

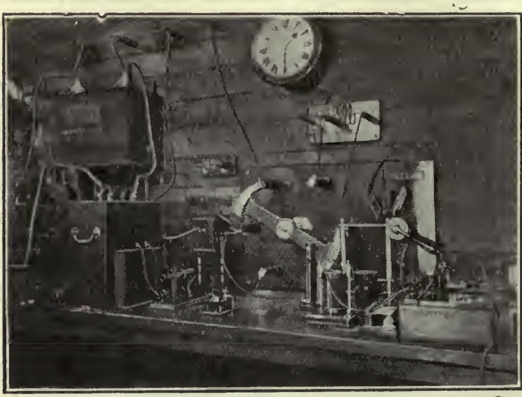
Middlesbrough Dock has a water space of 26 acres with a depth of 27 to 32-ft., admitting the largest class of vessels. There are nearly 50 cranes with lifting capacities varying from 35 cwt. to 30 tons. Two 40-ton hydraulic coal hoists can load the largest cargo steamers afloat at the rate of 400 tons per hour.

Hartlepool has six docks, one basin, two tidal harbours, and four timber ponds, in all a water area of about 200 acres. The import of timber is immense, a special feature being the pit props used extensively in the collieries on the coalfields served by the port and railway. The appliances for the rapid shipment of coal include new staithes with belt spouts, having a loading capacity of 700 tons per spout per hour. The modern warehouses are capable of storing 150,000 quarters of grain. Steam trawlers can land their catches at all states of the tide. The Company keeps a fleet of nine powerful sea-going tugs for port services only.

At Newcastle-on-Tyne the North Eastern Railway Company owns the Tyne Dock, 50 acres in extent, exclusive of timber ponds. The facilities for dealing with cargoes include 40 steam and hydraulic cranes up to 40 tons' lifting capacity, 40 large warehouses for the accommodation of grain and other cargoes, together with 215 acres of space for timber storage.

The Great Eastern Railway steamship energies are confined to the important services between Harwich and the Hook of Holland and Antwerp. The chief vessels employed are the *St. Petersburg*, *Munich*, and *Copenhagen*, triple turbine steamers (21 knots), the first-named of 2600 tons, and the two latter 2500 tons. They are fitted for wireless telegraphy and submarine signalling. Among the largest railway steamships sailing under the British flag, they have in their passenger accommodation many features of the latest type of Atlantic liner. The fleet of twin-screw steamers performs the services to and from Antwerp. Three smaller paddle steamers ply between Ipswich, Harwich, and Felixstowe.

The Great Eastern Railway possesses a wireless telegraphy land station at Parkeston Quay (Harwich). The operators on the eight boats and at the land station are always on duty until the steamships have reached their destination. During the passage calls are made between the Great Eastern Railway boats at sea and the land stations at Parkeston and Scheveningen in accordance with a regular time-table. Excellent communication is obtained between the boats, when alongside Antwerp Quay and Parkeston land station, a distance of 130 miles.



INTERIOR OF PARKESTON WIRELESS TELEGRAPH LAND STATION
(Great Eastern Railway)

The Lancashire and Yorkshire Railway has the largest fleet of any British railway company, but the London and North Western is interested in the seven largest vessels, two of which are triple-screw turbine steamers (*Duke of Argyll* and *Duke of Cumberland*), while the others are twin screws, the slowest boat having a speed of 15½ knots. Of the remaining vessels most of them are single screws. The chief services are between Fleetwood and Belfast, Fleetwood and Londonderry, and between Liverpool and Drogheda; and in summer between Fleetwood and the Isle of Man. At Fleetwood the Company owns very extensive docks, with special provision for the fish traffic.

In 1905 the Lancashire and Yorkshire Railway purchased the fleet of the Goole Steamship Co., and commenced to run steamers from Goole and Hull to Hamburg, Copenhagen, Amsterdam, Antwerp, and other European ports, followed later by a fast passenger service between Hull and Zeebrugge. Goole, the most inland port on the east coast, has dock accommodation for dealing with an immense traffic, around which the Lancashire and Yorkshire has a network of sidings capable of containing 4000 wagons. The facilities for handling merchandise, and the rapidity with which it can be passed on to destination, is exemplified in the case of butter shipped from Denmark. Arriving on Sunday at 11 p.m., the cargo is unloaded and on rail three hours later, and by means of two special butter trains is in Manchester and ready for delivery at 5 a.m.

Grimsby, the largest fishing port in the world, owes its success to the enterprise of the old Manchester, Sheffield, and Lincolnshire

THE HERRING SLIP, GRIMSBY DOCKS
(Great Central Railway)

Railway, which spent large sums in the construction of docks which now have an area of over 100 acres. Since the railway named became the Great Central, Grimsby has received additional attention. The accompanying photograph shows the herring slip, where the barrels are being packed ready for transport by rail, as shown in the fish train on page 215. At Immingham the Great Central Railway is constructing a huge dock of 71 acres extent, capable of taking the largest vessels at any state of the tide, with special facilities for dealing with the coal traffic from the collieries of South Yorkshire, Derbyshire, and Nottinghamshire. By means of the most modern appliances 40,000 tons of coal can be shipped within twelve hours.

With the exception of the *Immingham* (2008 tons) and *Marylebone* (1972 tons), turbine steamers (18½ knots), the Great Central Railway fleet consists of vessels of the ordinary screw type, of which the *Accrington* and *Dewsbury*, each 1631 tons, are the largest and fastest (13½ knots). The services are to Hamburg, every week-day, and to Antwerp and Rotterdam, three times per week.

The London and Southampton Railway (now the London and South Western) Act was passed in 1835, and before the end of the next year the Southampton Dock Co. was formed to construct the outer dock, which, although incomplete, was in use by P. and O. steamers in 1845. Particulars of dock extensions during the succeeding half-century need not be detailed, until in 1891 the South Western completed the Empress Dock (18½ acres), which was at that time the only dock in Great Britain that the largest steamers could enter or leave irrespective of tides. The Railway Company bought the Southampton Dock Company's estate in 1892, since which time there have been constant additions and improvements, that have made Southampton one of the foremost ports in the world, with every imaginable accommodation for shipping, not even excluding the White Star leviathans the *Olympic* and *Titanic*.

The "Prince of Wales" Graving Dock, opened by his late Majesty King Edward VII in August, 1895, was then the largest graving dock in the world. Ten years later the Trafalgar Dock, much bigger, was completed. Its length was 875-ft.; entrance width, 90-ft.; greatest depth of water over sill, 33-ft.; capacity, 85,000 tons of water, which could be emptied in 2½ hours. The increasing tonnage of modern liners necessitated the enlargement of this dock to 900-ft. by 100-ft. by 35-ft.; and this work was followed by the construction of a new 10-acre open dock (40-ft. at low water), the deepest dock in the country.

The unique position of Southampton gives the port four tides a day, and a constant great depth of water in the docks and harbour. From the outset His Majesty's Post Office has used Southampton as a mail-packet station, 250,000 packages of mails passing outwards and 66,000 inwards per annum. Not only do important British steamship lines use the port, but foreign steamers, such as those of the Norddeutscher Lloyd and Hamburg–American companies make it a port of call. In 1910 the vessels arriving at the port numbered 3536, with a gross tonnage of 7,225,000 tons; quite 304,000 persons entered or left the docks, exclusive of the movement and shipment of troops under the Admiralty Transport Department. Between September and May, the trooping season, 50,000 men of all ranks pass in and out of port. The cargoes in and out totalled 1,325,725 tons, while the bunker coal amounted to 600,000 tons.

On page 216 reference was made to the early spring vegetable produce exported to Great Britain from the Channel Islands and France. In the season twenty special trains of new potatoes are often sent in one day from Southampton to Nine Elms. The foreign chilled and frozen meat trade is enormous ; on the Test Quay stands the largest cold store in Europe, capable of holding 15,000 quarters of beef, 155,000 carcases of sheep, with additional space for the storage of butter, fish, poultry, eggs, etc. A South Western meat train is shown on page 413. At the dock sides there are 34½ miles of railway lines, upon which the marshalling of wagons is performed to assist the speedy make-up of trains.

The London and South Western Railway steamships, of which the triple-screw turbine vessels the *Sarnia* (1500 tons) and *Cæsarea*

THE NEW 16-ACRE DOCK AT SOUTHAMPTON
Showing cranes working at the Dock-head

(1500 tons) are the largest, trade between Southampton and the Channel Islands, Havre (for Paris), Cherbourg, St. Malo, Honfleur, and Granville. There are five smaller steamships, not included in the list at the commencement of the chapter. These vessels ply between Portsmouth, Stokes Bay, and the Isle of Wight ; they are jointly owned by the South Western and the London, Brighton, and South Coast Railways.

The London, Brighton, and South Coast Railway's continental traffic is an important item in the Company's business. The chief route is between Newhaven and Dieppe, two passenger services being run each way daily throughout the year, with frequent cargo sailings, as called for by the traffic.

As far back as 1792 fast-sailing ships traded regularly between Brighton and Dieppe, and in 1824 the first steamer, the *Rapid*, was put into service. The following year the Newhaven–Dieppe service was opened with the General Steam Navigation Company's steamer *Eclipse.* The foregoing services were prior to the advent of the railway. When the London and Brighton Railway reached Shoreham, the Steam Navigation Company ran steamers between Shoreham and Havre in connection with the trains. In 1847 the Railway Company established the Brighton and Continental Steam Packet Co., with three steamers working between Brighton and Dieppe, but as the services did not pay, the shareholders caused the Steam Packet Co. to be dissolved at the end of two years; and arrangements were made with the General Steam Navigation Company to commence fresh services between Newhaven and Dieppe.

In 1852 the London, Brighton, and South Coast Railway obtained Parliamentary powers to own and work steamships; the *Paris* and *Rouen* formed the nucleus of the fleet, and nine boats were added during the next two years. In 1862 the *Rouen* performed the passage between Newhaven and Dieppe in 4 hours 8 minutes (the present-day fastest time is about 3 hours; in 1875 the Ouest Railway Company of France added two vessels, the *Newhaven* and *Dieppe,* to the fleet; in 1888 were floated the *Paris* and *Rouen,* named after the original couple that commenced the fleet, and the last paddle boats to be added to the service. Between 1888 and 1902 eleven new vessels made their appearance, some of them French-built boats, for the service is worked jointly by the London, Brighton, and South Coast and the French State railways.

The year 1903 commenced a new era with the *Brighton* (22 knots), the first twin-screw turbine steamer in the service. This was followed in 1905 by the *Dieppe,* a very similar vessel, but in some respects a little larger; length, 273-ft.; breadth, 34-ft. 6-in.; depth, 13-ft. 6-in.; gross tonnage, 1215; speed, 22½ knots.

The South Eastern and the London, Chatham, and Dover Railways, before their amalgamation, could boast of good steamship services, even at periods in their history when little that was good could be said of their locomotives. For services to France, Folkestone Harbour was used by the South Eastern and Dover by the London and Chatham. It is proposed to devote but little space to the earlier traffic, but it may be said that the vessels at different periods reflected the never-ceasing improvements in steam navigation. Both companies obtained the necessary powers from Parliament to own and work steamers in 1852, the same year as the London, Brighton, and South Coast. At first the South Eastern and the Chatham railways worked their Channel services with vessels acquired from various private companies, but very speedily put into service boats of their own building. The Chatham paddle steamers, the *Maid of Kent* and the *Samphire,* were particularly fine boats of their period; nearly 200-ft. long, 24-ft. beam, and 160 horse-power, compared to 9000 horse-power of the best present-day steamships engaged in the same service.

With the amalgamation of the two companies in 1899 additional energy was imported into the steamboat section. In June, 1903, the turbine steamer, *The Queen*, was put into service. In the adoption of the turbine the South Eastern and Chatham led the van; the Brighton Company was building a similar steamer; but no turbine vessel appeared in any Atlantic-going fleet until the Allan liner, *Victorian*, took the water in 1904. At the end of 1911 the South Eastern owned five fine turbine Channel steamers. They are all very similar in size: length, 324-ft.; breadth, 42-ft.; depth, 24-ft.; gross tonnage in each case nearly 1700 tons; speeds varying from 21¾ to 22½ knots per hour.

TURBINE STEAMSHIP "EMPRESS"
(South Eastern and Chatham Railway)

The Company's steamships trade between Dover and Calais, and between Folkestone and Boulogne, the latter being the quickest route to Paris. The South Eastern carries the Continental, Indian, and Australian mails, and therefore the steamship services form a most important section of the activities of the line. From Dover to Ostend the services are worked by steamers belonging to the Belgian Government, while the services between Queenborough and Flushing are performed by the Zeeland Steamship Co.

Dover, the nearest port to France (21 miles), has grown into a seaport of more than cross-Channel importance within the last few years, thanks to the construction of a harbour, a square mile in extent, at a cost of 3½ millions sterling. A tunnel under the Strait of Dover has not only been suggested, but a few years ago the work was actually commenced. On the English side 2000 yards of the work were completed, but Parliament refused sanction to continue a scheme that might endanger Britain's insular position.

The London, Tilbury, and Southend Railway steamships ply between Tilbury and Southend, in addition to which they are often used as tenders to P. and O. and other liners, just as the Great Western tenders at Plymouth and Fishguard are employed for embarking and disembarking passengers and luggage, transferring the mails, etc., to or from ocean-going liners calling at those ports.

The Furness Railway steamers trade between Barrow and Fleetwood (for Blackpool); and in addition to the four vessels tabulated, the Company owns seven small paddle boats plying on Windermere Lake, and a couple on Lake Coniston.

The Scottish railway steamships, with the exception of two, are paddle steamers that work from pier to pier, chiefly in the Firth of Clyde and the West Highland lochs, the latter especially in the summer tourist season. The steamboats on Loch Lomond are owned jointly by the Caledonian and North British Railways. The Caledonian Railway owns very important docks at Grangemouth, while its own metals and running powers give the line access to practically every important port in Scotland. The North British owns extensive docks at Methil, Burntisland, Bo'ness, Alloa, Tayport, and Silloth. Methil and Burntisland are the chief outlets of the Fifeshire coalfield, and during the year 1910 the coal exports totalled 5,054,000 tons.

PLATE XII.

THE ORIENT EXPRESS ENTERING CONSTANTINOPLE.
Passing the Mosque of S. Sophie.

SECTION II.—FOREIGN AND COLONIAL RAILWAYS

CHAPTER XXVI

RAILWAYS OF EUROPE

THE Continent of Europe has an area of 3,769,000 sq. miles and a population of over 391 millions. At the end of 1908 (the latest date to which figures for all countries are available) the total length of railways was 202,068 miles (including the mileage of the United Kingdom), working out at a little over 5 miles of railway per 100 sq. miles and about 5 miles per 10,000 inhabitants. Taking countries separately, the corresponding figures afford very different reading. In the United Kingdom there are 19 miles of railway per 100 sq. miles; Germany has 17·5 miles, France 14·5 miles, Russia 1·8 miles, Turkey 1·9 miles, Norway 1·4 miles; but Belgium (including light railways) has over 44 miles of line per 100 sq. miles.

With the exception of Belgium the British figures are the highest of all the countries of the world. Belgium is not twice the area of Yorkshire; its population is less than that of Yorkshire and Lancashire; and therefore its 5049 miles of railways give it a metalled density unequalled in any other country in the world. Russia with its immense area is almost a century behind the rest of Europe. The low railway mileage per 100 sq. miles in the case of Norway is no reflection upon the energy of the people, but drives home the fact that a great portion of the country is mountainous and too sparsely populated ever to expect a great railway mileage; but in the case of Turkey the figures are typical of the indolence, bigotry, and opposition to Western progress that are ingrained features of the Ottoman character.

In the United Kingdom there are 5·6 miles of railway per 10,000 inhabitants; Germany has 6·5 miles, France 7·7 miles, Denmark 9·6 miles, Turkey 2·1 miles, Belgium 7·5 miles, and Sweden 16·5 miles of railway per 10,000 inhabitants. In this second aspect of European figures Sweden stands out prominently. The population of the whole country does not greatly exceed 5 millions; yet there are 8470 miles of railway, or not a thousand miles less than in Spain, which has three times the population of Sweden.

In any review of the Continental railways we are at once met with the question of State ownership. The railways of Germany, Portugal, Roumania, Servia, and Switzerland practically are all owned directly by the State. In all the other countries, with the exception of Spain and Greece, the railways belong to private companies, and the State in varying proportions; but in some cases, notably in France, the lines held by private companies have been built under concessions and guarantees of the State, which will take sole control at the expiration of agreed periods.

In some countries, as France and Germany, the absolute possession of the railways is a vital necessity for military strategic purposes; but in the case of Great Britain, its insular position and its powerful navy cause the railways to loom less largely in the matter of offensive or defensive tactics; although the establishment of the Engineer and Railway Staff Corps shows that the British military authorities keep their fingers on the railway pulse in case of emergency.

The nationalisation of British railways is a vexed and oft-discussed question, and perhaps never more so than at the time of the great, but brief strike of railway workers in August, 1911; but it may be observed at once that strikes are not unknown on State railways.

The fact of the matter is that in railway matters each country must be a law to itself. Off-hand comparisons are often exceedingly misleading. Fares may be cheaper upon Belgian State-owned railways than upon British lines; but Belgian railways cost less than £20,000 per mile to construct, whereas British cost over £48,000 per mile; and such disproportionate capital must entail appreciable differences in working. Again, a State-owned railway may transport goods at lower rates than for similar commodities on British lines. Inquiry may show that the foreign railway finds no difficulty in making up loads of 500 tons to run a distance of 500 miles, and, consequently, can afford to charge a lower rate than a British company conveying only 50 tons for 50 miles; for the cost of loading and unloading at the terminals is the same in both cases. It is not the fault of British companies that our restricted area prevents most of them from being able to obtain a haul of even 200 miles.

It is often urged that State ownership would vastly improve the conditions of labour for British railway employés. Even that may be a debatable point. One of the most fatal accidents in modern times occurred on a Belgian railway, caused by the error of a pointsman who was in receipt of the munificent weekly wage of 14s. 4d. British railway pay may not err on the side of liberality, but our railway trade unions would see to it that no man entrusted with the lives of the travelling public was paid at so beggarly a rate.

In conclusion it may be remarked that it has been estimated that the sum of £1,975,000,000 would be required to buy up the British railways; but so long as the present management does not fail in its obligations to the public, there seems little reason for charging the nation with so vast an expense, to obtain, more or less, speculative advantages.

The leading feature of Continental locomotive practice is the almost uniform adoption of the compounding of the cylinders. British locomotive engineers, save the notable exceptions Mr. F. W. Webb and the elder Mr. Worsdell, never adopted compounding extensively, although in very recent years the Great

RIVIERA EXPRESS LEAVING MONTE CARLO
(Paris, Lyons, and Mediterranean Railway)

Western gave a trial to French-built compounds of the de Glehn type, and on the Midland and the North Eastern some engines were built on Smith's system, in which Webb's method of three-cylinder compounding was exactly reversed, for instead of two high-pressure cylinders outside and one low-pressure inside, Smith's system provides for the high-pressure inside and the two low-pressure cylinders outside.

On nearly every railway in continental Europe and North America two-cylinder compounds were for a long time the general rule; but they have given way largely to various types of four-cylinder compounds. In the "tandem" type the cylinders are set in pairs end to end, the high-pressure cylinder usually in front of its corresponding low-pressure fellow on the same side of the engine. The Vauclain compound has one high-pressure cylinder above a low-pressure one on each side. The inventor was one of the partners of the famous Baldwin Works at Philadelphia; and thousands of this type of engine have been built, but otherwise aiming at few complications, while retaining all the advantages claimed for compounding.

M. de Glehn's method goes further than the preceding systems, in that he has to a greater degree solved the difficulty of "balancing," thus avoiding the necessity of wheel-balance weights, which

2–6–6–0 ARTICULATED 4-CYLINDER MALLET COMPOUND LOCOMOTIVE
(Eastern Railway of France)

in many cases are imperfect, causing heavy blows alternately backward and forward as the wheel revolves, harmful alike to engine and rails. The four-cylinder compound establishes a balance of reciprocating parts by similar horizontal moving parts, effected in the Vauclain and Cole balanced compounds by one valve rod, carrying two valves on each side, as in the ordinary simple engine. But M. de Glehn employs separate gear for the high and low-pressure cylinders, the latter being placed inside and driving on to the cranked axle of the fore pair of driving wheels, while the high-pressure outside cylinders drive on to the hinder pair of coupled wheels.

To see the de Glehn compounds at their best one must go to the Northern Railway of France, on which line the four-cylindered engines have snatched the European speed record from Great Britain. Nord expresses from Paris to the Belgian frontier run from 95 to 120 miles without a stop, hauling trains up to 200 tons at 61½ miles per hour. Consequently there is little wonder that the de Glehn type has become the standard for French expresses to some extent even on the P.L.M., which in 1902 announced its intention of reverting to simples.

In 1876 Messrs. Schnieder, of Creusot, built for the new Bayonne and Biarritz line three six-wheeled (four-coupled) and two six-coupled tank engines on the Mallet system. They were provided with two outside cylinders of different diameters, for high and low pressure respectively, and were fitted with a starting arrangement for working at will with single or double expansion. The cylinders were 9·45-in. and 15·75-in. diameter, and the stroke in each 17·72-in. The coupled wheels were 3-ft. 11¼-in. diameter; total

ONE OF THE FIRST "MALLET" COMPOUND LOCOMOTIVES (1876)
(Bayonne and Biarritz Railway)

heating surface, 488·5 sq. ft.; working pressure, 140 lbs. per sq. in.; wheel-base, 8-ft. 10-in. In working order these engines weighed 19 ton 10 cwt., of which 15 ton 5 cwt. counted for adhesion. After some time all five engines were furnished with chimneys of abnormal height to prevent exhaust steam and smoke from annoying passengers on the open upper deck of the two-storied carriages then used on the railway. In themselves these engines scarcely would be worthy of particular notice, were it not for the remarkable developments in the Mallet locomotives, such as is shown in the photograph of the 2 – 6 – 6 – 0 articulated four-cylinder compound, No. 6001 (Eastern Railway of France). The total weight of the engine is nearly 92 tons, of which 81 tons rest on the coupled wheels. The greatest developments in the Mallet system have taken place in America, and these engines will receive further attention in later pages.

In the adoption of superheating for engines working on full load and travelling long non-stop distances French locomotive engineers were far in advance of their British *confrères*. At the end of the year 1910 there were only about seventy superheated locomotives in the British Isles, and nearly half of them were owned by the Lancashire and Yorkshire Railway; but in France the Paris-Orleans Railway alone had 110 such engines at least a year earlier.

In the present chapter the Continental railway systems will be taken generally, country by country, but first various facts may be tabulated for the purposes of easy comparison, arranging them in the order of their mileages. The figures are but approximate. In the case of some countries the mileage includes non-standard gauge lines, while in other instances the latter are omitted. In the matter of locomotives and rolling stock generally, the available returns in a few instances are not very reliable. The locomotives as a rule include those working on non-standard gauge lines, but do not comprise electric locomotives.

COUNTRY	MILES OPEN	STANDARD GAUGE		LOCOMOTIVES	CARRIAGES	WAGONS
Germany . .	37,586	4	8½	27,040	56,030	561,250
Russia in Europe .	34,465	5	0	15,200	19,000	356,000
France . .	30,028	4	9	14,000	33,000	344,000
Austria-Hungary, etc.	26,523	4	8½	9,670	20,320	235,220
United Kingdom .	23,280	4	8½	22,778	72,000	766,600
Italy . . .	10,640	4	8½	4,500	10,000	75,000
Spain . .	9,020	5	6	2,000	5,000	35,000
Sweden . .	8,470	4	8½	1,764	3,746	43,670
Belgium . .	5,049	4	8½	4,006	9,880	85,900
Switzerland . .	3,131	4	8½	1,526	3,950	16,800
Holland . .	2,252	4	11	1,157	3,490	18,850
Denmark . .	2,115	4	8½	693	1,671	10,250
Turkey, Bulgaria, etc.	2,018	4	8½	270	700	6,000
Roumania . .	2,207	4	8½	690	1,600	12,270
Portugal . .	1,758	5	5¾	420	1,164	7,630
Norway . .	1,912	4	8½	300	800	8,000
Greece . .	845	3	3½	140	445	1,510
Servia . .	421	4	8½	95	220	2,880

It will be well at this stage to complete the list of locomotive wheel arrangements left over from page 52, for now we shall find engines wheeled in fashions utterly unlike anything to be seen upon British metals, except in the case of the few "Fairlies" in use on several narrow-gauge lines. The wheeling of a locomotive is not merely to meet the fancy of any individual designer, but is governed entirely by the work which the machine is called upon to accomplish. What to British eyes may appear to be an abnormal wheel arrangement is the plan calculated to obtain the maximum of adhesion in hauling loads up severe gradients, or to afford the highest degree of flexibility in negotiating sharp curves; and not infrequently an engine has to be wheeled with a view to meeting both of those requirements.

Locomotive Wheel Arrangements

The following seven types are used almost solely for tank engines, and are seldom employed in British practice, a notable exception being the 0 – 8 – 4, which is employed in the shunting engines at Wath concentration yard (Great Central Railway), and illustrated on page 395.

0 – 4 – 4	..	OOoo
0 – 6 – 2	..	OOOo
0 – 6 – 4	..	OOOoo
2 – 6 – 4	..	oOOOoo
0 – 8 – 4	..	OOOOoo
4 – 4 – 4	..	ooOOoo
2 – 8 – 4	..	oOOOOoo

Many of the American engines are of the following types. Strictly speaking, a "decapod" is a twelve-wheeler, but in our Great Eastern Railway monster locomotive shown on page 58 the leading pony was lacking.

2 – 6 – 4	..	oOOOoo
2 – 8 – 2	..	oOOOOo
4 – 8 – 0	..	ooOOOO
4 – 6 – 4	..	ooOOOoo
2 – 10 – 0	..	oOOOOO
2 – 10 – 2	..	oOOOOOo

In locomotives of articulated design there are generally two sets of coupled wheels, and therefore in the numerical nomenclature the middle figures are duplicated thus:—

0 – 4 – 4 – 0	..	OO OO
0 – 6 – 6 – 0	..	OOO OOO
2 – 6 – 6 – 0	..	oOOO OOO
2 – 6 – 6 – 2	..	oOOO OOOo
0 – 8 – 8 – 0	..	OOOO OOOO
2 – 8 – 8 – 2	..	oOOOO OOOOo
4 – 4 – 6 – 2	..	ooOO OOOo

FRENCH RAILWAYS

French engineers at a very early period were interested in steam locomotion, and Cugnot produced a practical steam road carriage thirty-three years before Murdock completed his little model at Redruth. Nevertheless, it was in England that the locomotive made such rapid strides, and where the first public railway surprised the civilised world. France did not suffer from a railway mania, and time was taken to consider the best means of utilising a peaceful revolution in the ways and habits of mankind. Eventually the French railways came under the closest supervision of the Government, which in some cases furnished money to facilitate construction. The chief systems were built up under concessions and guarantees from the State, which at the end of ninety-nine years was to become the sole owner in consideration of annual payments made towards that end ; but if a company desire it, the Government is bound to purchase its system, even before the expiration of the concession.

The chief railway systems of France are the Northern (Nord), the Eastern (Est), Paris-Orleans, Paris, Lyons and Mediterranean, the Midi (Southern), and the State Railways. The Nord and Est cover areas closely corresponding to their names ; the latter lost about 500 miles of line, ceded to Germany at the end of the war of 1870–2. The French Government pays the company annual compensation until the year 1934, when the concession expires. The Orleans line mainly follows the valley of the Loire from Orleans to the sea ; but with a line extending from Tours to Nantes, entering right into the territory of the Western Railway Company (Ouest), which has recently been absorbed by the State, although the concession would not have ceased automatically until 1935. The Paris-Lyons-Mediterranean system has its main line principally along the valley of the Rhone. The Midi serves a large corner in the extreme south-west and south. The original State lines were such as did not offer much attraction to private companies, lying chiefly between the Orleans and the Western systems.

In the year 1909 the French railways carried 480,000,000 passengers and goods 158,166,000 metric tons ; the gross receipts totalled £69,181,000, of which just about one-third was derived from the passenger traffic. In comparing these figures with corresponding British returns it must be remembered that France possesses few very large towns; and it is the large towns and congested industrial areas that bring traffic to railways. Of the French railway employés (300,000) about 10 per cent are women, of whom 15,000 are employed as gate-keepers at level crossings, at wages often as low as 12s. per month, where the traffic is light and makes little inroads on a woman's domestic duties.

A feature in French railway work that is absent in Great Britain is the international traffic with Belgium, Germany, Switzerland, Spain, and Italy, giving the French railways access to practically the whole of the lines in Europe. Internally France is well supplied with railways, and future extensions will be concerned chiefly in shortening the communications with the countries on her borders, especially Switzerland, in order to reap advantages from the opening of the latest Alpine tunnels; and it is far from improbable that the French will yet bore through the Alps, near Mont Blanc, for another route to Italy, as an alternative route to the Mont Cenis tunnel. The long-discussed Channel tunnel would put London and Paris within five hours of each other, rendering it possible to leave London after an early breakfast, spend five hours in Paris, and be back in London before midnight. There have been various proposals for ferrying trains across the Strait of Dover, which would save passengers two changes, and in the case of goods traffic there would be a saving of time and expense in obviating the twofold breakage of bulk.

PARIS TO BRINDISI EXPRESS AT MODANE HEADED BY AN ITALIAN ENGINE
(Paris, Lyons and Mediterranean Railway)

The permanent-way in France varies: on some systems the rails are flat and rest directly on the transverse sleepers except for the employment of a flat metal plate to spread out the weight; on other systems chairs are used, but with steel keys, as wooden ones would work loose in the hot weather. On the P.L.M. the rails are flat-footed and weigh 97 lbs. per yard; and in recent years rails nearly 79-ft. long have been employed on some sections. On the Orleans line bull-headed rails, 86 lbs. per yard, are laid in chairs, as on British lines. On Continental lines generally there is no outlay beyond what is absolutely necessary for the safe running of the trains; and therefore they present rather an unfinished and untidy appearance compared to British railways.

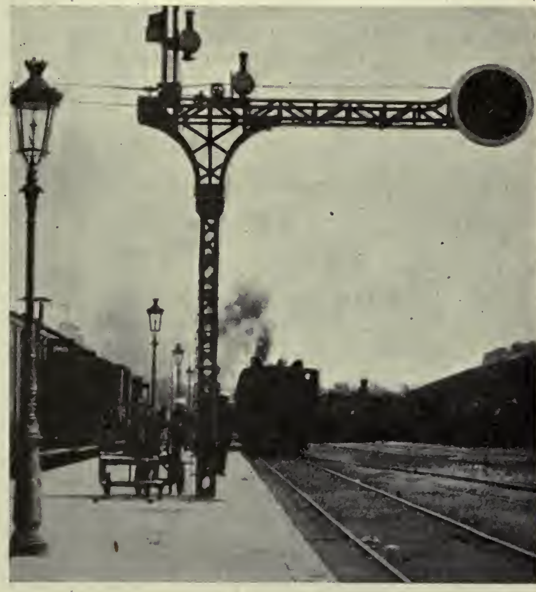
SIGNAL AT MENTONE STATION

The methods of signalling on French lines are largely reminiscent of our old disc signals (see illustration, page 155). A common signal for bringing trains to a dead stop is the chessboard device, consisting of a square divided into four equal parts, two red and two white, which, when turned outwards towards an advancing train, indicates "danger." Two red lights arranged diagonally form the danger signal at night, while a white light gives "line clear." The chess-board is painted green and white for "distant" signals, but often it is used merely to notify the driver that a red and white chess-board presently will demand his attention.

The red disc signal, which is a round plate painted red, edged with white, moves in the same manner as the chessboard. At night a red light shows "danger" and a white light signifies "clear."

The block system is in use on all the chief lines, each section protected by a single semaphore signal, preceded by a red disc. The semaphore in a horizontal position by day, or showing a red and green light by night, indicates "danger"; the semaphore hanging down vertically, or showing a white light, denotes "line clear." At junctions fish-tailed semaphores on a single post are employed, their number corresponding to the number of roads. The top semaphore refers to the outermost line on the left hand, and the lower signals accordingly. To signal a train on, the semaphore belonging to the open road points obliquely downwards, the others remaining in a horizontal position.

Among the original concessionnaires interested in French railways were more than a few well-known names in British railway circles. The first locomotives displayed all the faults of our own, and some of the earliest engines running upon French lines were constructed in British workshops. The Orleans Company has preserved an engine constructed for its service by Stephenson in 1846; and other British-built engines were in service on some lines until well past the beginning of the twentieth century.



A DISC SIGNAL
(Paris, Lyons, and Mediterranean Railway)

The Paris, Lyons, and Mediterranean Railway is the largest system in France. It includes various great international highways together with numerous branches and cross-country services that make up a grand total of more than 6000 miles of line, serving an area of 62,000 sq. miles, or about one-fourth of the whole of France. The capital of the Company is over £200,000,000, and the employés number 75,000. The rolling-stock comprises 3200 locomotives, 7000 carriages, and nearly 100,000 wagons. During the course of a year 1,250,000 trains are run, transporting 80,000,000 passengers and 30,000,000 tons of goods, minerals, etc., from which the annual receipts are about £20,000,000.

At the end of the year 1901 it was announced that the Company, after many carefully conducted experiments, did not propose to build any further four-cylinder compound locomotives, and many new simples were put into service in due course. The great increase in the traffic to the Riviera, necessitating the haulage of 400-ton trains over the severe gradients of the main line from Paris to

Marseilles and Vintimille, called for additional locomotive power. In 1909 the engineer-in-chief designed and put into service two new engines of the "Pacific" type, which in dimensions and power exceeded any locomotives hitherto built for that route. Their weight caused the French Minister of the Interior to limit their service to the section between Laroche and Dijon, pending the strengthening of bridges on other sections.

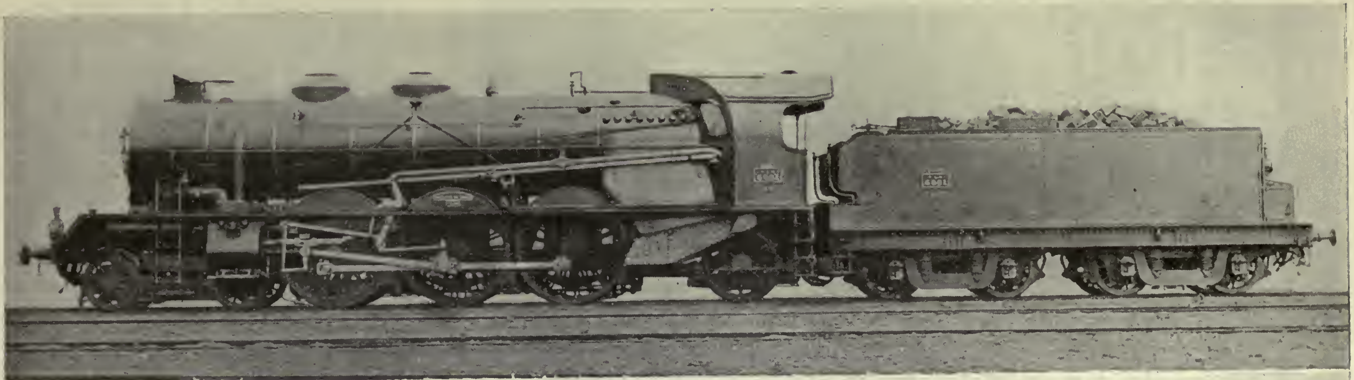
Apart from their huge bulk and power, these engines are interesting as affording a further trial of two different systems. One, No. 6,001, is a 4-cylinder compound, while the other, No. 6,101 is a superheated 4-cylinder simple. Generally the dimensions of wheels and boilers are practically identical, but differed in details as shown below :—

TYPE	NO. 6·001 COMPOUND	NO. 6·101 SIMPLE
Cylinders (high-pressure)	15¾-in. by 25⅝-in.	18¾-in. by 25⅝-in.
,, (low-pressure)	24½ by 25⅝-in.	—
Coupled wheels . .	6-ft. 6¾-in.	6-ft. 6¾-in.
Wheel-base (total) .	36-ft. 10-in.	36-ft. 10-in.
Boiler pressure . .	227 lbs.	171 lbs.
Heating surface—firebox	169 sq. ft.	169 sq. ft.
,, tubes	2875 sq. ft.	2177 sq. ft.
,, superheater		694 sq. ft.
,, total	3044 sq. ft.	3040 sq. ft.

We illustrate No. 6·001, which weighs approximately 93¼ tons, of which 54¼ tons rest on the coupled wheels. The tenders of both engines carry 5 tons of coal and 5070 gallons of water.

The Paris, Lyons, and Mediterranean Railway provides the quickest services from Paris to Switzerland, the Riviera, and Italy ; and is a favourite route to Spain, Tunisia, Corsica, Egypt, India, and the Far East. A large number of *trains de luxe* are operated, among which are the following : Calais–Mediterranean ; Riviera Express (Berlin, Frankfort, Lyons, and Nice) ; St. Petersburg–Vienna–Nice Express ; Nord–Sud–Brenner Express (Berlin, Munich, Innsbruck, Nice) ; Rome Express ; Bombay Express (Calais–Marseilles for passengers to India) ; Peninsular Express (Calais–Brindisi) ; Carthagena–Barcelona Express (Paris, Lyons, Carthagena) ; Savoy Express (Aix-les-Bains, Geneva, Evian-les-Bains) ; and Vichy Express. To these must be added the famous "Cote d'Azur Rapide," the fastest of all the long-distance Continental trains (13 hours from Paris to the Riviera).

As on most of the lines in France, the very best trains cater only for first-class passengers ; but the speeds are inferior to those on the Paris–Orleans and the Northern Railway. The fastest run is up from Dijon to Laroche, 99¼ miles, at 55·7 miles per hour. The fastest first-class train from Paris to Marseilles occupies 12 hours



1. 4-CYLINDER COMPOUND LOCOMOTIVE, NO. 6001 (Paris, Lyons and Mediterranean Railway)

2. "BALTIC" TYPE (4-6-4) PASSENGER LOCOMOTIVE. ONE OF THE HEAVIEST ENGINES IN EUROPE (Northern Railway of France)

14 minutes for the 536 miles, while the trains for all classes take 13 hours 49 minutes.

Perhaps no other line in the world leads to so many varied and charming spots, of which two are world-famed. There is Mt. Blanc (13 hours from Paris by the Chamounix Express), with its eternal snows during the summer season. The Riviera has the enchantment of the sun in winter ; there is Cannes, the "drawing-room of the world" ; Nice, "a section of Paris by the sea" ; Monte Carlo, "the palace of fortune"—and over all the azure of the sky shows no difference from the colour of the sea, eternally blue.

The Paris–Orleans Railway territory lies principally between the Loire, on the north, and the Pyrenean peaks, on the south ; the chief feature of the system is the three straight lines running southwards from Paris to Toulouse and Bordeaux, and westwards to Nantes. Upon its 4355 miles of line the Company carries nearly 50,000,000 passengers per annum ; the locomotives number 1850, carriages 4200, wagons 42,000.

Upon this railway, in 1907, appeared the first 4 – 6 – 2 express locomotive built for service on a European main line. At that time it was the largest and heaviest (89 tons) passenger engine in Europe ; but there were at least fifty "Pacifics" building for French and German lines, and in England the Great Western Railway's "Great Bear" (97¼ tons) appeared to eclipse the French engine in size and weight. Perhaps no other company has developed the "compound" system at so fast a rate as the Orleans management, the "simple" engine meantime remaining almost a stationary type. In the year 1908 alone no less than 120 locomotives were under construction ; 30 of them were "Pacifics," built at the Schenectady works of the American Locomotive Company, while the remainder were 4 – 6 – 0's and "Consolidations," the last-named for goods trains on the difficult gradients of the Central Plateau.

The carriage stock on the Orleans line includes some very fine trains for the day *rapides* between Paris and Bordeaux. The first-class bogie carriages exceed 75-ft. in length between the buffers, and are the longest coaches on any of the railway lines of Europe. Special features are the ladies' drawing-room car and the smoking-saloon, and each carriage has a spacious toilet and dressing-room. A librarian, who accompanies the train, sells books and papers to travellers *en route*.

The Orleans line surpasses the P.L.M. in speed, having three runs at 58 miles per hour. The most notable train on the system is the Sud Express (Paris to Madrid), which concerns the Company for the 363¼ miles between Paris and Bordeaux. The timing is 6 hours 43 minutes, which gives an average speed of 56·6 miles per hour ; and it is fairly claimed to be the fastest train running a distance of over 360 miles. This is a *luxe* train, which beats the best train carrying third-class passengers by 1 hour 38 minutes.

The Northern Railway of France, although its mileage (2500 miles) is comparatively small, is one of the busiest lines in the country. Its income is bigger proportionately to mileage than the P.L.M., due in a great measure to the huge coal traffic on the northern line. The Nord locomotive stud numbers about 1900, carriages 4700, wagons about 70,000. Since the year 1900 the Company has developed regular booked speeds that rank among

PARIS–CALAIS EXPRESS
(Nord Railway of France)

the fastest in the world; and therefore the locomotives call for particular notice.

In the early part of 1910 the Company put into service a new type of four-cylinder compound express that presented several uncommon features. The wheel arrangement was unusual, the large, wide firebox requiring a four-wheeled bogie under the foot-plate for its efficient support. Apart from its dimensions the firebox was quite exceptional, for it contained a number of water tubes, and was extended into a combustion chamber, which combination gave 1000 sq. ft. of heating surface, irrespective of the Serve tubes in the barrel of the boiler. The boiler had a diameter of 5-ft. 1½-in., and was pressed to 256 lbs. per sq. in. The total heating surface amounted to 3417 sq. ft.; grate area, 38·1 sq. ft.

The engine in working order weighed nearly 76 tons; the tender, with coal and 4230 gallons of water, nearly 42 tons.

Since the appearance of these fine engines, the Company has produced locomotives bigger and more powerful than ever before seen upon the line, ranking among the largest passenger locomotives in Europe, quite dwarfing such a giant as our own "Great Bear," and only equalled by a few monster engines on the Belgian State Railways. The particular engines referred to, Nos. 3·1101 and 3·1102, are 4–6–4's, known as the "Baltic" type. A description of No. 3·1102 will serve generally for both monsters. The cylinders are arranged on the de Glehn system; high pressure, 17⅝-in. by 25⅛-in.; low pressure, 24⅜-in. by 28¾-in.; the piston valves are actuated by Walschaert's gear. The coupled driving wheels have a diameter of 6-ft. 8¼-in.; leading and trailing wheels, and tender bogie wheels, 3-ft. 5-in. diameter. The total wheel-base of engine and tender is 69-ft. 7¼-in. The boiler barrel contains 155 flue tubes, which are 16-ft. 4⅞-in. long; 38 are 2¼-in. diameter, 90 of 2¾-in. diameter; and 27 of 5¼-in. diameter, containing the smaller steam tubes of a Schmidt superheater. The total heating surface is 4565 sq. ft.; grate area, 46·07 sq. ft.; working pressure, 227 lbs. per sq. in. The weight of the engine in working order exceeds 100 tons; the tender carries 7 tons of coal and 5730 gallons of water; total weight of engine and tender, 156 tons. This locomotive was built by Messrs. Schnieder & Co., but the sister engine was constructed at the Nord Railway works at La Chapelle, Paris. The latter's Belpaire firebox is without water tubes, and the total heating surface is 666 sq. ft. less. These massive, powerful machines are capable of a speed of 75 miles per hour on the level with loads of 300 tons, and can attain 60 miles per hour on gradients of 1 in 200.

The coaching stock of the Nord Railway is fairly typical of French carriage accommodation generally. The *de luxe* trains, composed of the International Sleeping Car Company's vehicles, carry only first-class passengers at high extra fares; the *rapides* are first and second class only, and consist of fine side corridor vehicles; but the ordinary vehicles are far behind the corresponding carriages on British lines, being quite innocent of upholstery for the third-class passengers.

In the United Kingdom there are only three regular bookings at 60 miles per hour, namely, North Eastern, Darlington to York; Caledonian, Forfar to Perth; and Great Central, Woodford to Leicester; but the Nord can boast of eight such runs over distances of from 80 to 100 miles; and out of about 40 French non-stop runs of 100 miles and over the Nord claims nearly a half. There is little satisfaction in comparisons between country and country, or even between line and line, unless there is a common basis for comparison. A train running a short distance on a level track cannot be compared fairly with another train traversing a much longer and a harder graded road. In the matter of long non-stop runs Great Britain, with more than 150 examples, is easily ahead of France, and the whole average of speed is higher than France can show for anything like the number of trains. In France there are really four types of passenger trains, viz. *de luxe* (first-class only), *rapide* (first and second class), *express*, equivalent, but only in theory, to the British "fast" trains; and *omnibus*, or slow trains. In our country the third-class passenger generally enjoys the same privileges as the higher-fare passengers in the matter of speed; there are infinitely more "fast" trains; and even if their speed fall short of the French *luxe* trains, the services are, nevertheless, excellent, and are shared in by the multitude.

PASSENGER TRAIN DRAWN BY TWO REBUILT "CRAMPTONS"
(Eastern Railway of France)

Returning to the Nord's fastest trains, more as a testimony to the engines than for any other purpose, three runs out of Paris deserve special notice. From Paris to Longueau, 78¼ miles; to St. Quentin, 95¾ miles; and to Busigny, 112½ miles, all accomplished at over 60 miles an hour, are exceptionally fine performances. The train loads are seldom less than 250 tons, often more, which have to be hauled in each case over an 8-mile rise of 1 in 200, while on the Longueau run there is also a 25-mile ascent with grades varying from 1 in 200 to 250.

On June 18th, 1911, the Nord ran a special train of a decidedly unusual character from Paris to Liége. Its purpose was to enable passengers to witness some portions of a great aeroplane race from Paris to Liége, Brussels, London, and back to Paris. The train-load, approximately, was 200 tons, and was drawn by an engine of the "Atlantic" type. To enable passengers to be in time at Liége for the arrival of at least some of the aviators, it was necessary to schedule the train at a high velocity. To St. Quentin (95 miles) the speed was over 61 miles per hour; and from St. Quentin to Jeumont on the Belgian frontier the average was 58 miles per hour. This was the first express train ever run on the Continent for the purpose of following an aeroplane race.

The remaining railways of France must be dismissed briefly. The Eastern Railway has 3630 miles of line, upon which work 1650 locomotives, 3900 carriages, and 48,000 wagons. The line from Paris to Igney Avricourt (254¼ miles) is the route of the Orient Express, which is run over this section of its long journey at about 50 miles an hour, but from Paris to Châlons (107½ miles) the speed is 55 miles an hour, the fastest on the system except for one or two 50-mile runs at 56 miles per hour. The Southern Railway has 3946 miles of line; 990 locomotives; 2546 carriages; 29,000 wagons. At one time the Company ran a *luxe* train from Bordeaux to Dax (92 miles) at 62 miles per hour; but after an accident to the Sud Express, which the Company operates between Bordeaux and the Spanish frontier, its fastest train was decelerated to 51 miles per hour.

The French State Railways, having recently absorbed the Ouest, have a total length of 4968 miles; locomotives, 2300; carriages, 6500; wagons, 46,100. The various lines composed in the system were built by the State because the various routes offered poor prospects to ordinary investors; and therefore it lacks any lengths of line of great importance, save perhaps Paris to Rouen (86¾ miles), which came into the State net with the Ouest Railway. All trains cater for first, second, and third-class passengers; and the run from Chartres to Thouars (148 miles) at 52½ miles per hour is distinctly above the average for French trains of a similar type.

French railways exhibit nearly all the best points of continental practice; and therefore succeeding countries may be treated at lesser length.

BELGIAN RAILWAYS

The Belgians were the first Continental nation to establish a railway, which was completed in the early part of 1835. During the next five years various lines were constructed and operated entirely by the State; but when the bitter competition of the waterways caused the railways to show adverse financial results, the Legislative Chambers refused permission for the Government to incur further liabilities. This led to the system of granting concessions to private companies to construct lines to be operated by the State, while in some cases the companies worked their own lines. By combination some of the private companies were able to work to the disadvantage of the older State lines, which led the Government from 1870 to refuse further concessions to private companies, the State adopting a policy of acquiring the privately owned lines, until at the present time only about 250 miles of line are under private management. The train mileage on the State lines exceeds 55,000,000 miles, about two-thirds of it being concerned with goods traffic, indicative of the intensely industrial character of the country. The passengers number about 160,000,000 including season-ticket holders; and on Sundays about half the nation appears to be travelling.

The Belgian State Railways possess about 4000 locomotives, 9900 carriages, and 82,000 wagons. One of the earliest locomotives

OSTEND-BRUSSELS ORDINARY TRAIN
(Belgian State Railways)

in Belgium, No. 2 on the books of the Railway Administration, was the goods engine "L'Elephant," built by Messrs. Stephenson and Co., England, and put into service May 1st, 1835. The State's first engine of Belgian build was No. 6 "Le Belge," constructed by John Cockerill, Seraing, the Stephensons having supplied the five previous locomotives.

For hauling express trains on the main lines the present-day locomotives are chiefly of two types, viz. 4 – 6 – 0's and 4 – 6 – 2's. For an example of the latter we cannot do better than consider No. 4501, one of the type "10" which appeared in 1910, designed by M. Flamme, the chief of the mechanical department of the State Railways, to work express services on the line from Brussels to Verviers and Herbesthal. The leading dimensions are: cylinders (4), each 19⅝-in. by 26-in., with piston valves actuated by Walschaert's motion; coupled driving wheels, 6-ft. 6-in. diameter; boiler diameter, 5-ft. 11⅞-in.; working pressure, 199 lbs. per sq. in., with four safety valves arranged in pairs. Heating surface:

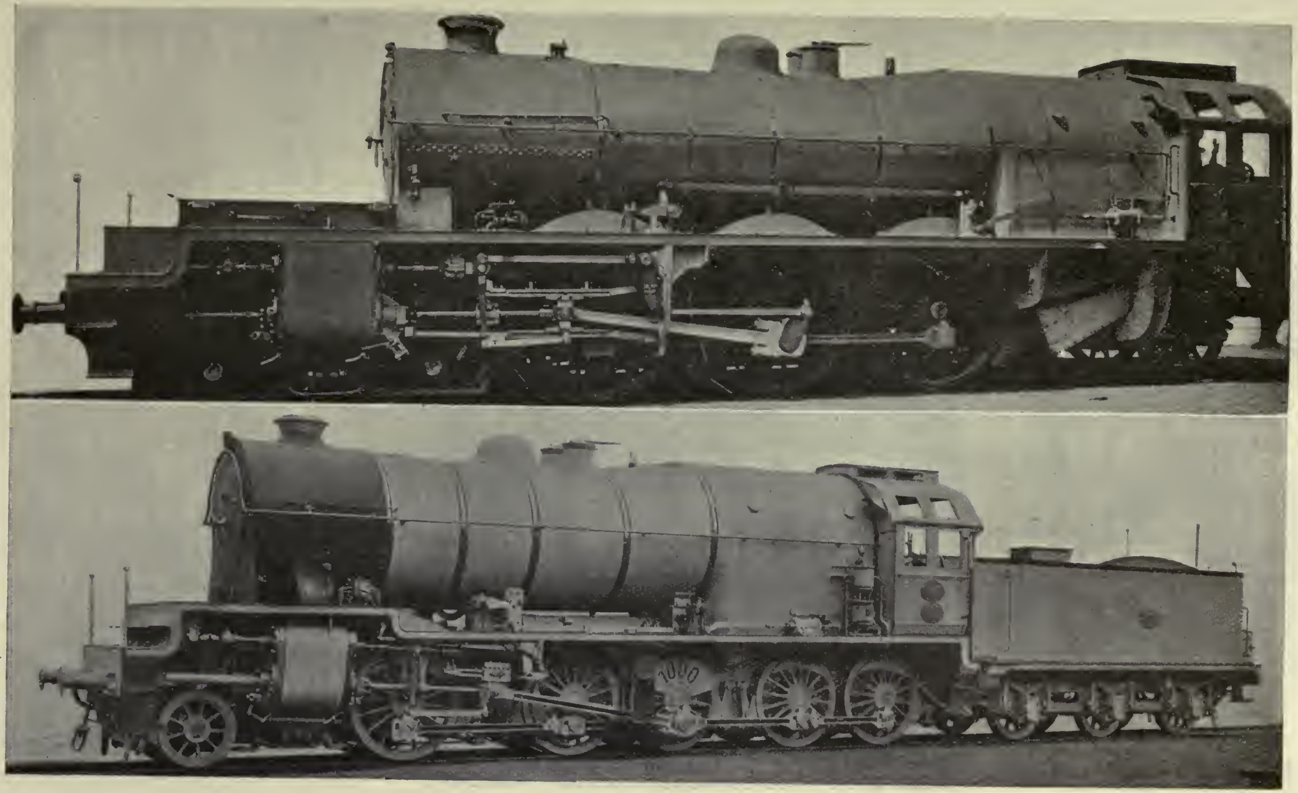
firebox, 201·3 sq. ft.; tubes, 2368·12 sq. ft.; total, 2569·42 sq. ft.; grate area, 53·82 sq. ft.; superheater surface, 692·14 sq. ft.; weight of engine alone, in working order, about 100¼ tons, of which 56¼ tons rest on the coupled wheels. The capacity of the tender is 7 tons of coal and 5280 gallons of water.

Type "36" is exemplified by tender engine No. 4405, with a 2–10–0 wheel arrangement. These engines are built for the heavy goods traffic on the hilly route between the industrial districts of Luxemburg and Alsace. The cylinders are of the same dimensions as in the foregoing engine; coupled wheels, 4-ft. 9-in. diameter. Total wheel-base, 33-ft. 2-in. The boiler is fitted with a superheater and has a total heating surface of 2563·65 sq. ft. Weight of engine in working order, 98 tons 8 cwt. 3 qrs. Its tractive power is about 45,635 lbs. compared to 33,550 lbs. of the "10" class.

An interesting point in Belgian locomotive practice was the adoption of engines of the Caledonian Railway of the "Dunalastair" class, designed by Mr. J. F. M'Intosh. Five of these locomotives were built for the Belgian State by Messrs. Neilson and Co., of Glasgow. The Scottish engines have had a marked effect on the Belgian 4–4–0's, which, even when greatly modified "Dunalastairs," look far more symmetrical than the purely home-designed product. A "Dunalastair" is shown at the head of the Brussels train just leaving Antwerp station. Belgian locomotives are painted black, with red linings, but not infrequently they are much dirtier than British engines, and the linings are indistinguishable.

The signals on the lines using the block system much resemble those of England, except that some of them denote "line clear" by an upper position of 45 degrees. Signal lamps often are raised or lowered by means of a wire rope, instead of by the use of ladders. The block system is in operation on about 50 per cent of the lines; and on the others the French chessboard signals and discs are employed to work the time interval, or one engine in section system.

The Belgian coaching vehicles comprise many types, not a few of the older ones running on four or, at most, six wheels; but even if some of the carriage stock lacks modern comforts, the fares are on an exceedingly low scale, Belgian second-class being about equivalent to British third-class. A five-days' season ticket enables a person to travel over the whole of the State lines (2890 miles) for five days at a cost of 9s. 5d. On many of the purely Belgian express trains voiture-saloons, or Pullman cars, are run; in some cases the cars provide restaurant services, and these are termed voiture-saloon-restaurants. For the important traffic between Brussels and Antwerp several special set-trains (all classes) are in service. The vehicles are long and spacious and mounted



1. 4-6-2 PASSENGER LOCOMOTIVE, NO. 4501. 2. 2-10-0 FOUR CYLINDER (SIMPLE) LOCOMOTIVE, NO. 4405
(Belgian State Railways)

on bogies; and the internal equipment comprises all modern improvements. For the trains operating international traffic the coaches are often of foreign origin, being provided by the country which is concerned with the greater proportion of the mileage. The Luxemburg line has many severe grades, and between Namur and Arlon goods trains of 500 or 600 tons are commonly hauled by two engines and banked by a third.

There are no striking railway speeds in Belgium. The heavy goods and mineral traffic leads to congestion of the lines, for, except between Brussels and Antwerp, the same metals serve for both goods

BRUSSELS TRAIN IN ANTWERP STATION, WITH "DUNALASTAIR" TYPE LOCOMOTIVE ATTACHED

(Belgian State Railways)

and passenger trains. Again, practically all the principal towns are within a 50-mile radius of the capital, negativing long non-stops, even if the numerous junctions did not militate against anything like high speed. On the international route from Brussels to Luxemburg for Switzerland three summits have to be crossed with many grades of 1 in 96 and 1 in 63; on the route to Germany, between Liége and Herbesthal, there is a 25-mile continuous climb, chiefly of 1 in 215, but often of 1 in 100. On these two routes runs the bulk of the international traffic. Another particularly hard grade is 1 in 53 for 3½ miles from Liége to Ans on the 61·9 miles run to Brussels. Thus we find that, out of about six-score non-stop runs, the longest is between Ostend and Brussels (76·3 miles);

and the fastest train is between Ans and Schaerbeek, Brussels (56·7 miles), accomplished in 71 minutes, or at the rate of 48 m.p.h.

The Belgian international services are of great importance. The Ostend-Vienna-Constantinople *train-de-luxe* generally has 320 tons behind the tender; and not infrequently is hauled by a couple of modified "Dunalastairs" from Ostend to Brussels. Among other important services are the Nord Express between Ostend, Brussels, Berlin, and St. Petersburg, and thence onwards by the Trans-Siberian Express to Japan in fourteen days; Ostend—Brussels—Alsace-Lorraine—Switzerland—Italy; Ostend—Trieste, and then via steamer to Alexandria.

The chief Belgian railway stations, like those generally of many continental countries, have remarkably fine exteriors. Antwerp Central is one of the finest stations in Europe, although it only deals with 260 trains daily; Brussels (Luxemburg) deals with 420, Namur with 560, and Liége with 847 trains daily. Upon the other hand, some of the stations are mere halts, where an old coach does duty for station buildings. The platforms are usually very low, rendering entrance to the trains a matter of considerable exertion.

GERMAN RAILWAYS

At the end of 1910 Germany possessed the longest railway mileage of any country in Europe, namely, 37,586 miles, excluding any lines of narrower gauge than the normal 4-ft. 8½-in. Of the whole of the railways only about 2700 miles are worked by private companies. The States owning more than 1000 miles of line are Prussia (20,270 miles), Bavaria (4170 miles), Saxony (1638 miles), Baden (1113 miles), and Würtemberg (1079 miles); there are also 1100 miles of railway in Alsace-Lorraine. Consequently there are about 4000 miles of line to be divided among about a score of different State administrations, of which the smallest is Lübeck, with 8 miles of State and 30 miles privately owned. The passengers carried in a year number about 1365 millions, and goods about 461 million metric tons.

The Prussian State Railways, which may be taken as exemplifying most of the best features of railway working in Germany, own 20,280 locomotives, 37,000 carriages, and 433,000 wagons. At the outset it may be stated that throughout the country there is no really fast running. Even the express trains across the northern plains rarely exceed 45 miles per hour, and, including stoppages, the average is considerably less. This is due not only to the numerous connections between important towns, but in the early days of railways towns of relatively little importance got clauses inserted in the Acts, making it compulsory for all trains to stop at their respective stations.

Block signalling is in force everywhere, and the signalling equipment receives very careful attention. The signals themselves are constructed of open ironwork, painted white on the near side, and are raised from a horizontal position to an angle of 45 degrees to indicate line clear.

A few years ago several railway accidents in Germany were proved to be the result of drivers failing to see signals, which led to the adoption upon some of the Prussian State lines of a new visual electric signalling apparatus working on the engine itself. While a train is yet about 100 yards from a signal, a bell is set ringing in the cab, and a white slide is exposed before the driver's eyes; and with this stimulation of his attention he is without any excuse

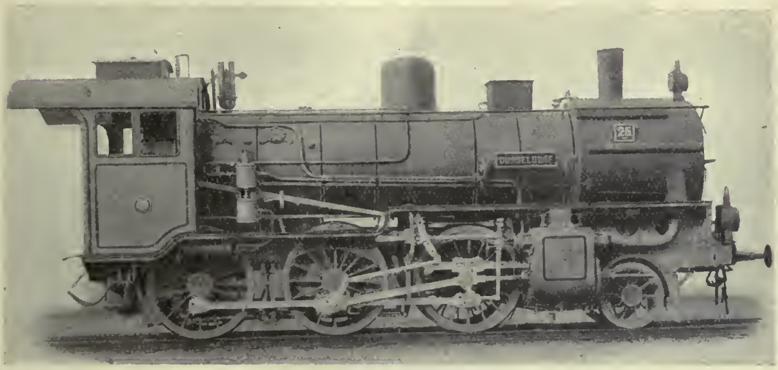
BERLIN SUBURBAN TRAIN
(Prussian State Railways)

for running past a signal. The apparatus is simple in construction and in working. The locomotive carries a broom of pliable copper wires, which sweeps between two parallel iron bars mounted by the side of the track at a fixed distance from the signal post. The electrical contact thus set up acts upon the mechanism in the cab, with the result stated above. The bell and the white slide remain in action until the driver presses a button, so that ignorance of the signal cannot be pleaded.

In a country so extensive and with physical features so varied, it follows that German railway engineers have had to overcome many natural obstacles. To carry a double track railway across the River Wupper, near Mungsten, necessitated the construction of the loftiest trussed bridge in the world, with a clear span of 525-ft., and at a height of 350-ft. above the stream.

Compound locomotives are the rule in Germany. They are ungainly in appearance, but of large size, for the loading gauge is less restricted than in Great Britain. The latest express locomotives are of the 4 – 4 – 2 type, but the older engines, which are used for working second-class fast trains, are 4 – 4 – 0's, and considerably smaller. Much of the local and suburban passenger traffic is worked by powerful 0 – 6 – 2 tanks, but 2 – 4 – 0 tanks of antiquated design are still largely in evidence.

A rather popular type of passenger locomotive on the Prussian State Railways is the 2 – 6 – 0, such as is illustrated herewith. Its leading dimensions are: cylinders, 21¼-in. by 24¾-in.; driving wheels, 5-ft. 3-in.; steam pressure, 170 lbs. per sq. in.; rigid wheel-base, 6-ft. 6¾-in.; total wheel-base, 21-ft. 2-in.; grate area, 24 sq. ft.; heating surface: boiler 1570 sq. ft., superheater



2 – 6 – 0 PASSENGER LOCOMOTIVE WITH SUPERHEATER
(Prussian State Railways)

surface 340 sq. ft.; adhesive weight, 44¼ tons; weight in working order, 57 tons; tractive power, 16,500 lbs. Tender: tank capacity, 3500 gallons; coal capacity, 5 tons; weight in working order, 42¼ tons.

For a second example of a Prussian State express locomotive we may note No. 947, "Hannover," which was exhibited at the Brussels Exposition, 1910. It is a four-cylinder compound of the "Atlantic" type. The boiler is of large dimensions, with a wide firebox at the rear of the coupled wheels; the barrel has a mean diameter of 5-ft. 3-in., and contains 272 tubes 17-ft. 0¾-in. long and 2-in. in diameter. The heating surface is as follows: firebox, 150 sq. ft.; tubes, 2550 sq. ft.; total, 2700 sq. ft.; and the grate area is 43 sq. ft. The cylinders have the following dimensions: high pressure, 13-in. by 23⅝-in.; low pressure, 22¾-in. by 23⅝-in. Diameter of coupled wheels, 6-ft. 6-in.; rigid wheel-base, 7-ft. 6½-in.; and total wheel-base, 35-ft. 3-in. The engine weighs

68·4 tons empty, and 75·4 tons in working order, of which 33 tons rest on the coupled wheels.

The tender is of large capacity, containing 6872 gallons of water and 7·4 tons of coal, being specially designed for the service of 158 miles without an intermediate stop between Hanover and Berlin. It weighs 25·4 tons empty and 64 tons full, the gross moving weight of engine and tender being 139·4 tons. About 100 engines of this type are in service, chiefly on the main line between Cologne, Hanover, and Berlin.

With the locomotive just described we may compare a 4 – 6 – 2 four-cylinder compound on the Bavarian State Railways. Leading dimensions: cylinders, $16\frac{3}{4}$-in. by 24-in. and $25\frac{3}{4}$-in. by $26\frac{3}{8}$-in.; coupled wheels, 6-ft. $1\frac{2}{3}$-in. diameter; heating surfaces: firebox,

4 – 6 – 2 FOUR-CYLINDER COMPOUND LOCOMOTIVE
(Bavarian State Railways)

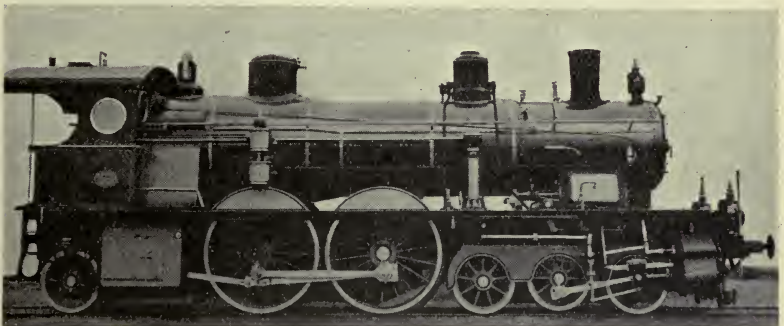
157 sq. ft.; tubes, 2194 sq. ft.; superheater surface, 538 sq. ft.; grate area, 48·4 sq. ft. In view of its large dimensions the engine is relatively light, being less than 85 tons. The tender weighs over 53 tons in working order, carrying $7\frac{1}{2}$ tons of coal and 5720 gallons of water.

A twelve-wheel locomotive under the same administration is well worth attention. The twelve wheels are divided into two groups of six, the forward group being articulated to the main frame of the engine. The rear group is driven by a pair of outside high-pressure cylinders, and the forward group by a pair of outside low-pressure cylinders, the latter thus practically forming a steam bogie.

As in France, the fastest trains (*trains-de-luxe* and through corridor trains) are not open to the lower-class passengers. On the ordinary trains the third-class compartments are not upholstered, but they are spotlessly clean. The fares for express trains work out approximately at $1\frac{3}{5}$d. first class, $1\frac{1}{5}$d. second class, and $\frac{4}{5}$d. third class. Upon many local trains there is a fourth class, standing accommodation only, at about $\frac{1}{4}$d. a mile.

In the matter of non-stop runs Germany does not figure prominently for reasons already stated. On the Prussian State Railways there are only forty runs of 100 miles and over; the fastest is between Berlin and Halle, 101 miles, at 55 miles per hour; the longest is between Berlin and Hanover, 159 miles, at 47·5 miles per hour. The only other State that has a non-stop approaching these in length or speed is the Bavarian State run of 127 miles between Munich and Nuremberg at 46·5 miles per hour.

The comparatively low speeds of even the fastest trains is no fault of the German engines. Until the year 1906 the best running



6–4–2 FOUR-CYLINDER COMPOUND LOCOMOTIVE
(Bavarian State Railways)

in the country was between Berlin and Hamburg ($53\frac{1}{2}$ miles per hour), about which time German locomotive engineers sought to construct engines capable of 62 miles per hour for sustained periods in order to compete with electric-railway traction. Upon the railway between Hanover and Spandau, $151\frac{1}{2}$ miles, the Prussian Minister of Public Works instituted trials between three different types of locomotives, among them a Glehn compound from the Nord Railway of France. With a train of 318 tons the French engine attained a speed of 77·6 miles per hour, and with a train of half the load the speed was 82·5 miles per hour. This high speed was performed under ordinary running conditions, but it was found that the signalling arrangements would call for modification, and more powerful brakes would be required.

AUSTRIAN RAILWAYS

In Austria-Hungary there are 26,523 miles of railway, of which more than half are owned by the two States in almost equal proportions ; about 7150 miles of private companies' lines are worked by the State, and 4500 miles are still worked by companies themselves. The passengers carried in a year number quite 353,000,000, about two-thirds of the traffic being Austrian ; the goods traffic amounts to 222,000,000 tons, again two-thirds of it being Austrian and one-third Hungarian.

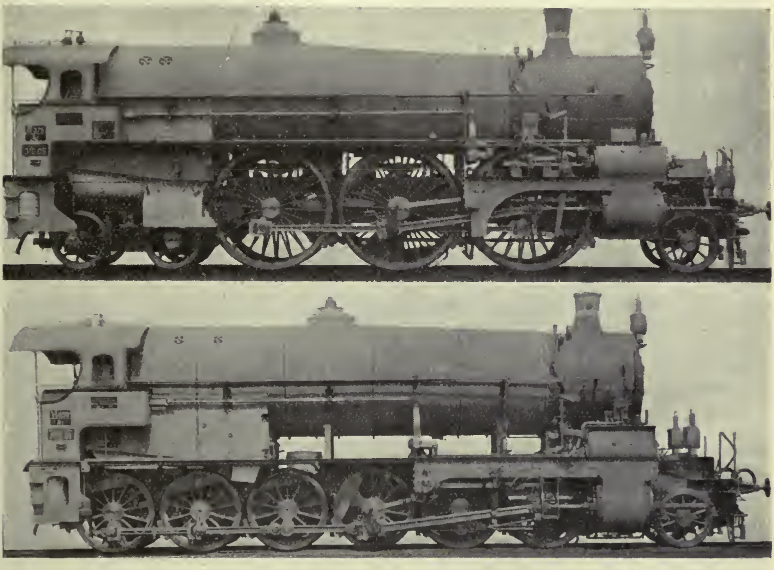
The ordinary everyday working of the railways in Austria-Hungary presents no features differing greatly from German practice. Two notable services that are operated in part over the main line of the country are the Orient Express from Paris to Constantinople and the Ostend-Vienna-Constantinople Express.

On the Imperial Northern Railway there is still in existence an engine built in 1841 by the English firm of Jones, Turner, and Evans, of Viaduct Foundry, Newton, near Warrington. It was a 0 – 4 – 2 with cylinders 14-in. by 20-in. ; coupled wheels, 5-ft. 1½-in. diameter ; working pressure, 95 lbs. ; total heating surface, 660 sq. ft. ; and weight, 21½ tons. To gauge the progress made in locomotive construction one has only to compare this old-time engine with one of Herr Goldsdorf's four-cylinder compounds (2 – 6 – 4), designed in 1908 to work 400-ton express trains on the Vienna-Kraken-Lemberg section, which has gradients of 1 in 100. In a trial run with a load of 406 tons, one of these monsters covered a distance of 963 miles at a speed averaging from 52 to 65¼ miles per hour over different portions of the route.

Later locomotives of the 2 – 6 – 4 type differ principally in respect of being provided with a superheater instead of a steam dryer. Some of the leading dimensions are as follows : cylinders, high-pressure 15⅝-in. by 28⅜-in. and low pressure 26-in. by 28⅜-in. ; coupled wheels, 7-ft. 0¼-in. ; total heating surface, 2758·8 sq. ft. ; working pressure, 220½ lbs. per sq. in. ; total weight of engine, 84 tons 13 cwt., of which more than half rests on the coupled wheels. In service these engines haul express trains regularly at over 62 miles per hour.

In 1911 a remarkable engine appeared on the Austrian State Railways, probably being the first twelve-coupled locomotive ever designed for express-passenger traffic. Intended to haul heavy trains up gradients of 1 in 35 and 1 in 40, with sharp curves, it was necessary to make special provision to enable an engine with so long a wheel-base (34-ft. 1¾-in.) to negotiate the curves. In addition to the radial axle-box of the leading wheels, which has a lateral play of nearly 2-in. on each side of the centre line, the third and sixth axles have side play to the extent of 1-in. either side ;

the trailing axle has side play of over $1\frac{1}{2}$-in.; while the fourth or driving axle has wheels with blind tyres. Although only designed to attain a speed of less than 40 miles per hour, the engine runs smoothly and without oscillation at 57 miles per hour. Leading dimensions: cylinders, high-pressure $17\frac{3}{4}$-in. by $26\frac{3}{4}$-in., low pressure $29\frac{7}{8}$-in. by $26\frac{3}{4}$-in.; coupled wheels, 5-ft. $0\frac{1}{4}$-in. diameter; total heating surface, 3186·18 sq. ft.; working pressure, 235 lbs. per sq. in.; total weight, 94 tons 5 cwt. 2 qr.



1. 2–6–4 FOUR-CYLINDER COMPOUND PASSENGER LOCOMOTIVE
2. 2–12–0 FOUR-CYLINDER COMPOUND PASSENGER LOCOMOTIVE
(Austrian State Railways)

Austria, like many other countries, has experienced the inconveniences attached to various of its railways being of different gauges. Upon some of the narrow-gauge systems "Rollböcke," or rolling trestles, were introduced. By the use of "Rollböcke" it was possible to mount normal-gauge wagons, and run them upon 3-ft. 6-in. gauge lines without breaking bulk; but the method proved both unwieldy and expensive, and consequently numerous narrow-gauge lines were converted to the normal width.

There is nothing more notable in the whole history of European railways than the manner in which the Alps have been pierced in order to quicken transit. Mont Cenis tunnel, $7\frac{1}{2}$ miles long, was the first of a series of stupendous undertakings. It occupied thirteen years in construction at a cost of £220 per yard. It was opened in 1871, and provided unbroken communication for the Anglo-Indian mail from Calais to Brindisi, via Paris, Mont Cenis, and Turin.

The Austrian Government undertook the third great Alpine tunnel in order to gain access to France without the necessity of traversing Italy. The Arlberg Railway, 136 miles long, is the western branch of the Austrian State Railways, and connects Innsbruck, the capital of the Tyrol, with Bregenz, situated on Lake Constance, with a train ferry to the Swiss railways at Romanshorn.

Commencing at Bregenz, the line works straight up the main valleys, often almost clinging to mountain-sides, and crossing lateral valleys by more or less high viaducts and bridges which naturally are a feature of the line; while in the higher regions snow-sheds are provided in the sections exposed to mountain slides. In the first 14 miles to Bludenz the line rises 400-ft., and in the succeeding 23 miles there is an additional rise of 2090-ft., with gradients as steep as 1 in 32.

The Arlberg tunnel is the principal feature of the line; it is 6 miles 587 yards long, 26-ft. wide, and 23-ft. high. It was constructed in 1880–3 at a cost of £1,300,000, or about £100 per yard, cheaper by more than half compared to the Mont Cenis tunnel, which latter was bored before the invention of the rock-drill.

From Langen the tunnel ascends a steep gradient to the highest point on the metals between Paris and Vienna, namely, 4300-ft. above sea-level, but nevertheless 1600-ft. lower than the difficult Arlberg Pass from Blundenz to Landeck and Innsbruck. From the highest point the line descends some 30-ft. to St. Anton at the eastern end of the tunnel, and the highest station on the railway. From St. Anton to Landeck, which is really the end of the Arlberg Railway, the line falls more than 1700-ft. in little more than 20 miles, the steepest gradient being 1 in 38. Shortly before reaching Landeck the rails are carried across the Sanna by means of the Trisanna Viaduct, 280-yards long and 280-ft. high. The Arlberg Railway is a single line for the greater part of its length, but the tunnels are furnished with double tracks.

Naturally upon a line so difficult, powerful locomotives are required. Formerly 2 – 8 – 0's were employed, but it was found that the "Consolidations" required assistance up the stiffest gradients, and therefore locomotives of the 2 – 10 – 0 type came into use, which frequently haul their heavy loads without the services of a banking engine.

The construction of the Arlberg Railway was to facilitate the international traffic between Paris and Vienna, and against it in sharp contrast we may place the single-line railway from Saràjevo in Bosnia to Visegrad, near the frontier of Servia. This railway appears to lead to nowhere, its terminus being 100 miles from the nearest centre of communication, while the meagre traffic does not pay for the coal and oil used by the engines. The line certainly was not laid down with a view to ordinary traffic, but merely to expedite the transport of troops and military stores to the

VIENNA EXPRESS AT BREGENZ
(Austrian State Railways)

western threshold of Servia, which can be accomplished in about 7 hours. The northern boundary of Servia is reached easily by Austrian main lines, and thus, if necessity arose, Austria could sandwich the unhappy country between two great forces, and absorb Servia into the Austria-Hungarian Empire, as were Bosnia and Herzegovina in 1908.

SWISS RAILWAYS

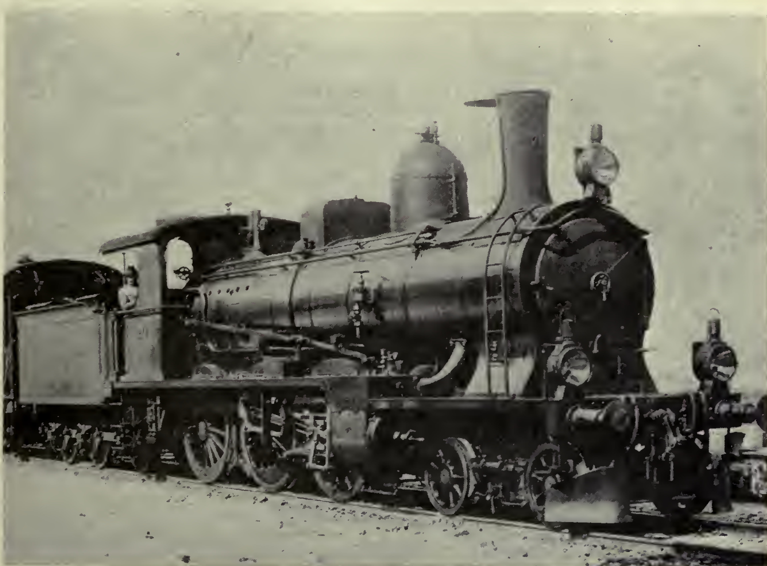
It was about the commencement of the present century that the Swiss Federal Republic decided to nationalise its railways; the reasons advanced being the desire to free the lines from foreign capitalists, to economise in working, to afford improved services, with an all-round reduction in fares. The total length of Swiss lines, exclusive of purely mountain railways, is about 2800 miles, of which the State has acquired already about two-thirds, including all lines over 50 miles in length, with the exception of a narrow-gauge railway of 120 miles. Under State control the services have been improved and the fares reduced; but working expenses have shown a continual upward tendency, and in the year 1908 the railways were worked at a loss. The passengers carried number nearly 100 millions and goods about 18 million tons.

The most important Swiss line, forming Division I, is the Jura-Simplon, which was taken over by the State in 1903. The St. Gothard Railway (Division V) was absorbed in 1909, but as it had been managed with marked success, the Swiss Government retained its officials and work the line as a separate railway. Each of the five divisions has its own separate repair shops and its own locomotives, carriage and wagon stock, which are circulated as much as possible only in the division to which they belong, while the stock of another division is viewed as "foreign," and is returned to its owners in the same manner as is done in England.

The standard permanent-way consists of Vignoles rails about 93 lbs. to the metre (39·37079-in.). They are spiked direct to the sleepers, of which about 80 per cent are iron; but it may be said that very often when sleepers are renewed wooden ones replace them. In signalling matters Swiss railways are not very advanced; the block system, however, is being adopted, and semaphore signals of the German pattern are replacing the older discs.

Until recent years most of the carriage stock was of the central corridor type, with open gangways which rendered privacy impossible and very unsuitable for long distance, and especially night, travelling. Modern side corridor stock is roomy and comfortable, and the first and second class carriages, with sliding seats to make beds, compare well with any Continental, or even British similar vehicles. Externally they are painted green, but owing to traversing numerous tunnels, and the fact that the engines burn "briquettes," the colour is oftener black than the standard green. On all of the chief trains there is a postal car, and letters may be posted without extra charge. Mail-bags are thrown out as stations are passed, for there is no mail-catching apparatus as in Great Britain.

The working of the Swiss railways calls for powerful locomotives to negotiate the severe gradients that are not only frequent, but often of great length. "Mogul" locomotives are a popular type. For heavy passenger and goods trains simple-cylinder engines, weighing 54¾ tons with a speed of 46½ miles per hour, render very good service. Another class very similar in type are built on the three-cylinder compound system. A later series (Nos. 1333–1349), constructed at the Swiss locomotive works at Winterthur, show improvements in various respects. They have two high-pressure cylinders only, and are fitted with a Schmidt superheater and a



SIX-COUPLED COMPOUND BOGIE LOCOMOTIVE—GOTHARD RAILWAY
(Swiss Federal Railways)

new type of smoke-consumer, the invention of the railway company. The leading dimensions are: cylinders, 21¼-in. by 23⅝-in.; diameter of six-coupled wheels, 4-ft. 11⅞-in.; boiler pressure, 170 lbs. per sq. in.; total heating surface, 1640 sq. ft.; grate area, 24¾ sq. ft.; weight of engine, 55 tons 16 cwt., of which 44 tons 10 cwt. rest on the coupled wheels; capacity of tender: 3527 gallons water, 4 tons coal.

No better locomotives are to be found in Switzerland than those engaged on the Gothard Railway. We illustrate No. 211, six-coupled four-cylinder compound of the de Glehn-du Bosquet type, the first of which was put into service in June, 1894, later engines embodying the various improvements dictated by experience.

The leading dimensions of these locomotives are: diameter of high-pressure cylinders (which are inside the frames), 10⅝-in., and of the low-pressure cylinders (outside the frames), 23⅝-in.; stroke, 23⅝-in.; diameter of bogie and driving wheels, 2-ft. 10¼-in. and 5-ft. 11-in. respectively; diameter of boiler barrel, 4-ft. 11-in.; 227 tubes, 13-ft. 1-in. long and diameter 2-in.; total heating surface, 1676 sq. ft.; boiler pressure, 220 lbs. per sq. in.; weight of engine

PARIS–ROME EXPRESS AT BRIGUE
(Swiss Federal Railways)

in working order, 64 tons; tender: capacity, 3740 gallons of water and 5 tons of coal; weight, 36½ tons.

In any consideration of the Swiss railways the Alpine tunnels appeal most to the imagination. The St. Gothard Tunnel, the second of the great Alpine borings, is 2 miles longer than the Mont Cenis; but the work occupied four years less and cost only £145 per yard, thanks to the rock-drill coming into use and permitting more rapid progress, even through harder surface. Nature was not harnessed without a struggle, for during the arduous operations the contractor and 600 workmen lost their lives. The new tunnel was constructed to give Germany access to Italy via the Swiss lines.

The Simplon tunnel entailed burrowing for 12 miles at a depth of 7000-ft. under a stupendous mountain mass, in whose interior treacherous strata and hot and cold springs were known to exist. The operations entailed one of the most titanic struggles in which engineers ever engaged. Working at such a depth meant that the workmen had to delve in a temperature that was only rendered bearable by the men being sprayed with water as they engaged in their toilsome tasks. On February 4th, 1905, the borings from the opposite ends met, and thus London was brought 70 miles nearer to Milan. This notable victory of the engineer was achieved at a cost of £133 per yard and the loss of 85 lives during the protracted operations.

The latest Alpine boring is the Loetschberg tunnel, which was pierced successfully in the spring of 1911 after 4½ years of continuous work. This undertaking is a logical outcome of the Simplon tunnel, since it effects a further shortening in the Simplon route for travellers from or via Germany to Italy. It gives a through route from Basle and Berne, via the Simplon, to Milan, Bologna and beyond, shortening the journey to a number of places by from three to six hours. Loetschberg tunnel is 9 miles long, and the approaches, especially between Brigue and the southern entrance, involved the construction of many short tunnels, viaducts, and extensive earthworks. The tunnel is bored for a double track of metals, and upon its completion in 1913 will be operated by electric traction.

Switzerland, in the very nature of things, presents the railway engineer with gradients of the severest type. We may take the Geneva-Olten-Zurich line via Berne as one example. As far as Lausanne (35 miles) the route is fairly level, the hardest grades being 1 in 100, and only for 5 miles in two sections. The next 22 miles provide a hard uphill grade, more than half the distance being 1 in 55, and the best of it no easier than 1 in 100. For 55 miles the line is undulating, chiefly 1 in 100, but between Burgdorf and Arrau there is a fall for 34 miles of about the same grade, except for a 3 miles' rise of 1 in 166 to Arrau. For the remainder of the distance to Zurich the general trend is uphill, including nearly 4 miles of from 1 in 250 to 333, 16 miles at 1 in 100, and 5 miles at 1 in 83.

Along the Gothard line the through trains from all points in North-Western Europe to Italy run over continuous and hard grades, but often with the compensation of corresponding falls. Some of the difficulties of the road are: a rise of over 20 miles out of Basle, including 4 miles at 1 in 83, 5 miles at 1 in 90, and 6½ miles at 1 in 47; a descent of 5½ miles at 1 in 37½, which is a trial to heavy trains; while a 23¼ miles' rise at 1 in 100 is followed by 7 miles of similar grade. Leaving Lucerne there are 17 miles of uphill at 1 in 138, then 8 miles downhill at 1 in 110, followed by 14 miles of like grade to Erstfeld. Leaving the last-named and climbing for not

GOSCHENEN VIADUCT, GOTHARD RAILWAY
(Swiss Federal Railways)

quite 15 miles, an elevation of 2322-ft is attained, the line passing into a spiral tunnel from which it emerges at a height of 100-ft. above the lower portal. Later, it passes through a semi-spiral tunnel in which it rises 70-ft., and, reversing its direction, again proceeds down the valley, having on the right the line already referred to. Passing the station of Wassen at an altitude of 2789-ft., it enters the second semi-spiral, and after rising 80-ft. again reverses its direction, thus assuming its proper route to Goschenen, having climbed 1018-ft. in 8½ miles. Reverting to the gradients, the St. Gothard Bank of 18 miles includes 8½ miles at 1 in 40 and 9½ miles at 1 in 38½, just before reaching Gothard tunnel, through which there is an up grade of 6½ miles at 1 in 166 and 3½ miles down at 1 in 500.

On the Simplon route the tunnel under the Alps is 1384-ft. lower than the Gothard tunnel, yet this line presents a number of severe inclines. Starting from Pontarlier, 14 miles within the French frontier, the Swiss trains have an up grade of 1 in 100 to 1 in 44 for 10 miles to the frontier, followed by 28½ miles of downhill, mostly 1 in 40 to 1 in 50 to Lausanne. Over the next 52½ miles the grades are more or less compensating, rising at 1 in 100 and falling at 1 in 145, so that as a whole the line ascends to the beginning of the 46-mile bank to Brigue, the northern portal of the 12½-mile Simplon tunnel. This bank has for its worst section 7½ miles of 1 in 100, 5½ at 1 in 140, 10½ at 1 in 83, and 1 in 100, the other parts being 200, 250, and 500. The tunnel is at 1 in 200 up for 7 miles, and 1 in 123 down for 6, followed by 11 downhill miles of 1 in 40 and 1 in 46 from Iselle to Domodosolla, the junction with the Italian State Railways, during which the train makes a complete circuit inside the mountain, passing through a spiral tunnel south of Iselle. The trains are worked through the tunnel by electric traction. Some portions of the electrical equipment of the line are shown in the illustration on page 562.

Upon the Swiss railways no great speed is attained, nor are there any lengthy non-stop runs. The fastest trains are between Geneva and Lausanne, 37⅛ miles in 55 minutes, or 40·9 miles per hour; while the longest run is the 60 miles between Zurich and Ragatz, mostly over a single line at 30·1 miles per hour. Two of the best through runs are from Lucerne to Milan, 172 miles in 5 hours 25 minutes, or 31·8 miles per hour, and between Geneva and Zurich 181 miles in 5 hours 16 minutes, or 34·3 miles per hour, not at all bad running considering the grades, and the long sections of single line.

Switzerland furnishes a number of examples of mountain railways, in the construction of which the railway engineer has been set tasks far more difficult than laying a railed track to the summit of Snowdon, up which, in 1905, Mr. Harvey du Cros drove a motor-car. The rack railway up Mont Pilatus has an average grade of 1 in 2⅘, and in not a few sections the line rises 1-ft. in every two. The following description of the Pilatus Railway is taken from the *Wide World Magazine:* "The summer of 1886 saw the commencement of the railway which was to take passengers from the delightful little hamlet of Alpnachstaad right up to the breezy Pilatus-Kulm station, 6791-ft. above the level of the sea. The Pilatus Railway is nearly 3 miles in length, and the maximum gradient is 48 in 100. From the lake shore upwards the foundation of the line consists of a continuous wall of solid masonry, covered with enormous slabs of granite. The ravines and torrent-beds are spanned by arches of masonry, and the rack-rail runs midway between the two smooth rails, but at a somewhat higher level. The locomotive and the carriage, with four compartments, holding eight passengers each,

ASCENDING THE RIGI

form one piece of rolling-stock. The curious thing about this railway is that, instead of hauling or pulling the carriage, the engine *pushes* it up. The speed both in ascending and descending is 65 yards a minute. This extremely difficult undertaking was completed in the course of two short summers—little more than 400 actual working days. The first stoppage on the way up is made at the Wolfert ravine, where a halt is made for the purpose of taking in water. One's glance at this point falls almost perpendicularly down into the Bay of Alpnach. Steamers passing by beneath look no bigger than walnut-shells. An upward glance reveals the continuation of the railway line at so tremendous a height above, and on a rock of such appalling steepness, that one momentarily asks oneself whether it is really possible for a train to reach that point, which appears beyond the power of even an eagle. Arrived at length at the summit, one gazes with astonishment and awe into the frightful abysses and precipitous valleys, and towards the beautiful country between the mountain itself and Lucerne."

The Rigi, an isolated mountain mass situated between the lakes of Lucerne, Zug, and Lowerz, commands magnificent views of some of the finest Swiss scenery. The slopes of the mountain are well wooded, and there are verdant pastures to the summit. There are railways up the height from Vitznau and Arth-Goldau. The rack and pinion principle is employed, a cog-wheel under the engine working on the crossbars which connect two inner rails. The average speed is from 4 to 6 miles per hour. The engine is always placed below the passenger car. The Rigi-Kulm (5905-ft.) is the highest and northernmost point of the mountain, and from the summit terminus most magnificent views are obtained; especially fine are the light effects at sunset and sunrise.

One of the latest Swiss mountain railways is a line nearly 8 miles long from Scheidegg almost to the summit of the Jungfrau, 14,000-ft. above sea level. Except for the lowest section of about 1¼ miles, the track is tunnelled through hard limestone, the boring being 12-ft. 2-in. wide, 14-ft. 3-in. high, with a semicircular roof. Being thus under cover, the track is protected from landslips and avalanches. The speed up or down the mountain is limited to 5½ miles an hour, so as to obviate too rapid changes in temperature, which would affect the health of the thousands of tourists who ascend the Jungfrau to obtain a never-to-be-forgotten view.

ITALIAN RAILWAYS

The bulk of the Italian railways were taken over by the State on July 1st, 1905. Within three years orders had been given for 1338 locomotives, 1978 carriages, chiefly corridor vehicles, 646 luggage vans, and 25,740 trucks, at a cost of about £15,000,000. The transference of huge transport concerns from one authority to another must necessarily involve unavoidable problems, especially during the time of transition, but it would appear that in Italy the difficulties were allowed to remain over a very extended period, and that the new management left itself open to criticism in various directions, as shown by the remarks of the *Marina Mercantile Italiano:* "The advocates of State control promised new and fast rolling-stock; rates were to be reasonable; employés were to be obedient to their duties, while the actual number was to be greatly reduced. There was to be an abolition of favouritism and sinecures, a punishment of abuses, and in all construction and operation there would be the exercise of the greatest possible economy, all resulting from State control. But the whole railroad atmosphere is under a cloud." In the course of further criticisms it was asserted that the Board of Directors of the Railways had purchased 880,000 lbs. of pumice-stone, and 250,000 metres of red velvet at fifteen lire per metre, quite enough to last up to the twenty-first century; while millions had been spent in uniforms only for them to be stored in warehouses, where vast quantities of the clothing would remain until too old to be usable. Concerning the promised reduction in the number of employés, the figures at the end of three years of State management were very illuminative: on July 1st, 1905, the employés numbered 97,000; in 1908 they had increased to 137,000.

At the Paris Exposition of 1900 the Italian Southern Railway exhibited a four-cylinder compound locomotive that was a bold departure from the general style. The ordinary arrangements were reversed, the cab and firebox being placed at the front end over the bogie, with the smokebox behind, so that the engine appeared to be running backwards. This method of construction rendered it possible to get a width of grate of 59-in., with an area of 32 sq. ft., as the coupled wheels were out of the way. The two high-pressure cylinders ($14\frac{1}{8}$-in. by $25\frac{1}{2}$-in.) were on one side of the engine, and the two low-pressure cylinders ($23\frac{1}{8}$-in. by $25\frac{1}{2}$-in.) on the other side; coupled wheels, 6-ft. $3\frac{1}{2}$-in. diameter; boiler pressure, 213 lbs. per sq. in.; capacity of coal-bunkers on each side of the firebox, 4 tons; weight of engine in working order, $69\frac{1}{2}$ tons; tender, simply a tank carrying 4400 gallons of water, $36\frac{1}{2}$ tons. The cab arrangement had obvious advantages; thanks to being placed on the bogie, the engine-men suffered less from the motion of the engine when running, and their view of the road was no longer obscured by a large high-pitched boiler. A number of these locomotives were built and put into running, and their work was watched with great interest in railway circles. They proved capable of drawing a 440-ton train at 68 miles per hour on the level, or a dozen miles an hour more than the maximum speed then permitted on Italian railways; but even 56 miles per hour was undesirable with heavy engines, until many sections were laid with heavier rails. Notwithstanding the success of these unusual locomotives on the Southern Railway, they have not been adopted elsewhere in Italy.

For heavy mountain roads mammoth ten-wheel (all coupled) compound locomotives are used extensively, e.g. up the steep inclines of the Ligurian Apennines as far as Ronco, on the direct line from Genoa to Milan, Florence to Bologna, etc. Goods trains on the mountain sections vary from 200 to 600 tons in weight, and these engines will haul a train of 272 tons at 17 miles per hour up a 16-mile bank with gradients averaging 1 in 16; whereas three ordinary goods engines would be required, two to pull and a third to push behind. On these very steep gradients not only does the extra adhesion of the ten-coupled wheels count heavily, but the almost perfect balance of the decapod engine is also an invaluable feature.

Some of the latest examples of Italian locomotive practice were shown at the Turin Exhibition of 1911. Among these was a 2 – 6 – 0 simple locomotive with inside cylinders for hauling passenger traffic on routes with heavy and frequent gradients. In this engine the leading wheels and the front pair of coupled wheels form a bogie; and it is fitted with a Schmidt superheater and Walschaert's gear. The following are the leading dimensions: cylinders, $19\frac{1}{4}$-in. by $27\frac{1}{2}$-in.; coupled wheels, 4-ft. $11\frac{1}{2}$-in. diameter; working pressure, 170 lbs. per sq. in.; firebox heating surface, 106·56 sq. ft.;

A BOLD DEPARTURE IN LOCOMOTIVE CONSTRUCTION. 4 – 6 – 0 FOUR-CYLINDER COMPOUND ENGINE

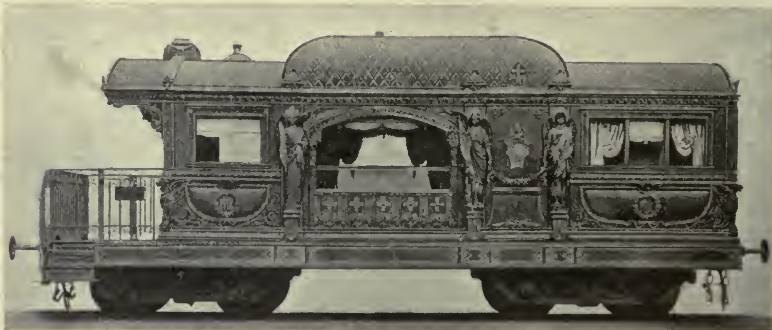
(Italian Southern Railway)

tubes, 1059·2 sq. ft.; superheater, 360·6 sq. ft.; grate area, 26·05 sq. ft.; weight of engine, $52\frac{1}{2}$ tons; maximum speed, about 50 miles per hour. An engine of this type is illustrated on page 573.

For hauling heavy goods trains on different gradients a 2 – 8 – 0 is fitted with a superheater and Walschaert's gear, as in the foregoing engine: cylinders, $21\frac{1}{4}$-in. by $27\frac{1}{2}$-in.; coupled wheels, 4-ft. $5\frac{1}{2}$-in.; boiler pressure, 170 lbs. per sq. in.; total heating surface (firebox and tubes), 1786·87 sq. ft.; superheater, 462·86 sq. ft.; grate area, 26·91 sq. ft.; weight of engine in working order, 66 tons; maximum speed on the level, $43\frac{1}{2}$ miles per hour.

As in France, and in Southern Europe generally, wine figures largely in the goods traffic of Italy, and calls for the use of rolling-stock specially constructed to meet the requirements of vine-growers and merchants. A common form of wine vehicle is a box wagon containing three casks, permanently fixed in the car body, each cask containing about 1100 gallons of wine, which is run off into smaller barrels upon arrival at destination. Sometimes huge casks are affixed simply to a wagon framing, while a third form of wine wagon consists of a cylindrical tank. In the illustration of the Goschenen viaduct (page 564) is shown a train from Italy, in which the first three vehicles are wine wagons of the three types mentioned.

When the Italian Government commenced railway management upon its own account, it was found necessary to increase the locomotive power without delay. While new engines were building, notably a score by the Baldwin Company, Italian State officials paid a visit to Great Britain to obtain second-hand locomotives, which resulted in the purchase of fifty six-coupled goods engines from the Midland Railway.



THE PRIVATE SALOON IN THE SPECIAL TRAIN OF POPE PIUS IX
(Italian Southern Railway)

Of all the railway cars in the world none perhaps is more remarkable than the private saloon in the special train of Pope Pius IX, which, after overhauling in the shops of the Italian State Railways, was exhibited at the festival to commemorate the Jubilee of Italian unity at the Castle of S. Angelo, in Rome, in 1911. The historic train was presented to Pope Pius IX in 1857, the private saloon being the gift of the Rome–Civita Vecchia Railway, while two other coaches were provided by the Rome Railway officials. After the Pope lost his temporal power in 1871 the special train fell into disuse.

The private saloon was built at a cost of £5500, and various distinguished artists were employed in its decoration. The external features are distinctly religious in type, and almost suggestive of a funeral car. The body is overlaid with plastic material, silvered and gilt. The three figures in relief represent Faith, Hope, and Charity. The open platform in the centre leads from the vestibule and reception-saloon to the private apartments, which comprise an oratory, or chapel, with a portable altar, reading-room, and toilet apartment. The internal decorations include almost priceless paintings and frescoes, the upholstery is chiefly in white velvet, and the general fittings are of a most ornate description. Of the other two coaches one is open on three sides, richly decorated columns supporting the roof, while the second is a closed carriage, divided into a reception-room, vestibule, and reading-room.

The average train services in Italy are considerably behind those of other countries previously described. Of the various inter-

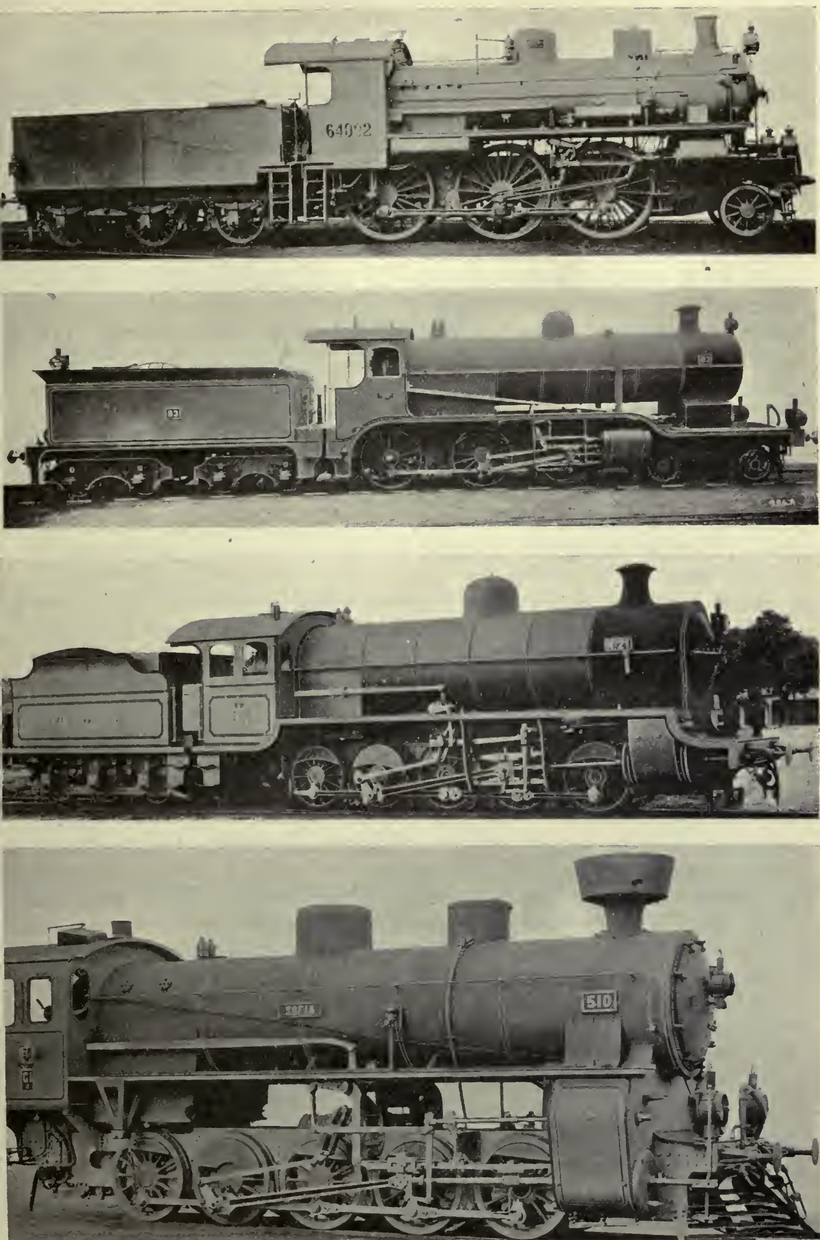
ROME EXPRESS LEAVING MILAN
(Italian State Railways)

national trains that traverse Italian territory, perhaps the most notable is the Anglo-Indian Mail on the Calais–Brindisi–Port Said route. Londoners easily can familiarise themselves with the despatch every Friday evening of the Indian Mail from the General Post Office. After leaving Cannon Street terminus, Dover pier is the first point of transhipment, then Calais, where the thousands of mail-bags collected from all parts of the United Kingdom and America are thrown hurriedly into the railway postal vans forming the special through mail train to Brindisi; these cars are of the French mail service, and some of the vans are filled prior to the arrival of the English boat. Over the rails of the Nord and P.L.M. (avoiding Paris by passing round the "Grand Ceinture" line) the train is hauled to the Italian frontier at Modane, and thence through the Mont Cenis Tunnel to Turin, where the Adriatic Railway of Italy continues the running through Bologna to Brindisi, 1459 miles from London.

The Mont Cenis tunnel, 7½ miles long, was opened in 1871, after thirteen years' continuous labour. It had not been expected to complete the work in less than twenty-five years, and in the meantime a British engineer, Mr. J. B. Fell, proposed and constructed a line over the Alps, following the road made by Napoleon for military purposes. Having to cross the summit of the Mont Cenis Pass at a height of 7000-ft., the gradients of the line (gauge 3-ft. 7-in.) were very steep, the average maximum being 1 in 10. For working the traffic special locomotives were employed. They had four cylinders, two to work the carrying wheels, while the second pair of cylinders drove two or more horizontal wheels, which gripped an inner rail by means of screw gear. The Fell Railway was opened in 1868, and for three years carried the international traffic between France and Italy, including the Indian Mail. With the opening of the Mont Cenis tunnel this notable, but almost forgotten, railway, the first one to cross over the Alps, found its occupation gone.

THE ORIENT EXPRESS

Three times in each week the famous "Orient Express" leaves the French capital for its long run of 1750 miles across the European Continent to Constantinople. On its departure from the Gare de l'Est, Paris, the train consists of five cars: a baggage car, diner and sleeper for Constantinople, and a sleeper and baggage car for Vienna only. The conduct of the train to the French frontier at Avricourt is performed by the Eastern Railway of France, and in traversing the French section of the journey engines are changed three times, namely, at Château Thierry, Chalons, and Nancy. At Avricourt the train passes on to German territory, the time changing to that of Central Europe (one hour later), and the German Customs officials visit the cars. The first section of the run across the Fatherland is over the Alsace-Lorraine railways to Strasburg, where a Baden State Railway locomotive is attached to haul the train to Vos, from whence a second Baden engine takes the train as far as Carlsruhe. Here a locomotive of the Würtemberg State Railways comes into service as far as Stuttgart, where another change of engine takes place to draw the train to Ulm. The first reversal of the train now takes place, and a Bavarian State locomotive works the train via Augsburg to Munich, where another reversal takes place, and a similar engine to the last is employed as far as Salzburg, the Austrian frontier station. During a ten-minutes' stop engines are changed, the water tanks of the cars are replenished, the Austrian Customs officials inspect baggage, and the whole train undergoes official examination.



1. 2–6–0 SIMPLE PASSENGER LOCOMOTIVE (Italy).
2. 4–6–0 BOGIE FOUR-CYLINDER COMPOUND LOCOMOTIVE (Portugal).
3. 0–10–0 GOLDSDORF COMPOUND LOCOMOTIVE (Servia).
4. 0–10–0 FOUR-CYLINDER COMPOUND LOCOMOTIVE (Bulgaria).

For the continuation of the journey a four-coupled Goldsdorf compound, belonging to the Empress Elizabeth's Railway, generally heads the train as far as Linz, where the air brakes are put out of action and the vacuum blown into service. From Linz a six-coupled Goldsdorf takes up the running to Vienna (Westbahnhof), where a rearrangement of the train takes place. The Paris–Vienna cars are detached, two similar ones in waiting, from Ostend via Cologne, Nuremberg, and Passau, taking their place. The train is then drawn out in reverse order by a tank engine to the Staatsbahnhof terminal, where a heavy Goldsdorf compound takes the head of the train; the air brakes are reinstated, and the train proceeds over the Austro-Hungarian State Railways to Marchegg. Here the Hungarian State Railways commence, and generally a four-cylinder tandem compound hauls the express to Budapest, in which terminal station there is another reversal, while the Berlin-Constantinople sleeper, which has previously arrived, is attached to increase the load to six cars. The Hungarian State line terminates at Zimony, but the engine runs on to Belgrade, thus forming the longest section (218 miles) performed by one engine.

At Belgrade the Servian Customs officials visit the train, the air brakes again give way to simple vacuum, and a Servian State Railways engine heads the train to the Bulgarian frontier station of Zaribrod, where time changes again one hour to Eastern Europe. The Servian engine is taken off and replaced by one belonging to the Bulgarian State Railways in readiness for the heavy pull over the passes of the Balkan Mountains. (For examples of Servian and Bulgarian locomotives, see page 573.) After negotiating the summit the train descends to Sofia, the capital of Bulgaria, where engine and cars take in water before tackling a miniature "horse-shoe" curve and a pass 1300-ft. above sea-level to the Turkish frontier station of Bellavo, where commence the metals of the Oriental Railways. The Bulgarian engine, however, continues to Sarambez, where it gives way to a Turkish engine, which hauls the train through a badly cultivated country with stations few and far between to Adrianople, where the last change of locomotives takes place. The speed now approximates to a crawl, through a wasted country to the coast of the Sea of Marmora; and after a long trundle amid ruined houses, walls, and cemeteries the train enters the terminal station of the city of the Sultans, 65 hours (allowing for changes in time) after leaving Paris. The "Orient Express" is a *train-de-luxe*, which in some respects forms a connecting link between the civilisation of the Occident and the semi-barbarism of the Orient. During the long journey the train passes through six different countries, and over lines owned by no less than thirteen railway administrations; and during its passage across so great a stretch of the European continent, there are twenty-one changes of locomotives. Coloured Plate XII shows the "Orient Express" passing the Mosque of S. Sophie at Constantinople.

The above brief description of the "Orient Express" may serve largely for the railways of the Balkan Peninsula, for, with the exception of the international services, the railways of Servia, Bulgaria, and Turkey present no special features, except those that point to general inefficiency, a remark that is especially applicable to Turkey.

The Servian railways have a length of 430 miles, there being only one principal line, viz. Belgrade–Nish–Vrangé.

The locomotive illustrated on page 573 is a 0 – 10 – 0 Golsdorf compound, with its first, third, and fifth axles allowing 1-in. of side play in each direction, as successfully employed in similar engines on the Austrian, Prussian, and Italian State railways. The boiler is of large dimensions, with a big grate to permit the use of Servian coal, which is light and requires a thin fire for effective combustion. The build of the cab is calculated to protect the engine-men from the inclemency of the Servian winters. The tender is chiefly noticeable for its large coal capacity (8 tons), indicative of coaling stations on the Servian system being situated wide distances apart. The total weight of engine and tender is 104 tons.

The Bulgarian locomotive shown on the same page is also a 0 – 10 – 0, and notwithstanding its massive appearance is a couple of tons lighter than the Servian example. Its leading dimensions are: diameter of high-pressure cylinders 22-in. and low-pressure $33\frac{1}{2}$-in.; stroke of pistons, $25\frac{5}{8}$-in.; driving wheels, 4-ft. $1\frac{1}{4}$-in.; steam pressure, 200 lbs. per sq. in.; heating surface, 2260 sq. ft.; total weight of engine and tender in working order, $101\frac{1}{2}$ tons. The external shapes of locomotive chimneys is largely a matter of the builder's individual fancy, but certain unusual designs are of set purpose. The basin-shaped funnel of the Bulgarian engine, as well as the inverted-cone design shown later in a Russian goods engine, are fitted with a wire meshwork spark arrester, which is particularly necessary in the case of locomotives that use wood fuel.

The "Orient Express," being a famous long-distance *train-de-luxe*, it will be convenient at this point to consider the carriages of the International Sleeping Car Company, which offer to the traveller the acme of comfort and luxury. The first sleeping-car on the Continent was run in Germany in 1875, and the first dining-car five years later. It is the combination of the sleeping and dining-cars that forms the modern *train-de-luxe*, the "Orient Express" being the first train of this type to run between Paris and Vienna in 1883. The earliest cars were 36-ft. long, and ran on two, or at most three, axles, whereas the present-day standard cars are 60-ft. long, some are 70-ft. over the buffers, and are mounted


SLEEPING CAR COMPARTMENT BY DAY


SLEEPING CAR ARRANGED FOR THE NIGHT

upon four or six wheeled bogies. The outside body of the cars consists of teakwood, and inside of mahogany; formerly each compartment accommodated four passengers, but the modern vehicles seat only two persons in each compartment. As shown in the illustration the compartments are luxuriously fitted rooms, not to be improved upon in the best hotels. For day use a sofa and table make even a long journey pleasant, while for night the sofa is changed by an attendant into a comfortable bed. The *trains-de-luxe* are booked at higher speeds than the fastest ordinary expresses, and in a long journey across Europe there is a saving of perhaps as much as twenty hours. In most of these trains, too, the examination of baggage by Customs officials takes place during travelling, whereas on ordinary expresses travellers often have to alight from a train, possibly in midwinter in the small hours, for their baggage to undergo the inquisitorial process.

The speed of *trains-de-luxe* varies in different countries, only those in France being booked at between 40 and 60 miles per hour. There are thirty-two express *trains-de-luxe* running on the Continent, more than half of them being in service in France. In addition to trains there are 600 sleeping and 400 dining cars *de luxe* on the various continental railways.

Between Paris and Avricourt (346 miles) the Orient express averages 46 miles per hour; in Germany and Austria it drops to about 40 miles; but in Turkey 25 to 35 miles per hour is considered good running.

RUSSIAN RAILWAYS

Russia-in-Europe, with its vast area of more than two million square miles, is but sparsely railed, for it has only about 1 mile of line to every 57 sq. miles of territory, which compares very unfavourably with many other countries of Europe. Of the European mileage about 70 per cent is worked by the State, and the acquisition of the lines has been responsible for quite one-third of the national debt. An authority upon the subject recently stated that, including the Trans-Siberian and the Amur lines, "the total amount of debt contracted by Russia up to the year 1908 for the purpose of her railways was £500,000,000, or more than half the whole national debt." The interest on the "railway debt" alone is about £13,000,000, and the annual loss varies from £5,000,000 to £10,000,000. These figures go to prove the contention that successful nationalisation of railways in one country must not be the sole criterion for another country to follow suit. The passengers carried on the Russian railways in a year number about 160,000,000; goods and minerals, 190,000,000 tons.

Among Russia's earliest locomotives were a considerable number of British build, while Germany also got a share of orders; but nowadays the Railway Administration prefers to have engines built in the home workshops, although under pressure of transport requirements some locomotives have been obtained from America even within recent years. Upon many sections of the Russian railways the locomotive fuel is wood, but a great number of engines are fired with oil fuel, of which there is an abundant supply in the Baku region. At one time it was considered questionable whether oil-fired engines were safe for hauling passenger trains, but experience has proved that with a high flash-point the bulk of the liquid fuel carried is quite safe from untimely ignition. In our own country railway collisions have frequently involved the shattered carriages and injured passengers in a devastating

GOODS LOCOMOTIVE—OIL OR WOOD BURNER
(Russian State Railways)

fire, owing to the contents of the firebox being scattered over the debris. In the case of a similar accident to a train drawn by an oil-fired engine the corresponding danger is not more, but less; for the shock of the collision, not only inevitably severs the oil-fuel pipe between engine and tender, but usually instantaneously extinguishes the fire. The majority of the world's oil-burning engines are at work on more or less ill-laid tracks, where mishaps, such as derailments, are of frequent occurrence, yet no accident that we can call to mind has ever involved a train in fire.

We illustrate a six-coupled bogie locomotive on the Nicholai Railway, which is typical of the best engines in the country. Some Russian locomotives present almost a weird appearance to Western eyes. It is nothing unusual to find a "Fairlie" tank with the air reservoir for the brake resting upon the petroleum tank, which itself is supported by the boiler; add to this in many cases a diamond smoke-stack, and it will indicate that Russian locomotive builders do not pay great heed to appearances. Engines, such as just mentioned, have cylinders 15-in. by 20-in.; coupled wheels, 3-ft. 6-in. diameter, arranged in two groups as bogies; total wheel-base, 29-ft. 3-in.; total heating surface, 1625 sq. ft.; capacity of tanks, 1800 gallons; weight in working order, 48 tons. A large number of these engines are in service on the Trans-Caucasian Railway; more than twenty of them were built in England, but in recent years eight-coupled locomotives of normal build

SIX-COUPLED BOGIE PASSENGER LOCOMOTIVE—NICHOLAI RAILWAY
(Russian State Railways)

are replacing the "Fairlies," because they are more economical in working the inclines at Souram.

In signalling matters Russian practice shows an utter lack of modernity. Quite a common arrangement is the use of cones and drums hoisted by ropes over pulleys for day signalling, lamps replacing the drums at night. This primitive method is in use even at the chief depots. The starting of even a goods train is quite an event judging by the formalities. The scarlet-capped station-master gives a signal to a porter standing at the station bell, who reverently gives one stroke, then two, and finally three, the driver meantime receiving the train staff, for most of the Russian railways are single track. Following the three strokes on the bell the guard whistles, and the driver acknowledges it with a prolonged sound from the engine; the guard repeats, and the driver gives a finishing blast. This last is the intimation that the train is about to start, which causes the pointsmen in the yard to spring to "attention," and blow horns or trumpets one after another.

To obtain a general idea of Russian railway working we may visit a couple of lines. On the St. Petersburg and Warsaw Railway we find four-coupled tandem compound express locomotives hauling the through fast trains from the capital to Warsaw, and to the German frontier at Eydtkuhnen. They are built at the Poutiloff Works, in St. Petersburg, and though capable of running at a high speed, in actual service they seldom exceed 35 miles per hour. The passenger coaches are higher and wider than is permissible by British loading gauges. All three classes contain folding berths. The vehicles, however, are poorly lighted, for the windows

"FAIRLIE" TYPE LOCOMOTIVE HAULING TRAIN OF LOADED OIL TANKS, BLACK TOWN, BAKU

(Trans-Caucasian Railway)

are not only narrow, but are often restricted to two in each compartment. At night candles supply the only illumination, so that reading during travelling is practically impossible. Upon the top of other shortcomings the Russian carriages are seldom clean. This last remark does not apply to the vehicles of the International Sleeping Car Co., which run upon this line principally in the Nord Express for Paris and London, via Eydtkuhnen, and the Nice and Cannes express, via Warsaw and Vienna.

Every Saturday a complete train leaves the Kursk station in Moscow for the long run to Irkutsk, Siberia, a distance of 3164 miles. The trains of the Russian State Railways run alternately with those of the International Car Co. A Railway Administration train consists of five large four-wheeled bogie cars. The first car has a baggage compartment, a central room for an electric-lighting plant with engine and boiler complete, berths and accommodation for the men, and a kitchen equipped with cooking utensils, etc. The second car has a chamber forming living quarters for the train staff, but a commodious dining-room and restaurant occupies the greater portion of the vehicle. The third car is a second-class of the compartment type, accommodating twenty-six passengers. The fourth car is a first-class with compartments or state-rooms to accommodate eighteen persons. The fifth car is another second-class vehicle ; it carries a post-box, and has an observation end. This train on the " Special Siberian Service " is really sumptuously equipped, but is quite eclipsed by the International Car Co.'s train.

BATH CAR
(Russian State Railways)

Russia can boast of one class of car that is probably unknown upon the railways of any other country. At the more remote stations on the Southern Railways in the summer months there is a great scarcity of water, and certainly none to spare for ablutionary purposes. To provide facilities for bathing the employés, suitably fitted cars have been provided. The interior is arranged as a spacious bathroom with appliances for pumping and warming the water. The second vehicle, shown in the photograph, is an old carriage converted into dressing-boxes.

MISCELLANEOUS EUROPEAN RAILWAYS

The railways of Spain and Portugal, although so near neighbours of France, are woefully behind the times compared to the latter country. Spain has only a little over 5 miles of line per 10,000 inhabitants. All the railways are in the hands of private companies, but under State concessions and often under Government subventions. The standard gauge in the Iberian Peninsula is 5-ft. 5¾-in. The principal train is the Sud Express, a *train-de-luxe* between Paris, Madrid, and Lisbon. From Paris to Bordeaux on the Orleans Railway the train has a fast schedule, viz. an average speed of 55 miles per hour. At the Spanish frontier station at Irun, on the southward journey, or at the French frontier station at Hendaye, going north, travellers have to change cars owing to the difference in the gauge of the lines in the two countries. Arrangements are in progress for the provision of a third rail to suit the Spanish gauge from the frontier station to Biarritz, and similarly to suit the standard 4-ft. 8½-in. gauge from the frontier to San Sebastian, so that the express trains may run right through to the latter place. King Alfonso has expressed a desire for the mixed gauge to be extended as far as Madrid. The illustration depicts the Paris-Madrid express drawn by a Spanish six-coupled bogie compound locomotive.

The main northern line from Madrid to the frontier is being doubled, and when completed the Sud Express in Spain will attain a greater speed than the customary 25 miles per hour. Ordinarily Spanish and Portuguese trains do not exceed 15 miles per hour, and even then are usually much behind their booked times. The average coaching stock is inconvenient and uncomfortable; the third-class carriages, used almost exclusively by the lower classes, often have seats on the roof, or are complete double-deckers. The *trains-de-luxe* justify their title, but they are first-class only, and fares raised ten per cent; the accommodation, too, is limited, as the difficult mountain grades forbid long and heavy trains.

A ferocious bull intended for the bull-ring broke loose on October 12th, 1911, at Metapozuelos, near Valladolid. Labourers riding on donkeys on their way to the vineyards abandoned their mounts and climbed into trees. The bull gored and tossed the donkeys and then ran into the railway station, putting passengers and staff to fright. The furious animal wrecked the offices and waiting-room, and then charged the Galician express as it rushed through the station. It was killed on the spot by the engine, which was, however, derailed as it passed over the dead bull. Fortunately the passengers were not injured.

In giving evidence before a Parliamentary commission, George Stephenson stated that it would be "very awkward for the 'coo'" that strayed on to the line in front of one of his engines. The above accident—and many others could be quoted—tends to show that it may also be very awkward for the engine.

Portugal has about 1758 miles of railway, of which nearly one-third belongs to the State. The Sud Express from Paris to Lisbon runs on the same route as for Madrid as far as Medina, where the Portuguese section branches off via Salamanca and Pamphilhosa. Difficult grades must be expected in a country traversed from

PARIS–MADRID EXPRESS, IRUN STATION
(Northern Railway of Spain)

east to west by mountain ranges, while the most important traffic is from north to south. Upon the main line from Lisbon to Oporto the grades are 1 in 250, 1 in 100, 1 in 60, and 1 in 55, and the last-named in some cases is on curves of 300 to 325 radius. Passenger trains of about 320 tons are drawn by six-coupled four-cylinder de Glehns with 5-ft. 9-in. driving wheels, but the latest engines have drivers of nearly 6-ft. 3-in. The cab and engine head-lights are fitted with incandescent gas mantles. Much of the Portuguese rolling-stock is British-built; but on page 573 is shown a six-coupled bogie four-cylinder express locomotive built at the Borsig Works, Berlin, for the heavy passenger traffic on the Sul e Sueste section of the Portuguese State Railways, which has long gradients of 1 in 55.

The manner in which the railways have linked up the chief cities of Europe is shown in the fact that, with four exceptions, the capitals of the various countries are in unbroken rail communication with Paris, and consequently with Calais and other Channel ports. It is thus possible to travel from London to such distant cities as St. Petersburg and Constantinople with only the short Channel passage to break the long railway journey. One of the great cities cut off from the rest of Europe is Athens, for Greece has no railed connection with its northern neighbour, Turkey. Of course, the physical features of the country present many natural obstacles to the railway engineer, and in any case Greece is comparatively young as a European state. It is, however, neither of these two points that has debarred Greece from railway communication with the outside world, but rather the fear that international railway connections would assist the military operations of the Turks against the Greeks. The decline of the power of Turkey has robbed Greece of its greatest fears, and the railway from Piræus to Larissa has been completed, and is in course of construction to Keralik on the frontier, with a view to effecting a junction with the Salonika-Monastir line.

The chief railway of Greece is the Piræus–Athens-Peloponnesus Railway, a system some 460 miles long, upon which work about 90 locomotives, 230 carriages, and 800 wagons of various types. This railway labours under the disadvantage of closely following the coast, and thus is brought into competition with the cheap steamship lines.

The railways of Holland have a length of nearly 2000 miles, with a standard gauge of 4-ft. 8½-in. The State owns about half of the total mileage, but, nevertheless, the State Railways are worked by a company. The passengers carried annually number about 43,000,000; goods, 15,000,000 tons. The country on the whole is exceedingly flat, but upon some of the lines there is a considerable amount of uphill work. Speeds as a rule are only moderate, for the whole land is a network of waterways, and many of the bridges necessitate marked "slacks," e.g. even over the famous Inoerdijk Bridge no greater speed is permitted than 18 miles per hour. The average Dutch carriage stock makes no claim to excellence, but some of the main lines are traversed by German saloon carriages of distinctly good type.

For an important Dutch line we cannot do better than review the Netherlands Central Railway, whose main line from Utrecht to Zwolle forms an important link between the western and northern divisions of the State Railways system, over which the cross-country expresses are worked, which run from Amsterdam and Rotterdam respectively to Utrecht, where they are joined and handed over as one train to the Central Railway, which takes up the running as far as Zwolle, where the train is divided and thence hauled by State Railway engines to Groningen and Leeuwarden respectively. These trains, when combined, form the heaviest train in Holland, and in summer loads of 500 tons are the rule rather than the exception. The heaviest express train hauled in the course of the summer traffic of 1910 consisted of twenty-eight cars, making a weight of 700 tons behind the tender. It was run punctually on time, and a speed of 50 miles per hour was attained. On January 21st, 1911, a train of 23 cars, weighing 630 tons, was run from Zwolle to Amersfoort in 50 minutes (10 minutes under booked time), the average speed being 49 miles per hour.

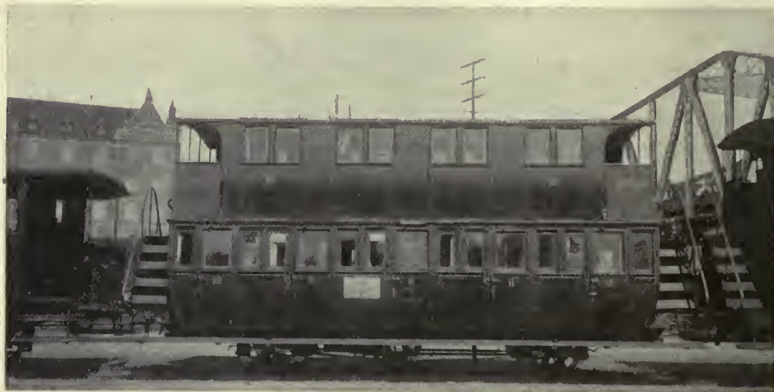
Generally speaking, the booked speeds are not high, 21 minutes

4–4–0 PASSENGER LOCOMOTIVE
(Netherlands Central Railway)

being allowed for the 13·1 miles between Utrecht and Amersfoort and 60 minutes for the 41·1 miles between Amersfoort and Zwolle, giving average speeds over the two sections of 37·5 and 41·1 miles per hour respectively. But when the weight of the trains and the undulating character of the road are taken into account it appears that the engines are performing smart work.

During the last few years a considerable number of 4–6–0 locomotives have been built for the various lines, notably the Central and the State Railways. In the latter case half a dozen four-cylinder simple express engines, built by Messrs. Beyer, Peacock & Co., Ltd., of Gorton, Manchester, are the most powerful express locomotives in Holland; and like all passenger engines on the State Railways, they follow somewhat closely the English style of outline. Passenger engines of the 2–4–0 and 4–4–0 types are more numerous than any other kind; and of the latter is shown a capital example of the Netherlands Central Railway locomotive stock.

Denmark is a very small kingdom only about half the size of Scotland, and with a population numbering 2,700,000. The State owns a little more than a half of the 2115 miles of railways, which have a gauge of 4-ft. 8½-in., except for 103 miles of 3-ft. 3¼-in. gauge. Copenhagen, the capital of Denmark, is situated on the eastern coast of the island of Zealand, only 15 miles from Sweden, on the opposite side of the Sound; and thus it is impossible to reach the capital except partly by water. The most interesting feature of the Danish railways is the working of the ferries across the different channels that separate various islands from each other and from the mainland. The main line of the Danish State Railways crosses



THIRD-CLASS DOUBLE-DECKED CARRIAGE
(Danish State Railways)

from Zealand over the Masnedo Sound to Orehoved, on the island of Falster, which the metals traverse from north to south to Gedser, from whence there is a ferry to Warnemünde on the Baltic coast of Germany, and thence onwards to Hamburg.

The Gedser–Warnemünde ferry is a passage of 24 miles; paddle-steamers are used for passengers, and twin-screw vessels for goods. The former vessels, which are considered the most suitable for work amid the ice during the winter months, are fitted to convey four passenger bogie carriages, each 65-ft. in length; the goods ferry steamers are fitted with double rails to accommodate twenty wagons. This ferry is the longest in Europe, and a greater distance than between the nearest points of England and France, between which a railway ferry has been discussed for a very long period. In connection with the proposed Strait of Dover ferry must be borne in mind the slight difference between the gauges of England and France, 4-ft. 8½-in. and 4-ft. 9-in. respectively. There would be little difficulty in the English vehicles running slack on the French metals, while the French cars would run tightly on the English rails; but trouble might arise from the fact that the Continental stock is built to a larger construction gauge than in this country. There is a notable railway ferry across Lake Constance, and also one across the Strait of Messina, connecting the

EXPRESS TRAIN LEAVING COPENHAGEN
(Danish State Railways)

Italian and Sicilian railway systems. The last-named is of considerable interest to ourselves, as it forms a link in the express route between Malta and London, via Syracuse, Messina, Reggio, Naples, Rome, Modena, and Paris.

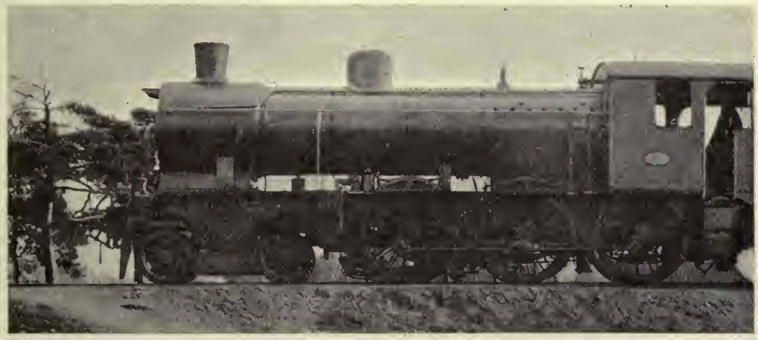
Returning more particularly to Denmark, there is a route from Copenhagen to the Danish mainland, via a ferry across the Great Belt to the island of Fünen, and across the Little Belt to Fredericia, from whence there is direct rail communication northwards to Frederikshavn, or southwards through Schleswig-Holstein to Hamburg.

The peninsula of Scandinavia, Norway and Sweden, is isolated from the remainder of Europe so far as direct railway communication is concerned. The first Swedish railway was opened in 1856. One-third of the total mileage is under State control. Most of the lines are single and chiefly of 4-ft. 8½-in. gauge. The yearly traffic is concerned with the transport of about 54,000,000 passengers and 34,000,000 tons of goods. Passenger travelling is not speedy, but it is comfortable. Sweden, compared with Norway, is flat, except in the north, where the Kiölen Mountains form the boundary between the two countries; but, nevertheless, in various parts of Sweden Proper (Svealand) the gradients are far from easy. The greater portion of the country's mileage lies in the network of lines in Southern Sweden. The trunk lines from Stockholm to Gothenburg and to Christiania are worked by the Government as far as the frontier, as well as other chief through routes in the south. There is a great line northwards, running fairly parallel with the east coast. At Storlien it joins with a line from Trondheim, in Norway, and at Boden a junction is effected with another line that originally was built to connect the Gelliwara iron mines with the port of Lulea on the Gulf of Bothnia. Continuing northwards, the metals eventually reach Narvik, on Ofoten Fiord, in Norway, and far beyond the Arctic Circle.

For an example of a Swedish passenger locomotive we show a 4-6-0 inside cylinder engine employed on the Stockholm-Vesteras-Bergslagen Railway. This locomotive and others of the same type are fitted with the Schmidt superheater, and a valve motion which is a modification of that introduced by Mr. R. M. Deeley on the Midland Railway a few years ago. The leading dimensions are: cylinders, 20½-in. by 24-in.; coupled wheels, 5-ft. 7¾-in.; total heating surface, 1376·7 sq. ft.; superheater surface, 382·1 sq. ft.; working pressure, 170 lbs. per sq. in.; total weight of engine and tender, 89¼ tons.

Norway possessed a railway two years earlier than Sweden, namely, a line between Christiania and Eidsvold, which was built by British capitalists under arrangement with the Norwegian Government. In proportion to its area the railway mileage of the country is the lowest in Europe, but according to population it ranks twice as high as Sweden, and, in fact, is higher than Great Britain. Most of the lines are under State control; about two-thirds of them are 4-ft. 8½-in. gauge, and the remainder 3-ft. 6-in. The greatest railway development is in the region dominated by the capital, from whence there is a trunk line to Trondheim via Hamar (change of gauge from 4-ft. 8½-in. to 3-ft. 6-in.), Österdal, Röros, and Stören. There are four lines into Sweden, viz. from Christiania, Frederikshald, Trondheim, and Narvik. The last-named is the point farthest north in the world reached by the locomotive, as it is many miles nearer the North Pole than any point on the White Pass and Yukon Railway in Alaska. It is possible to see the midnight sun from the cars of a fine passenger train that runs between Narvik and Stockholm. The passengers carried on the whole of the Norwegian lines number nearly 16,000,000, and the goods traffic amounts to 6,500,000 tons.

The most notable portion of the Norwegian railways is the Bergen–Christiania line, 305 miles in length. One section is a marvel of engineering constructed in the face of climatic difficulties greater than ever met with elsewhere in Europe. Between Gulsvik and Voss the line crosses the great watershed of the Lang Mountains in a region where the winter lasts eight or nine months, and sometimes longer. The highest point of the line is at Fagerboln (4267-ft.). Finse, the highest station (4008-ft.), is in the heart



4–6–0 PASSENGER LOCOMOTIVE
(Stockholm–Vesteras–Bergslagen Railway, Sweden)

of the mountains, where huge glaciers are ever present, where the ice on the lakes melts late, if it melts at all, and snow seldom melts entirely in the villages.

It is interesting to compare this elevated line, in a latitude of 60 to 61 degrees north, with the Alpine railways, 45 to 47 degrees. The highest standard gauge rails go over the Brenner and through the Arlberg tunnel at a height of 4494-ft., and the Mont Cenis tunnel at 4244-ft., which is higher than either the St. Gothard or the Simplon. Even where the Southern Pacific Railway (U.S.A.) crosses the Sierra Nevada at a height of 8200-ft., the line does not rise above the belt in which the hardy fir tree will grow, but owing to its more northern latitude the Norwegian railway leaves the fir trees behind after it has ascended to 2000-ft. In the Gulsvik–Voss section, 62 miles long, there are a dozen miles of snow-sheds, about thirty miles of snow-screens, and nearly ten miles of tunnels. All along the route, too, the road-bed of the railway is raised considerably, so as to assist in retarding the formation of snow-drifts, for the dispersal of which rotary snow-ploughs often have to be called into service.

The crux of the engineering difficulties was the construction of the Urhoode tunnel, 5800 yards long, which entailed the most arduous labour between the years 1895–1906. Midway in the course of the operations about fifty Italians were employed, on account of experience gained in Alpine tunnelling. The Norwegians, however, had only to learn their methods for the Southerners to be discarded, for a hardy Norseman proved equal to any couple of Italians in actual labour. Altogether there are nearly 180 tunnels from end to end of the Bergen–Christiania line.

CHAPTER XXVII

RAILWAYS OF ASIA

The attitude of the bulk of the inhabitants of Asia towards the world at large until comparatively recent times presented no points of similarity with the forceful energy of the European. The Oriental appeared to view the peoples of the Occident with a feeling akin to contempt. Nor was the belief in his own superiority without some semblance of reason, for Asia was the birthplace of the human race, and it was there, and not where the sun goes down, that commenced the records of nations and sovereignties. Western civilisation, however, ignored the aloofness, the exclusiveness of the Orient, and the white man trampled on mere continental idiosyncrasies which begrudged him the tea and cotton, silk and spices which his own sombre environment denied him. Hindustan, long the envy and desire of her immediate neighbours, became the centre of a very maelstrom of European strife and contention, in which English, French, Dutch, and Portuguese intrigued and fought for the coveted prize. When India at length succumbed to physical force and became an appanage of the British Empire, her mental attitude long remained unchanged, in proof of which, after the lapse of more than half a century, the Mutiny peeps from the pages of our history like a ghastly nightmare.

John Chinaman—cunning, tenacious, and virile—for centuries kept the "foreign devil" at arm's length; in the end the persistence of the white man led to open warfare, eventually resulting in the cession of Hong Kong to Britain, and the opening of various Chinese ports to the trading vessels of Europe. But, however much the Chinese hated the white man, they commenced to recognise the value of railways, as shown in 1889, when the Emperor decreed the construction of a line from Peking to Hankow, and other lines speedily were in course of construction. It must be admitted that Russia's great Siberian railway project had much to do with stirring up the Chinese to lay down lines to counteract any Russian aims against the integrity of China.

The case of Japan is unique in the history of nations. In the course of less than two generations the little people broke their shackles, and with feverish impatience commenced to make amends for long ages of somnolent repression. They laid their quick hands upon every mechanical art, including railways; and within the course of but a few years seized upon the thousand and one benefits and comforts of civilisation, which Western peoples had gained only after centuries of application and strenuous effort.

In the last chapter we saw that the "unspeakable Turk" in his European domicile was far behind his neighbours in railway matters; but in Asia Minor, the real home of the Turk, the iron road, until quite recent years, had made scarcely any progress, there being no pressure from outside peoples desiring facilities for international railway services. Nowadays there are various railway schemes in progress that in the course of time will cause Asia Minor to occupy an important place among the railways of the world.

Asia, the largest of the continents, has an estimated population of 830,000,000, of whom about 400,000,000 live in China and 300,000,000 in British India. The railways have a total length of about 60,000 miles, of which more than a half are in India.

INDIAN RAILWAYS

There is no region in Asia in which steam locomotion has made such progress as in India, thanks to its long domination by the British. The country is of vast extent (965,000 sq. miles), and roughly contains one-sixth of the whole human race. The first sleeper was not laid until 1853, and now there are 33,000 miles of railways, of which the greater portion is owned by the State, although many lines are leased to and worked by companies. Some lines are controlled entirely by Native States, and three small lengths of line are worked by foreigners, the largest being a line (51 miles) which connects Portuguese India on the Malabar coast with the lines of British India. Apart altogether from the splendid economic results of railways in India, there has been an enormous moral effect. It was urged originally in many quarters that native prejudice, superstition, and "caste" distinctions would render successful railway working an impossibility, but the railway has broken down these barriers, and the "sweeper" and the native prince alike recognise the beneficent work that has been accomplished. No longer does the lowly native salaam and fall upon his face at the approach of the "fire-horse"; but he knows that, thanks to its agency, frightful famines no longer claim victims by the hundred thousand, since food can now be hurried to the stricken districts, just as in life he can travel to worship at some far-distant shrine, or in death his bones may be carried to rest with those of millions of fellow-worshippers.

Railway construction has been rapid and continuous, and every year sees a considerable increase in mileage. In 1895 the whole

PLATE XIII.

THE BOMBAY-POONA EXPRESS, LEAVING VICTORIA TERMINUS, BOMBAY.

of the Indian lines did not total 20,000 miles; ten years later there were nearly 29,000 miles; and at the present time about 33,000 miles of iron road assist in the commercial and moral progress of the "brightest jewel in the British Crown."

Of the whole of the railways in the country the State lines account for about 25,000 miles. The goods traffic on all the railways amounts to more than 60 million tons per annum, and the passengers carried number about 33 millions. The following are the railways, each owning more than a thousand miles of line:

RAILWAY	MILES OPEN—GAUGE	LOCOMOTIVES	CARRIAGES	WAGONS, ETC.
Bengal and North Western	1,791 (metre)	330	1,010	7,250
Bengal-Nagpur	1,788 (5-ft. 6-in.)	412	950	11,710
Bombay, Baroda, and Central India, and Rajputana-Malwa State	606 (5-ft. 6-in.) 1,774 (metre)	718	2,475	15,970
Burma	1,527 (metre)	305	1,107	7,415
Eastern Bengal State	507 (5-ft. 6-in.) 993 (metre)	369	1,312	8,805
East Indian	2,477 (5-ft. 6-in.)	1,063	1,950	23,120
Great Indian Peninsula	2,900 (5-ft. 6-in.)	950	2,500	13,500
Indian Midland (worked by G.I.P.R.)	1,128 (5-ft. 6-in.)	200	540	3,500
Madras and Southern Mahratta	1,031 (5-ft 6-in.) 1,520 (metre)	478	1,470	9,850
North-Western	4,460 (5-ft. 6-in.)	979	2,335	19,435
Oudh and Rohilk and	1,285 (5-ft. 6-in.)	207	612	6,155
South Indian	446 (5-ft. 6-in.) 882 (metre)	316	1,308	4,976

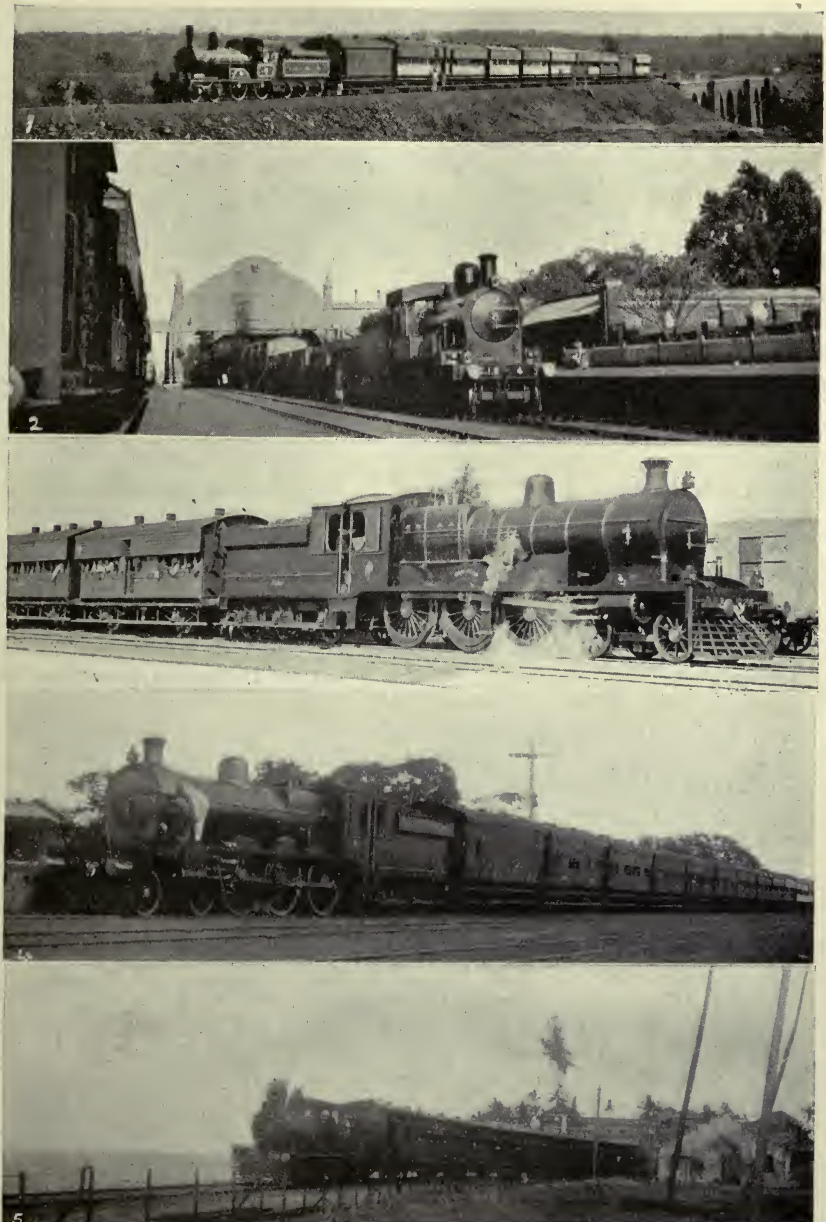
When railway building commenced in India the "battle of the gauges" was raging in Great Britain, and for the Indian lines a middle gauge of 5-ft. 6-in. was adopted, but there are now also thousands of miles of metre gauge.

The great centres of Hindu business and population are widely separated. Viewing Bombay, the nearest port to England, as the starting-point, it is 794 miles to Madras, 839 to Cawnpore, 885 to Lucknow, 982 to Delhi, and 1400 miles to Calcutta; from Calcutta to Tuticorin, in the south, on the Gulf of Manaar, it is 1700 miles, while from the last-named place to Peshawar, in the north, the railway journey occupies nearly a week. Along the great trunk lines postal expresses are booked at 40 miles per hour, and some of the best passenger trains over some sections accomplish 50 miles. The average running, however, is from 25 to 35 miles per hour. In some cases lines were constructed hurriedly for famine-relief purposes, and thus the permanent-way will not stand heavy trains at a great speed. Much time is wasted at stations, in some cases because dining-cars are not yet the general rule, but more particularly because the Hindu temperament is opposed to hurry and bustle. The native passenger usually arrives upon the platform many hours before the train is due, and when it arrives he is painstakingly deliberate in his movements.

Mail trains are particularly heavy, having to provide for no less than eight classes of passengers. There is a distinct provision for Europeans and natives, and females have separate compartments. The cushioned backs of the seats of the first and second class coaching-stock can be lifted into a horizontal position so as to provide sleeping accommodation. Many first and second class

AN ACCIDENT CAUSED BY THE SUBSIDENCE OF THE LINE AFTER A FLOOD ON AN INDIAN RAILWAY

native passengers take their own bedding with them, and third-class passengers are usually loaded with domestic paraphernalia, even to an oil-stove for cooking curry and rice *en route*. At all stations a water-carrier patrols the platform with a goatskin full of water to replenish the brass pots, which the natives eagerly hold out of the windows. The dispenser of water must be of high caste, or a Brahmin would suffer the worst pangs of thirst rather than accept a refreshing draught at his hands. The higher-class European passenger generally prefers to provide a dozen of soda-water and 20 lbs. of ice in his compartment, the latter being useful for lowering the temperature of the carriage, which across the plains may be 110 degrees in the shade. Even on the mail trains fares are low, about 1d. a mile for first-class, ½d. for second, while the third-class rate is 5 or 6 miles for a penny, and still cheaper on ordinary trains.



1. EXPRESS TRAIN (Indian Midland Railway)
2. JUBBULPORE STATION (East Indian Railway)
3. EXPRESS TRAIN (Bengal–Nagpur Railway)
4. MADRAS–CALCUTTA MAIL TRAIN (Bengal-Nagpur Railway)
5. TRAIN BETWEEN COLOMBO AND GALLE (Ceylon Government Railway)

The phlegmatic Hindu never travels for pleasure, and consequently excursion trains are rare. There are pilgrim specials to various famous religious resorts at certain periods of the year. These trains often cause the authorities considerable perturbation, especially when large batches of natives from a plague-stricken village decide upon a religious pilgrimage to a spot hundreds of miles away, involving the danger of importing the dread disease into a district that is not afflicted. In these cases medical men travel with the trains; they examine the passengers at frequent intervals, and quarantine all doubtful cases.

Many Indian passenger carriages are fitted with sunshades or awnings, but in the newest stock, on the Great India Peninsula Railway, for example, they are omitted in favour of a layer of non-conducting material between the inner and outer linings of the sides and roof. Upon the Bombay suburban services on the same railway the first and second class carriages are furnished with electric fans; and in the "purdah," or second-class Moslem ladies' compartment, an electric bell is set ringing when the conductor enters the end of the car, thus warning the ladies in time to cover their faces. The G.I.P. was the first railway to upholster third-class carriages and to provide Venetian shutters to the windows.

Formerly the three classes of passenger vehicles were painted in different colours. On the Madras Railway (the last of the old guaranteed lines, purchased by the State in 1907) the first-class carriages were white, second-class, dark green, and third-class, dark red; and as the sunshades were red-brown, a train was nothing like as neat in appearance as a string of carriages of uniform colour. On the G.I.P.R. the scheme of colouring is the same for all vehicles, irrespective of class; the upper panels are cream, lower panels rich red-brown with umber mouldings lined in cream, while the lettering is in plain gold with black shade. At one time double-decked carriages were used on some Indian railways, but were abolished because they were generally top-heavy.

Indian locomotive practice has been directed largely from London by a Standards Committee consisting of a number of eminent mechanical engineers; and, therefore, the locomotives used in Hindustan on the whole differ from those in use in Great Britain only in minor details demanded by their different environment.

For examples of Indian locomotives we may devote ourselves chiefly to the Great India Peninsula Railway, which is handicapped seriously on its through routes by the Ghat inclines, which occur on both main lines (the one to Jubbulpore and the other to Nagpur). A bordering fringe of mountainous heights runs parallel with the west coast, and as it is up and down this natural barrier that all traffic to and from Bombay over the G.I.P.R. must pass, the very best locomotive power is required.

The Poona race specials are the fastest booked trains in India, and now cover the 62 miles from Bombay to Kalyan in 75 minutes, or exactly at 50 miles per hour; the whole run between Bombay (Victoria) and Poona occupies 3 hours. It was in 1905 that a series of 4–6–0 express passenger locomotives made their advent to achieve several "cuts" in the G.I.P.R. time-tables, notably in the Punjab Mail service and the fast Poona trains. The news spread among the natives of Bombay Island that it was intended to run one of the "Englishmen's fire-carriages" faster than ever, and thousands of men, women, and children congregated along the track and at the stations in the suburbs to see the big engine with its train of handsome vestibuled cars rush along in its race against the first really fast time-table issued in India.

In 1907 appeared some "Atlantic" type express engines, Nos. 900–39, built by the North British Locomotive Co., Ltd., for mail-train service over level divisions, that bear comparison with any locomotives in Europe or America, as shown by some of their leading dimensions: coupled wheels, 6-ft. 6-in. diameter; length of boiler barrel, 15-ft. 6-in., and maximum diameter, 5-ft. 1¼-in.; 201 tubes, 15-ft. 10½-in. long by 2¼-in. diameter; total heating surface, 2037 sq. ft.; total weight of engine, 66 tons 15 cwt.; total weight of tender (10 tons fuel and 4500 gallons of water), 60 tons; total weight of engine and tender, 126 tons 15 cwt.

For hauling heavy passenger traffic over the Ghat inclines, upon which the maximum grade is 1 in 37, powerful eight-coupled tank engines (2–8–4) are employed. Their weight in service is 95 tons. The tanks carry 2200 gallons of water, and there is bunker space for 2¾ tons of coal. These engines will haul 350-ton trains up the incline of 1 in 37 at a speed of 10 miles per hour, and obviate the necessity of much double-heading, that was formerly the case.

To cope with the enormous goods traffic on the G.I.P. system it is customary for the average train to be made up to 1000 or even 1200 tons behind the tender. These immense loads are drawn over difficult gradients by fine specimens of British locomotive design (2–8–0) well calculated to give a good account of themselves in a country where rough treatment is accorded to engines more often than smooth. The chief dimensions of these "Consolidations" are: cylinders, 21-in. by 26-in.; drivers, 4-ft. 7-in. diameter; heating surface, 2079 sq. ft.; working pressure, 180 lbs. per sq. in.; weight of engine and tender in working order, 125 tons. Engines of this type are capable of drawing heavier loads than mentioned above, in which case, however, improved couplings will become necessary.

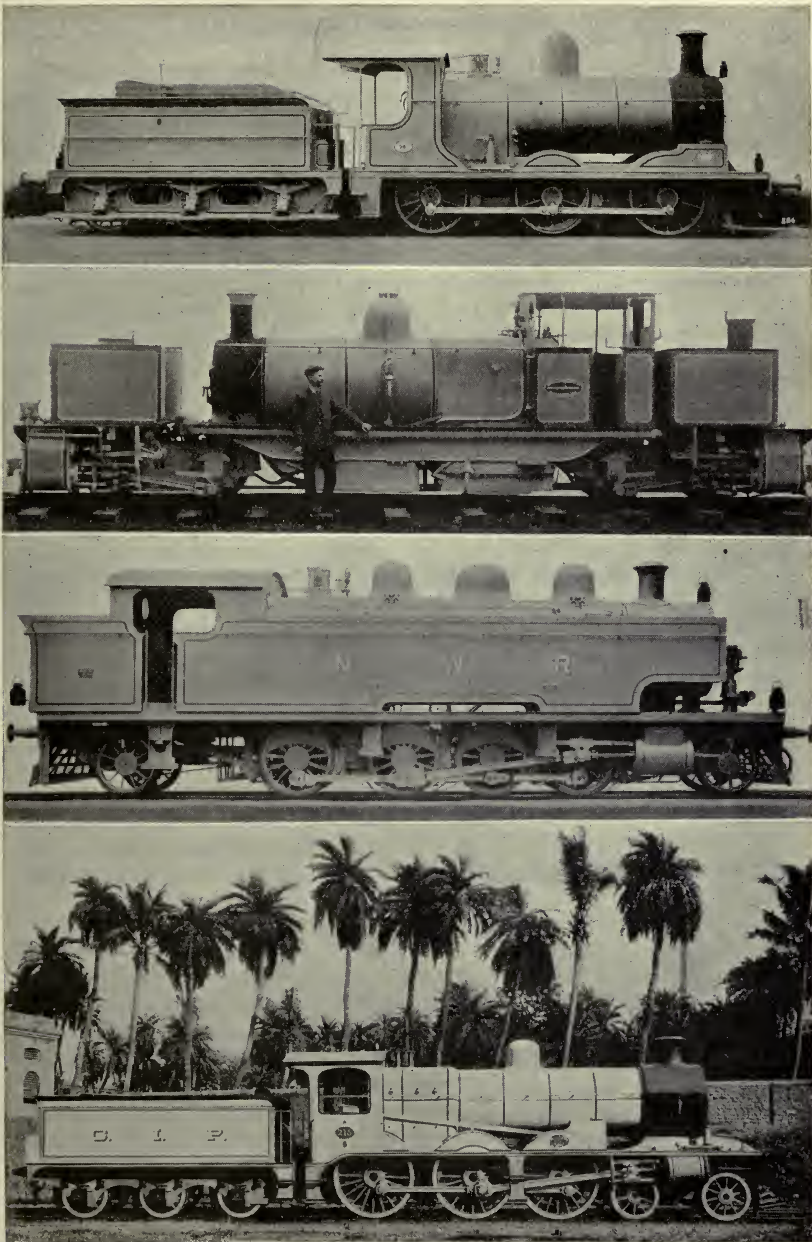
Upon the Bengal-Nagpur Railway the mail and passenger services are worked largely by 4–6–0's, engine and tender in working order weighing 104½ tons. In 1908 a new type, four-cylinder de Glehn compound "Atlantic," was put into service; and the illustration shows an engine suggestive of power while retaining greater simplicity of outline than is found in many

European locomotives of the de Glehn type. The high-pressure cylinders are 13-in. by 26-in., low-pressure cylinders 21½-in. by 26-in.; coupled wheels, 6-ft. 6-in. diameter; heating surface, 1899 sq. ft.; tender has a fuel space of 6 tons and water 3500 gallons; total weight of engine and tender, 112 tons 9 cwt.

On the Burma Railways a modified form of the "Fairlie" type of engine is used for working severe gradients and round sharp curves. They are successful up to a point—their great drawback is lack of speed, for 20 miles an hour over any considerable distance is punishment to a "Fairlie." The first superheater engines in India made their appearance in 1910 on the Madras and Southern Mahratta Railway, namely, four engines of the 2 – 8 – 0 type.

Upon many of the Indian railways wood is the principal fuel employed for locomotive steam-raising purposes. Most of the wood comes from Government forests. Owing to the consumption of wood fuel being nearly double that of coal, while the former occupies relatively a greater space on the tender, it is necessary for an engine to renew fuel on a trip at intervals of from 30 to 40 miles. So far as cost is concerned, wood has the advantage over coal, although Bengal coal runs it closely in that respect. Generally three men occupy the foot-plate of an Indian locomotive—the driver, fireman, and assistant fireman or "augwalla." So many natives are now qualified to take charge of a locomotive, that an English driver is the exception, whereas formerly he was the rule. The Parsees, in particular, make excellent drivers. The fireman is usually a Parsee or Eurasian, but the "augwalla" is almost invariably a Hindu. He does all the hard work of the run, trims the fuel, etc. If he is allowed to manipulate the whistle his joy is boundless. Not infrequently the third hand is of a lazy temperament, in which case he often goes to the front and crouches down on the front buffer beam out of the driver's way.

The East Indian Railway passes through the richest and most populous regions of British India, the main line traversing much the same country as the Ganges, which, until the advent of the railway, was the chief means of transporting the commerce of Bengal and the North-West Provinces. The line was in course of construction at the time of the Mutiny of 1857, and had the railway been completed that disastrous page in our history might have been very different reading. In Cawnpore Church there is a memorial tablet "to the memory of the engineers in the service of the East Indian Railway Company, who died, and were killed, in the great insurrection of 1857." There are inscribed the names of nineteen men, most of whom lost their lives at Cawnpore, Delhi, and Allahabad. In many cases Indian railway stations are some miles distant from the place whose name they bear, for from the Mutiny has been handed down the lesson that it is not advisable to allow the means of communication to be seized quickly by



1. SIX-COUPLED GOODS ENGINE (East Indian Railway)
2. GARRATT LOCOMOTIVE (Darjeeling Railway)
3. EIGHT-COUPLED BANKING LOCOMOTIVE (Mushkaf–Bolan Railway)
4. SIX-COUPLED EXPRESS PASSENGER LOCOMOTIVE (Great Indian Peninsula Railway)

possible enemies ; and, for the same reason, even in places of comparatively little importance, the station buildings are sufficiently substantial to afford Europeans safe refuge if, unhappily, occasion for it should ever arise.

The goods and mineral traffic of the East Indian Railway accounts for about seven-tenths of the gross earnings, the yearly total amounting to over 12,000,000 tons, half of it being coal from the coal-fields of Bengal. Of the 20,000,000 third-class passengers carried, a large proportion is accounted for by the swarms of pilgrims to the holy city of Benares, and many another holy shrine that pious Hindus visit on such occasions as the eclipse of the sun or moon, and at other specified red-letter periods in the religious calendar.

The train of most importance to the European residents in the country is the English Mail, whose progress across Europe was outlined on page 571. Every Friday, a few hours after the mail steamer is signalled as having arrived in the harbour, a vestibuled postal express train, composed of bogie vans of the Railway Mail Service, a first-class corridor sleeping-car, and a dining-car, leaves the Victoria terminus, Bombay, for a run across India of 1400 miles over the main lines of the Great Indian Peninsula and East Indian railways, via Jubbulpore and Allahabad. This train carries the Burma as well as the Calcutta mails. A run of 75 miles out from Bombay brings the train to Kassara at the foot of the Thul Ghat, where two heavy eight-coupled side-tank engines replace the six-coupled express engine, in order to pull the train up 10 miles of ascending grade, with a reversing station half-way up. This stretch of track and its counterpart, the Bhore Ghat, represent two of the most striking engineering feats in India. For 17 miles on the latter line the grade is 1 in 37 and in the section under notice there are twelve tunnels and six viaducts, one of the latter, the Ehegaon, being 190-ft. high.

There is a very heavy suburban traffic on the two railways running into Bombay, for the population of the island is about a million, and there is considerable travel to and from the residential districts and the city, as well as among the various localities where the cotton-spinning industry is of growing importance. On the Great Indian Peninsula Railway there is a frequent service along the main line as far as Kurla (9¼ miles) and Thana (20¾ miles), while a number of fast trains run out to Kalyan (33½ miles) as expresses, stopping only at principal stations *en route*. The Bombay, Baroda, and Central India Railway has a fine double-tracked road into the city, skirting the west coast of the island its whole length. Over the line between Bombay (Colaba terminus) and Bandra (10½ miles) there is almost a half-hourly service of seven bogie-car trains drawn by six-coupled tank engines.

Upon special occasions Indian locomotives accomplish performances in the way of speed far above the everyday bookings. On April 29th, 1904, His Excellency Lord Curzon of Kedleston left Simla for Bombay, *en route* for England. From Kalka, the commencement of the broad gauge (5-ft. 6-in.), to Bombay is a distance of 1139 miles, which was traversed in 39 hours 58 minutes. The last stretch, Kalyan to Bombay (32 miles), occupied 40 minutes.

When the Prince of Wales (afterwards King Edward VII) visited India in 1875, the railways were a medley of small and disjointed undertakings. The palatial Victoria terminus, Bombay, was not in existence, and the royal train of eight small four-wheeled carriages, drawn by a small four-coupled eight-wheeled engine, started for Kirkee (Poona), from a wooden shed at Parel, being the nearest station to the Government House of that day. In a journey from Bombay to Baroda, in the same train, but travelling over the Bombay, Baroda, and Central India Railway, a ludicrous incident happened at the start from the Churchgate Station. The carriages were of different standards, and scarcely two pairs of buffers were of the same level ; and, consequently, when the train was being shunted, some of the vehicles became "buffer-locked," and it took the exasperated railway officials a considerable time to free them, and bring the train to the platform. Upon the return journey there was another *contretemps*. H.H. the Gaekwar gave his august visitor so many presents that they had to be stowed in some extra vehicles that were attached to the royal train. The only stock available happened to be old third-class carriages that had been out of service for some time. The result was a succession of delays owing to hot boxes, which culminated in the offending vehicles being left behind. When our present monarchs (then Prince and Princess of Wales) visited India in 1905–6, they travelled about the country in palatial vestibuled trains replete with the latest refinements of modern travel, over trunk lines which link up even the most distant parts of our great Indian Empire.

The visit of Their Majesties the King-Emperor and Queen-Empress to India in December, 1911, was unique in the annals of the worldwide Empire over which His Imperial Majesty rules, for never before had the Sovereign left the centre of the Empire to visit his dominions over the seas. The various Indian railway companies made the most complete arrangements for the speedy and safe transit of the august visitors and their staff.

The East Indian Railway placed at the disposal of Their Majesties the most comfortable and luxuriously equipped train in the East. It measures 699-ft. 10-in. over buffers, and has an approximate weight of 427 tons, the ten vehicles of which it is composed comprising two royal saloons, one dining and one kitchen car, three saloons for the use of the staff, one combined dining and sleeping carriage for the European servants, and two brake vans. Each saloon, with the exception of the two brake vans, measures 71-ft.

8-in. over buffers, or 68-ft. $2\frac{1}{2}$-in. over the body, weighs 45 tons, and is carried on six-wheeled bogie trucks of special design. The two brake vans, which are carried on four-wheeled bogie trucks, measure 63-ft. 3-in. over buffers, and weigh 35 tons each.

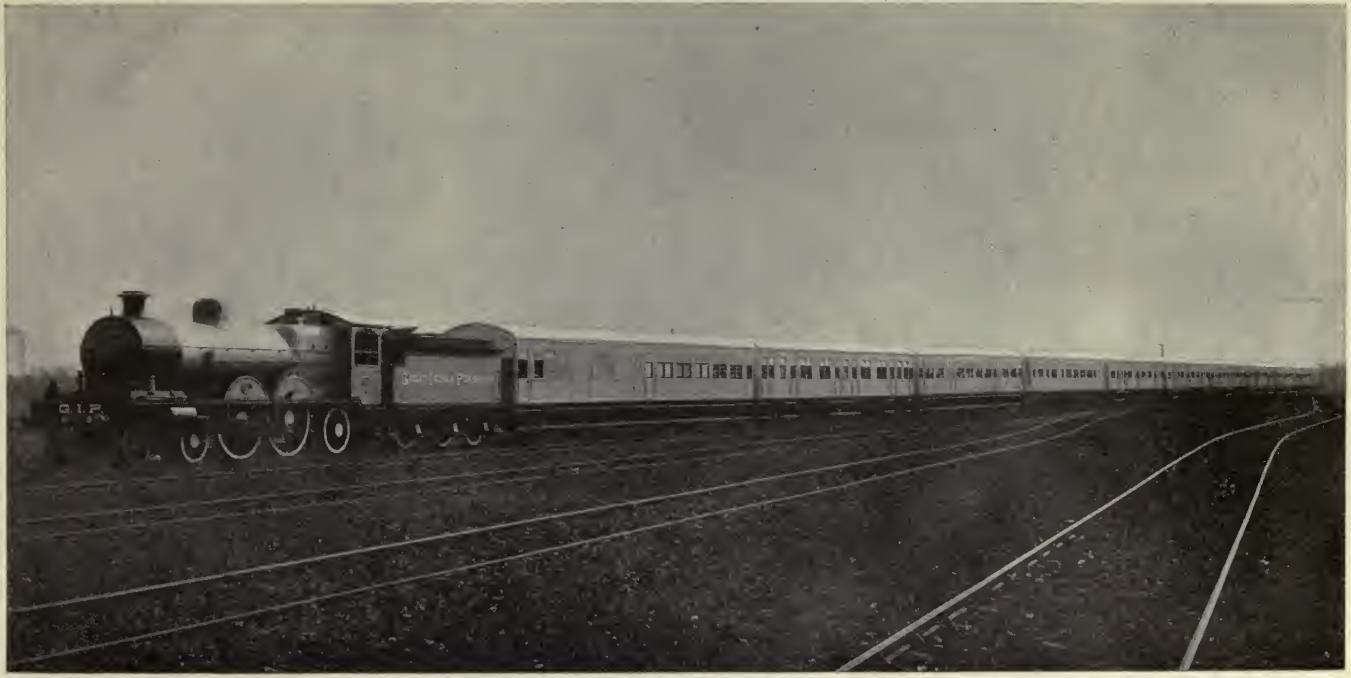
The train is corridor-vestibuled throughout. The saloons have an entrance through an open verandah of Pullman type and are fitted with massive hammered-iron gate screens.

The carriage roofs are clerestoried throughout, which allows for a thoroughly satisfactory system of ventilation. In the clerestory the electric lights and fans are fitted, power for these and the heating arrangements in the saloons being obtained from dynamos fitted to the under-frames of the carriages. Sunshades have been discarded, and, in place of these, heat-resisting materials have been used in the body side panels and roofs, with the result that the carriages are as cool and considerably lighter for traction. The bodies are constructed of Moulmein teak, and the under-frames and bogie trucks of steel. The train is painted white outside, the mouldings being picked out with gold lines. The royal coat-of-arms is displayed on the lower body-panels on each side of all the vehicles, and the arms are also embossed on the verandah gates of the two royal saloons, which are marshalled in the middle of the train.

The two royal saloons for Their Majesties' use are identical in interior arrangements. Each contains a day saloon and night apartment, measuring 18-ft. by 8-ft. 6-in. and 17-ft. by 8-ft. 6-in. respectively; a bathroom, 12-ft. by 6-ft. 6-in., and compartments for valets and maids, together with necessary box-rooms. For the internal decoration, polished Spanish mahogany, birds'-eye maple, and sycamore, picked out with mouldings of rosewood and teak have been used, care being taken to blend and to preserve the natural colours of these different woods. The floors are covered with Axminster carpets.

The furniture in His Majesty's saloon is upholstered in dark green morocco, and that in Her Majesty's in green silk tapestry. The tables, roll-top writing-desks in His Majesty's and escritoire in Her Majesty's, are finished off in keeping with the other decorations of the compartment. In the sleeping-apartments the bedsteads are of Cuban mahogany, inlaid with bird's-eye maple and rosewood mouldings, the royal arms appearing on diamond-shaped panels at the head and foot. The other furniture in these apartments consists of a dressing-table, hanging wardrobe, table and chairs, etc.

The dining-saloon is 50-ft. long by 8-ft. 9-in. wide, panelled in rosewood, walnut, and English oak. It accommodates twenty-four persons at eight side-tables, having four and two seats respectively. Between the tables is a whatnot of polished walnut and oak, for holding table accessories. The furniture, which includes a large



ROYAL TRAIN DRAWN BY "QUEEN EMPRESS"
(Great Indian Peninsula Railway)

sideboard, is of figured Spanish mahogany and oak. The chairs are upholstered in dark green morocco. Eight electric fans and ventilators, and sixteen lamps, with a total of 128 candle-power, with frosted glass shades, are fitted in the roof.

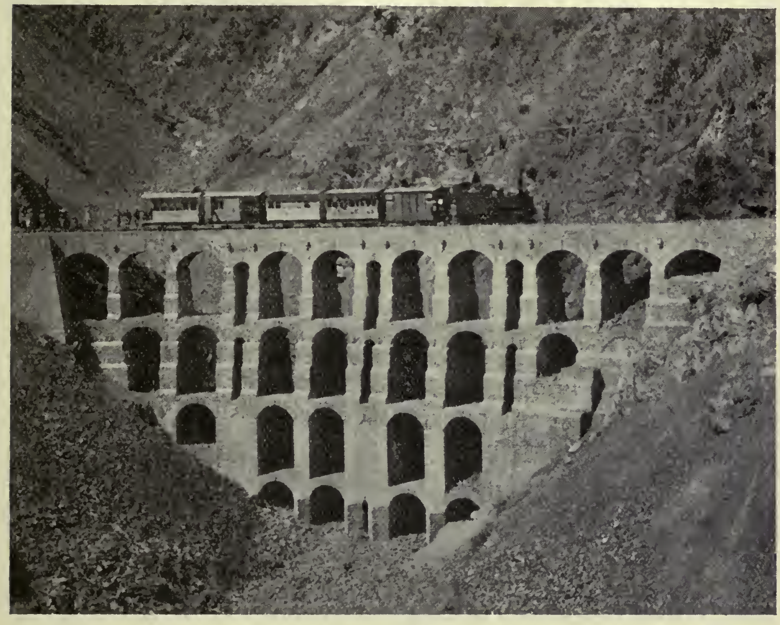
All the metallic fittings in the saloons, bed and bath rooms, including the electric lights and fans, switches, etc., are oxidised-silver finish.

Of various "supplemental" royal trains, one was provided by the Great Indian Peninsula Railway. This train consisted of eleven bogie cars, built at Parel Shops, Bombay, in 1911, and included a restaurant car, laundry car, etc., as well as a strong-room for the conveyance of the Crown Jewels. For the visit of the Queen-Empress to Kotah this G.I.P.R. train was requisitioned. It was headed by the "Atlantic" type locomotive, No. 922, "Queen Empress," formerly "Lord Clyde," one of the engines described on page 597. For working royal specials G.I.P. engines were painted dark blue with chocolate framing, gold lines, etc., with brass tops to the chimneys and bright brass domes. The Bengal-Nagpur Railway four-cylinder de Glehn compounds were painted green, while the Bombay, Baroda, and Central India Railway engines were painted black as usual.

The Burma railways operate about 1530 miles of metre-gauge track, connecting different centres of the country and terminating at Rangoon. Among various types of locomotive that have been used in Burma in addition to "Fairlies" already mentioned, are oil-burning engines on the well-known Holden system. In 1911 some new articulated Mallet compounds for service on the heavy grades were built by the North British Locomotive Co. They have cylinders 15½-in. and 24½-in. by 20-in., with driving wheels 3-ft. 3-in. diameter. The boiler is pressed to 180 lbs. per sq. in., and has a total heating surface of 1513 sq. ft.; total weight in running order, 58¼ tons. The tender has a coal space of 270 cubic ft., carries 2000 gallons of water, and weighs 31⅓ tons. Railways will doubtless play an important part in the progress of Burma when they are linked up, on the one hand, with the Assam-Bengal line, and on the other with the railways of China.

Railway travelling in India, on the standard and the metre gauge lines, has reached so high a level of general excellence that more need not be said of them, leaving us free to note a few railways that differ from the majority of lines in some outstanding particulars.

The Kalka-Simla Railway (2-ft. 6-in. gauge) connects Simla, the head-quarters of the Government of India during the hot weather, with the trunk lines of the country via Kalka, the terminal station of the East Indian and the Great Indian Peninsula railways. Simla is 7116-ft. above sea-level, and until 1903 it could only be reached by "tongas," or native carts. From Kalka the line ascends the spurs of the mountains at a gradient of 1 in 33, and where the spurs are not of a favourable nature the engineers resorted to tunnelling. The ridges are connected by "saddles" of varying heights. In spanning mountain gorges and ravines, masonry structures, called "galleries," are usually employed, instead of girder viaducts. These "galleries" somewhat resemble Roman aqueducts, consisting of tiers of arches, rising one above the other until rail level is reached. Tank engines work the passenger and goods traffic. The carriages and wagons have a loose wheel on each



A "GALLERY" ACROSS A GORGE
(Kalka–Simla Railway)

axle to take the curves, which are as sharp as 120-ft. radius. Passenger trains are limited to a speed of 15 miles per hour.

There are various mountain lines in India, e.g. the Nilgiri Mountain Railway (part adhesion and part rack), that would afford interesting reading, but none can compete with the Darjeeling Himalayan Railway, which twists and twines and zigzags amid the snow-clad peaks of the greatest mountain range in the world, to within sight of Mount Everest, and within 200 miles of the city of Lhasa, the holy and "forbidden." From Bombay this railway outpost may be reached by train, with no more trouble or fatigue than would be incurred in a railway journey from London to Switzerland or Italy.

The fast and direct run from Bombay to Calcutta in 36 hours need not be detailed. From Calcutta the passenger can take the vestibuled mail train of the Eastern Bengal Railway as far as Damookdeah on the Ganges, a distance of 116 miles, which is covered in 3 hours 24 minutes. The " Darjeeling Mail " (all classes) is a heavy train, generally hauled by a 4 – 4 – 0 with 6-ft. coupled wheels. On the other side of the river is Sara Ghat, the terminus of the metre-gauge section of the railway which forms the next link in the chain of travel. For the next 210 miles 4 – 6 – 0 locomotives of the Indian standard metre-gauge pattern haul the comfortable and well-equipped trains to Siliguri, from which point the gauge is reduced to 2-ft. Passengers and mails are transferred to the " Limited Mail " of the Darjeeling Himalayan Railway, with its severe gradients and remarkable curves of the 51 miles of track, terminating at Darjeeling.

After 7¼ miles of gradients averaging 1 in 281 the serious work commences, for practically the rest of the line is at a constant gradient of 1 in 30 until Ghoom is reached, 7407 ft. above sea-level. Various expedients are resorted to in order to keep the gradients from becoming impossible. One device is the American " switchback," or reverse, the train entering a dead end, from which it is reversed up another gradient into another dead end, whence it goes forward on its journey. Particularly interesting are the spirals or loops in which the line winds along the spurs of the hills. In one instance two complete turns are made within a very small area, accomplishing a 140-ft. rise in the process. In the photograph of one of the loops a train is shown about to cross over a bridge which only a few moments earlier it passed under. Occasionally two engines are required to haul the few carriages up a difficult slope, for in places the gradient is 1 in 23. At Kurseong, 31 miles out and 4864-ft. high, the train stops to enable the passengers to lunch, during which time the engine is coaled, watered, and the fire cleaned. Passengers generally take the opportunity of donning warmer clothes. Resuming the journey, the steep ascent continues until Ghoom is reached, from which point there is a 4-mile descent of 1 in 31 to the terminus at Darjeeling, the " Queen of the Himalayas."

The " Limited Mail " usually consists of eight vehicles drawn by a tank engine (0 – 4 – 0), with 2-ft. 6-in. wheels, their centres only 5-ft. 6-in. apart. In working order the engine weighs 14 tons, and can haul a load of 50 tons up a gradient of 1 in 25.

In the early part of 1911 Messrs. Beyer, Peacock & Co., Ltd., built for this railway a locomotive (0 – 4 – 0 – 4 – 0) on the Garratt principle. It consists practically of two locomotive bogies, fitted with cylinders and other gear, and an intermediate girder frame, on the ends of which the bogies pivot, and which also carries the boiler. This arrangement allows extreme flexibility to the bogies in every direction, and at the same time a boiler of relatively large dimensions. The water and coal are carried on the bogie frames, the leading bogie having a tank to hold 400 gallons, while the trailing bogie carries a combined tank and bunker, with capacities for 200 gallons of water and 1 ton of coal. There is also a wide flat tank below the boiler barrel, holding 250 gallons, thus bringing the total up to 850. The leading dimensions of the engine are: four cylinders, 11-in. by 14-in., one pair driving the coupled wheels of each bogie; diameter of wheels, 2-ft. 2-in.; wheel-base: each bogie 4-ft. 3-in., total 24-ft. 6-in.; total length over buffers, 33-ft. $1\frac{5}{8}$-in.; boiler: length of barrel 7-ft., diameter 3-ft. $10\frac{7}{8}$-in. outside

A TRAIN TRAVERSING A MOUNTAIN "LOOP"
(Darjeeling Railway)

largest ring, containing 195 tubes of $1\frac{5}{8}$-in. diameter; working pressure, 160 lbs. per sq. in.; heating surface: firebox 64 sq. ft., tubes 603 sq. ft., total 667 sq. ft.; grate area, 175 sq. ft.; weight in working order: on leading bogie 13 tons 17 cwt., on trailing bogie 14 tons 3 cwt. 3 qrs., total 28 tons 0 cwt. 3 qrs.

The Darjeeling Himalayan line originated in the desire to give the numerous hill tea-plantations ready communication with Calcutta, as well as to afford Anglo-Indians access to cooler regions wherein to find relief from the burning heat of the low-lying plains; whereas the Sind–Pishin Railway from Sibi to Quetta was constructed at the time of the Russian war scare in 1883–7. Built as a military railway, it was the main line to Quetta until 1897, when the Mushkaf–Bolan Railway was completed and opened.

Quetta is a most important and almost impregnable military station, from whence there is a line to Chaman on the Afghan frontier beyond, and only 60 miles from Khandahar, in Southern Afghanistan. The Mushkaf–Bolan Railway, which is a broad-gauge line, commences at Sibi, 451 miles from Karachi, and traverses the Mushkaf Gorge and Bolan Valley, above flood-level, to the plateau whereon Quetta is situated. It was a bold project, carried through a treeless and almost waterless country, and necessitating very heavy engineering works. The heat in the Mushkaf Gorge is terrific in summer, the bare rocks retaining and reflecting the heat. Thousands of the workmen left their bones to bleach along the route of this railway, which the safeguarding of our Indian Empire demanded should be built in the face of all obstacles. Of the tunnels, bridges, safety sidings, and terribly severe gradients there is no space to tell, but we may conclude with a few extracts from a letter sent to the *Locomotive Magazine* from a correspondent on the spot :—

"The most interesting part of the line is between Mach and Quetta. From Mach upwards it is a very stiff pull and the trains crawl up at a snail's pace, and I have actually known cases where we got out and walked by the side of the train. The fast trains from Karachi are generally worked by some heavy four-coupled bogie engines till at Sibi the trains are taken over by the eight-coupled tender engines, assisted up the bank by the eight-coupled tanks.

"In wet weather it is an anxious job to get the trains up the stiffest gradient, and even in dry weather the task is a heavy one for these powerful and heavy engines. The drivers have to be very careful in coming down as well, and the speed is not more than ten miles an hour. At frequent intervals are what are known as emergency sidings, so that should the driver by any chance lose control the train is switched off on to one of these sidings, which run up a very steep gradient to a stop-block. I have never heard of them being used for a passenger train, but once, I remember, a heavy bogie truck, full of stone, was allowed by the natives in charge to go down too fast, with the result that the stop-block was demolished, and they are still looking for the natives. But accidents are few and far between considering the dangerous road.

"Dotted along the line at short intervals are watch-towers, so that every part of the line is always under observation. This is a very necessary precaution, for the hill tribesmen are not at all to be trusted, and, apart from ordinary traffic, the line is most important from a military point of view. Even the guards carry revolvers, and these little articles come in very handy in railway work in that part of the globe.

"The most important of the tunnels are guarded at each end by strong iron gates. This is a military precaution, though, despite inquiries, I could never find out what was the use of the gates."

CEYLONESE RAILWAYS

The railways of Ceylon, which are under the control of the Government, consist of about 500 miles of line (5½-ft. gauge) and 70 miles of narrow-gauge line (2½-ft.). The first railway to be constructed was the Main Line, which runs from Colombo, in a north-easterly direction, to Polgahawela, and then takes a generally south-easterly course to Bandarawela, 160¾ miles from the starting-point. Serving the great tea districts of the mountain zone, the Main Line is the busiest and most profitable of all the sections. The engineers of the line were presented with a succession of obstacles, especially in the matter of gradients. Between Rambukkana and Kadugannawa, a distance of 13 miles, the line climbs 1400-ft. by means of a ruling gradient of 1 in 45, and a series of difficult curves. About 87 miles from Colombo the "ghat" section commences in real earnest, rising almost continually for 50 miles, much of it at 1 in 44 with curves as sharp as 110 yards radius, until at Puttipola the metals are 6225-ft. above sea-level; and after passing through the summit-level tunnel the line correspondingly falls to Bandarawela.

The Coast Line runs parallel with the coast in a south-easterly direction from Colombo to Matara (98½ miles) via Galle (71¾ miles). The Northern Line, 211¼ miles long, one of the newest sections of the Ceylonese system, extends from Polgahawela (junction with the Main Line) to Kankesanturai in the extreme north. At Colombo are the railway workshops, where a thousand native workmen are employed under skilled European foremen in the construction of carriages and wagons.

The locomotives used on the Ceylonese railways present no particularly striking features. They are designed for working difficult gradients and are British-built. Some 4-6-0 tender locomotives with side tanks on the engine, built by Messrs. Kitson and Co., Ltd., Leeds, are very effective machines. The coupled wheels are 4-ft. 5½-in. in diameter, and in running order the engine weighs 53½ tons. The tender runs on six wheels, a fixed leading pair and a four-wheeled bogie at the back. Five tons of coal are carried and 2700 gallons of water, of which 1800 gallons are in the tender tank and 900 gallons in the side tanks. Of tank engines perhaps none are more noticeable than the 2-6-4 type built by Messrs. Robert Stephenson and Co., Ltd. The cylinders are 19-in. by 26-in.; coupled wheels, 5-ft. diameter; total heating surface, 1323 sq. ft.; water capacity, 1750 gallons; coal space, 3½ tons. In full working order the engine weighs 71 tons 12 cwt., of which 41 tons 10 cwt. rest on the coupled driving wheels.

MALAY PENINSULA RAILWAYS

The federation of the various states of the Malay Peninsula was largely due to the labours and diplomacy of Sir Frank Swettenham. It was a great feat to engineer a grand Durbar at which for the first time in native history the Sultans of Perak, Selangor, Pahang, Negri Selangor, together with rulers of lesser importance, met for amicable conference under the tactful superintendence of the High Commissioner. Of the state of affairs in the Malay Peninsula at that time, it need only be remarked that one of the most charming potentates present at the brilliant gathering was the aged Sultan of Pahang, who had a record of 99 murders to the credit of his own hand.

The Durbar laid the foundation-stone of some sound empire-building, and the territory that was formerly a hot-bed of cruelty and ignorance is now one of the most thriving regions under the British flag. The story of the rise and progress of the Federated Malay States is practically the story of the evolution of rubber cultivation, an immense industry that originated with 22 plants sent to Singapore in 1877. Until the year 1898 nearly all the caoutchouc of commerce was derived from the wild vines or trees of tropical America and Africa; but about that time some sheet rubber prepared from trees planted in Perak was sold in London at 3s. 10d. per lb., and was the first cultivated Para rubber sold in the markets of Europe.

OLD TANK ENGINE, WEIGHT 13 TONS
(Federated Malay States Railways)

When the Malay States first came under British domination it seemed as if coffee cultivation would prove to be the staple industry, but coffee has disappeared in favour of Para rubber. The great alluvial plains between the central chain of mountains and the sea form an ideal home for rubber plants, which can be tapped all the year round, as the distinctions of seasons are practically absent. In 1905 the Straits Settlements exported less than 2000 lbs. of rubber; in 1910 the exports from the Federated Malay States and the Straits Settlements amounted to 12,246,000 lbs., valued at £5,695,000.

Railways have played an important part in the development of the Malay Peninsula; and with the opening of the Johore State Railway, in 1909, it became possible to travel by train for a distance of nearly 500 miles, through the heart of the rubber country. Penang (George Town) is separated from the mainland by a strait nearly 3 miles wide, and consequently a rail journey commences at Prai, the northern terminus of the railway.

The through express, which leaves Prai daily at 8.35 a.m., usually consists of six long bogie carriages, with central corridors and end platforms with connections between. The locomotive at the head is a 4 – 6 – 2 ("Pacific") type, with cylinders 15½-in. by

MODERN TANK ENGINE, 42 TONS
(Federated Malay States Railway)

24-in.; driving wheels, 4-ft. 6-in. diameter; total weight of engine and tender in running order, 76 tons.

On the way through Wellesley Province the course is mainly through rubber plantations. At the end of 21 miles the River Krian is crossed and the State of Perak is entered. A further run of 38 miles brings the train to Taiping, from whence there is a branch line to Port Weld on the coast. Between Taiping and Ipoh (112½ miles), the capital of Perak, an additional six-coupled tank assists the "Pacific" to haul the train over the heavy gradients of 1 in 80. Until the rubber boom set in tin was the chief item in the traffic of this region. At Tanjong Malim (188½ miles) Selangor State is entered, and the train winds among the hills to Kuala Lumpur (242 miles), which is reached almost exactly 10 hours after leaving Prai.

Kuala Lumpur is the head-quarters of the Federated Malay States Railways. About 2 miles distant are the new central workshops of the railway, where nearly 1000 men are employed, a considerable number of them being Chinese. The carriage stock is built almost entirely at Kuala Lumpur; the local timber is excellent; and electric power for driving the machinery is taken from the municipal supply, which is generated at a waterfall some miles away. The F.M.S.R. stock comprises more than a hundred locomotives, 240 passenger carriages, and 2000 wagons.

The express journey is recommenced next morning at 7.12 a.m. At Seremban (288½ miles), the capital of Negri Sembilan, there is a branch line to Port Dickson. Malacca is entered at Kendong; from Tampin (318½ miles) there is a branch to Malacca town, a little over 20 miles away. The next important town on the route is Gemas, on the frontier of Johore State, where the light green F.M.S.R. engine gives place to a Johore State Railway locomotive

ENGINE PUSHING A GIRDER INTO POSITION OVER THE SAYONG RIVER
(Johore State Railways)

painted dark blue. The journey is continued through about 100 miles of jungle country to Johore Bharu (472¾ miles), the terminus opposite Singapore Island. The passengers cross the ¾-mile-wide strait in a small ferry steamer to Woodlands, the station on the Singapore Government Railway. Goods wagons are ferried across, but not passenger vehicles. The construction of a bridge is under consideration, but the depth of water in the channel presents an expensive obstacle.

From Woodlands to Tank Road Station, Singapore, is about 15 miles, making up a total distance of 245½ miles from Kuala Lumpur and 487½ miles from Prai. The Singapore Government Railway employs half a dozen locomotives built by the Hunslet Engine Company. They are painted bright grass-green; the buffer beams are yellow. The cars (central corridors) are varnished teak.

The railways of the Malay Peninsula may be considered to have received more than a fair share of our attention ; but the resources of the region are only just becoming known, and there will be very important railway extensions in the near future. Surveys have taken place already so as to couple up with the Siamese railways, which would place Singapore and Bangkok into direct railed communication. Another possible development is the linking up with the Burma railways, and through them with the Assam-Bengal Railway and India generally through Chittagong. Indeed, it requires a not very vivid imagination to picture unbroken railway connections between Western Europe and Singapore.

RUSSIAN RAILWAYS

Russia owns no less than 10,500 miles of railways in Asia, or very nearly one-third of its European mileage. First we may survey those lines which would form part of a suggested new overland route from London to India. There is unbroken railed communication from Ostend, or any of the French Channel ports, via Vienna and Moscow, to Petrovsk, on the western coast of the Caspian Sea. Here occurs the first break, for there is yet no line round the southern coast of the inland sea, and consequently boat has to be taken to Krasnovodsk on the opposite coast. From that point there is a railway to Merv, an oasis in Turkestan, and a most important strategic position in Russian Central Asia. From Merv there is a line to Kushk, on the border of Afghanistan, which country possesses no railway, except a short local line at Cabul, the capital.

There is thus a break in the overland route between Kushk and Chaman or Peshawar, the advanced outposts of the Indian railways, from either of which points there is ready access to any part of our Indian Empire. If the two missing links were railed up, it would be possible to travel from London to Calcutta by the following stages and approximate times :

London to Moscow ..	2131 miles ..	$3\frac{1}{2}$ days.
Moscow to Merv ..	1700 ,, ..	$3\frac{1}{2}$,,
Merv to Peshawar ..	600 ,, ..	1 day.
Peshawar to Calcutta ..	1400 ,, ..	3 days.

a total of 11 days, whereas the quickest journey from London to Calcutta by the present overland route via Brindisi and Bombay occupies 13 days.

There is, however, a project to connect India to Europe by rail without touching Afghanistan. The route suggested is from Baku to Teheran, the capital of Persia, and from thence to Ispahan, Yezd, and Kerman, and across Seistan and Baluchistan to Quetta.

Reverting to the Russian railways, we come to the transcontinental line of Siberia, which brings St. Petersburg into direct communication with Vladivostok, 7680 miles away. The scheme was originated by the late Czar Alexander III, but it was the opening of the Canadian Pacific Railway that caused Russia to grasp the real importance of a band of iron all across her vast dominions from the banks of the Neva to the shores of the Pacific. Three routes had been discussed at various times, viz. via Ekaterinburg or Nishni Novgorod, or Ufa and Cheliabinsk on the eastern slope of the Ural Mountains. The last named was selected, and from Cheliabinsk there required to be laid a line 4700 miles in length to the Sea of Japan. A Committee was organised to carry out the great work, and the first meeting was held in 1893, under the

TRAINS ON THE TRANS-SIBERIAN RAILWAY

presidency of the present Czar, at that time the Grand Duke Tzarevich.

The work was commenced, and at the end of 1895 the rails extended from Cheliabinsk to Omsk (900 miles) ; a year later the Obi River was reached ; and by the end of 1897 Irkutsk was linked up, or 2000 miles of line towards the allotted total. When the line reached the western shore of Lake Baikal, the rails recommenced on the opposite shore, leaving the extremely difficult section round the southern end of the lake for a later stage. When this section was opened traffic was ferried across the lake by steamer in summer ; in winter temporary rails were laid down on the ice.

In the meantime at the Pacific end of the great line the rails had been laid from Vladivostok to Khabarovsk, but when the line from Europe reached Chita, the original plans were changed to avoid the cumbersome and costly route parallel with the Amur. The line left Russian territory to cross Manchuria to Vladivostok via Harbin, from which there was a branch line to Port Arthur, which played a tragic part in the war between Russia and Japan. One result of the struggle was the decision to connect Chita with Khabarovsk as originally proposed, so that the railway from end to end should be on Russian territory, and free from future possible complications, such as had arisen during the war with Japan.

In 1894 the Czar used the following words in speaking of the great project: "The fulfilment of this essential peaceful work, entrusted to me by my beloved father, is my sacred duty and my sincere desire. . . . I hope to complete the construction of the Siberian line, and to have it done cheaply and, most important of all, quickly and solidly." The metals were laid at a fair speed, but it must be remembered that the line is single almost throughout. Apart from the natural difficulties, on the Manchurian section in particular there was trouble from robber bands, who tore up the rails in order to forge them into pikes for offensive purposes, and troops had to be employed to guard the permanent-way. The gauge of the railway is 5-ft.; and as the rails weigh only 54 lbs. per yard, it is impossible to make up heavy trains or to maintain a great speed.

The opening of the Siberian Railway brought the world closer together, rendering it possible to travel round the globe in the space of 33 days. For Siberia, once known as "the cesspool of Europe," the iron road has worked wonders; and instead of being a dumping-ground for criminals and a frightfully repressive Bastille for revolutionists, the southern portion of the vast country promises to become one of the granaries of the world. The great transcontinental line has communication with Merv via Orenburg and Tashkent, and thus by a roundabout route there is unbroken connection between Ostend and Kushk (see page 613).

CHINESE RAILWAYS

The history of railways in China commenced with a short line between Shanghai and Wusung, which was opened in 1875. It was constructed by British capitalists without waiting for the permission of the Government, in the hope that the success of the line would win approval and lead to large railway enterprises in various parts of the vast empire. Popular feeling was against the Shanghai–Wusung Railway from the commencement, but when a Chinaman was run over and killed the rage of the Chinese knew no bounds. Forthwith the Government purchased the railway;

the permanent-way was torn up; the rails, sleepers, and rolling-stock were consigned to the island of Formosa, where they were dumped on the shore, and in due course were buried in the mud and sand. We illustrate one of the two locomotives that ran upon this ill-fated railway. They were built by Messrs. Ransomes and Rapier, to whom we are indebted for the photograph, which shows a few coolies placing an engine (weight 30 cwt.) on the rails.

In 1886, with the approval of Li Hung Chang, a short line was opened to connect the coal mines of Kaiping with the mouth of the Peiho River at Taku. The "Rocket of China," the first 4-ft. 8½-in. gauge locomotive in the country, was built in 1881 at the works

THE FIRST LOCOMOTIVE IN CHINA

of the Kaiping Mining Co. by Mr. C. W. Kinder, the present general manager and engineer-in-chief of the Imperial Chinese railways. The engine is still engaged in shunting at the Tongshan works. The utility of this railway proved to the Chinese the possibilities of the Western innovation, and the fact that the Japanese were constructing railways was not without its effect on John Chinaman. Nevertheless, only about 300 miles of track had been laid by the end of the century, about which time the Chinese railways were commenced in real earnest. At the end of 1910 there were 5200 miles of completed line, and before another decade has passed there is reasonable prospect of an additional 10,000 miles being constructed. In a recent article, accompanied by a very serviceable map, Mr. Stafford Ransome, M.I.C.E. (Editor of *Eastern Engineering*), said: "In many ways the map of China to-day affords the most extraordinary railway chart that has ever been seen. It shows not only an important system with main lines running between important points, but a number of isolated railways running apparently from a point of no particular importance to another equally insignificant. It shows lines begun apparently at the wrong end and others which are begun in the middle, and sometimes at a point where it seems almost impossible to have obtained the necessary materials without a vast expense. . . . The building of railways in China is the history of a veritable modern railway Babel. The British, French, Belgians, Germans, Russians, Japanese, Americans, and Portuguese have all their fingers deeply implanted in the financial and engineering railway pie, while Austrian, Italian, and other engineers are also to be found dotted about the country, surveying and taking part in the construction of one or another of the sections of this very mixed system."

Of the nineteen open railways we propose to note briefly only the most important. In Northern Manchuria is the so-called Chinese Eastern Railway, which is really a section of the Trans-Siberian Railway, and is under Russian control. The main line enters Manchuria from Siberia at Manchouli and leaves it on the east at Suifenho only—miles from Vladivostok. From Harbin there is a branch line southwards to Kuanchengtzu. This railway (5-ft. gauge) is 1077 miles in length.

The South Manchurian Railway runs southwards from Kuanchengtzu via Mukden to Port Arthur. There are branches to Newchang, Fushun, Antung, etc., making a total length of 719 miles, the whole system (4-ft. 8½-in. gauge) being owned and controlled by the Japanese, since the conclusion of the war with Russia.

The Imperial Railways of North China have a total length of 601 miles, all 4-ft. 8½-in. gauge, and under British and Chinese capital and control. The main line runs from Peking via Tientsin to Mukden with a branch from the capital to Tungchow, and one from Kowpangtzu to Newchang. At the railway works at Tongshan several thousands of Chinese are employed under the supervision of foreigners. The capacity of the works is about twenty new engines per annum, the raw material being imported chiefly from America and the United Kingdom.

The Peking–Kalgan Railway, 124 miles long (4-ft. 8½-in. gauge), is Chinese built and owned. We illustrate one of three large twelve-wheeled articulated compound locomotives on the Mallet system, constructed by the North British Locomotive Co., Ltd., in 1908. The conditions governing the design were, the haulage of heavy loads round curves of 500-ft. radius and up long gradients of 1 in 30. The following are the leading dimensions: high-pressure cylinders 18-in. by 28-in., low-pressure cylinders 28¾-in. by 28-in.; diameter of coupled wheels, 4-ft. 3-in.; working pressure, 200 lbs. per sq. in.; heating surface, 2591 sq. ft.; total weight of engine, exclusive of tender, in working order, 96 tons. The tenders for these engines were built in China.

The Peking–Hankow Railway commences a few miles south of the capital, with which it is connected by a short line controlled by the Imperial Railways of North China. Originally this railway was built under a Franco-Belgian concession, but has since been taken over by the Chinese. The whole of the system is of 4-ft. 8½-in. gauge except a short branch of metric gauge. A photograph is appended showing a train on this railway passing through the wall that surrounds Peking.

The Canton–Hankow Railway, of which at the time of writing only a portion is completed, will eventually attain a length of 750 miles, including several branches. It is Chinese owned and Chinese constructed under the supervision of British engineers.

The Canton–Kowloon Railway (4-ft. 8½-in. gauge) is a line that is of vital importance to British trading interests. From Kowloon to the British frontier, a distance of 23 miles, the railway is wholly British, while the remaining 89 miles to Canton are Chinese. It is not its length that makes the British section of the railway important, but the fact that it has ensured that the southern terminus of China's great trunk system shall be in British territory; for when the line is completed there will be unbroken railway connection between Peking and Kowloon, thus preserving Hong-Kong's future as the distributing centre for South China.

Although comparatively short in length, the British section of the Canton–Kowloon Railway provided numerous engineering difficulties. The track follows the coast-line for about 8 miles, and the rails had to be carried across numerous deep bays, where the soft silt provided the poorest of foundations, calling for heavy deposits of rubble. Undoubtedly the most difficult feature of construction was the tunnel work, which comprises ten per cent of the total length of the section. First of all a number of miners were imported from India, as the local natives could not be induced to undertake underground work. Later, however, returned coolies from South Africa were engaged, and as time went on a good deal of local labour was employed. On the whole the Chinese were found to be far better workmen than the Indians, especially at hard rock. Portions of the tunnel work were let out on contract to Italian contractors, whose methods of organisation were very highly praised. There are no fewer than twenty-nine bridges in the course of the 23 miles.

One of the biggest works in connection with the undertaking was the reclamation at Kowloon, for the terminal yard, goods sheds, etc. The extent of this work may be imagined when it is stated that it covers some 41 acres, and that eventually there will be about 7 or 8 miles of sidings here, which will connect with warehouses and godowns. A large amount of labour was expended in this enterprise and the work was expedited by bringing into use a standard-gauge track over which earth, etc., was conveyed from the heavy cuttings for the filling in, by wooden dump cars, hauled by engines belonging to the regular rolling-stock of the railway.

The whole of the rolling-stock for use on the section is British built and of the most approved type. Of the first four locomotives, two are heavy six-wheeled coupled side-tank engines built by Messrs. Kitson & Co., Leeds, and pieced together on arrival at Kowloon. The total weight of these two locomotives is 89 tons

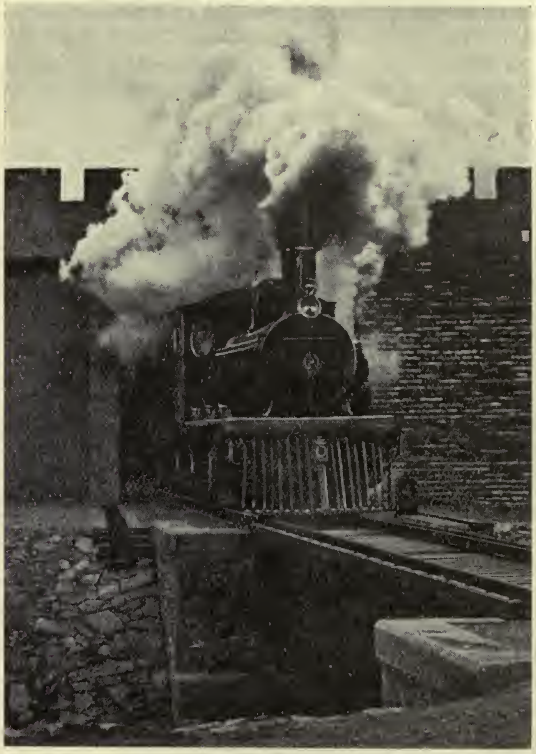
TWELVE-WHEELED ARTICULATED COMPOUND LOCOMOTIVE
(Pekíng–Kalgan Railway)

15 cwt. each. The object in securing engines ot this size is to enable the run through to the frontier to be made without the need of stopping to take in water, and also to render unnecessary the use of banking or assistant engines in negotiating the more difficult gradients of the line. The other two locomotives are also six-wheeled coupled saddle-tank engines of a much smaller type.

For dealing with the goods traffic there are open and covered bogie wagons, each with a carrying capacity of 30 tons and each 33-ft. in length, as well as four-wheeled covered and open wagons of about 14 or 15 tons carrying capacity. The passenger coaches are of the corridor bogie type and are thoroughly up to date, being fitted throughout with electric light and having every convenience provided for the comfort of passengers. The wood bodywork of these was built under contract at the Kowloon Docks, while the framework, wheels, and axles were supplied by British firms.

Of the four important lines under construction the Szechuan–

Hankow Railway doubtless will prove of immense utility. From Hankow it will extend westwards to Chengtu, a distance of about 800 miles. The Chinese, however, are building this line themselves, and lack of funds may delay completion of the full project indefinitely. The section first commenced was the 200 miles between Wansien and Ichang, from which latter point the River Yangtze is unnavigable for heavy traffic. The railway thus will render great service to the commerce of the region concerned in the easy carriage of goods where hitherto transport has been slow and expensive. In addition to meeting local needs, this extension westwards will be a real step towards effecting a junction with the Burma railways and India generally.



A TRAIN PASSING THROUGH THE PEKING WALL
(Peking–Hankow Railway)

Leaving the more immediate railway projects, we may attempt to estimate some important schemes that will revolutionise China in the not very distant future. The Trans-Siberian Railway will undoubtedly have its counterpart in a great central line that will link up with the railways of Turkestan and afford a second route to Moscow. Of greater interest to British commerce, however, will be a southern route across Europe, skirting the southern end of the Caspian Sea, and from thence via Persia to India and from Calcutta onwards to Yunnanfu, from whence there may be a direct line to Canton, and easy communication with all important trading centres via Hankow. The one great gap in this last scheme is

Persia, but Britain and Russia are gradually coming to an agreement concerning the future of the Shah's dominions. At one time it seemed that the southern route would come into being long before the central route, but recent political events in China, which have thrown Mongolia under the protection of Russia, rather indicate that, after all, the central route may take precedence. From whatever aspect these great railway schemes are viewed, it is fairly evident that just as the great Western nations held the eyes of the world in the nineteenth century on account of their progress, so China may reasonably expect that the twentieth century may be hers, for railways will spell a steady improvement in the conditions of life, and will develop the immense natural resources of a nation with 5000 years of traditions behind it.

In discussing the future of railways in Southern China we must not lose sight of French interests in the Siamese Peninsula, where some 15,000 French residents naturally have led to more rapid railway development than otherwise would have been the case. Of the 850 miles open a great proportion has been laid in Tonking, in which region various important extensions are projected, the chief of which is a scheme for tapping Nanking.

JAPANESE RAILWAYS

Railways in Japan commenced earlier than in China, but thirty years elapsed before the country possessed 3000 miles of line. When one remembers that China has constructed about 5000 miles of railways in the last dozen years, there is perhaps a tendency to conclude that Japanese assiduity in seizing upon Western aids to civilisation has been overrated. But Mr. Stafford Ransome reminds us that while "the Chinaman has been pushed and helped and driven by all and sundry to carry out this work, the Japanese, though they employed foreign technical assistance for many years, always decided their railway problems for themselves, financed all their own undertakings, and cut their railway coat according to their cloth."

In the year 1869 there was a rice famine in Kiūshiū, the southern island. There was abundance in the north of the country, but, owing to the poor communications, food could not be brought to the stricken region in time to prevent great loss of life. Sir Harry Parkes, who was then the British representative in Tokyo, urged the Japanese to construct railways with a view to prevent a repetition of the great mortality from famine. The result was the building of an 18-mile line between the capital and Yokohama. There was the bitterest opposition to the project, but when the Mikado himself opened the line in September, 1872, opposition died out, and this initial railway was left to gain converts by its practical utility.

It did not take long for the Japanese to recognise the value of railways, and their natural imitativeness served them well in grasping the salient features of railway work. In 1877 there were 120 British engineers, drivers, foremen, etc., employed by the Railway Administration, but by 1880 only three foreign advisers remained; and at the present time the Japanese are capable of building and operating their railways, constructing their own engines, carriages, and wagons, and even manufacturing their own steel rails.

The present-day railways in Japan have a united length of more than 5000 miles, of which nine-tenths are the property of the State. The locomotives number 2400, carriages 6500, and wagons 37,000. The passengers carried annually number about 150,000,000 and the goods traffic aggregates quite 26,000,000 tons.

The greatest railway engineering difficulties were encountered during the construction of the Tokyo–Takasaki–Karuizawa Railway, which is 88 miles long from end to end. In the last 7 miles between Yokogawa and Karuizawa there is the Usui Toge incline with gradients of 1 in 40 and 1 in 15, the latter necessitating the employment of a central rack rail of the Abt type. For the heavy work on this incline Messrs. Beyer, Peacock & Co., Ltd., of Gorton Foundry, in 1909 built four 2 – 6 – 2 tank locomotives. They are designed to haul a load of 100–120 tons up a gradient of 1 in 40 by ordinary adhesion, and up 1 in 15 by the use of the rack rail at a speed of 5 miles per hour. The locomotives are fitted with the Holden system of liquid-fuel firing, the fuel tank being carried on the top of the boiler. The following are the leading dimensions: cylinders for adhesion wheels (outside the frames) 15½-in. by 20-in., and for rack gear (inside the frames) 11¾-in. by 16-in.; diameter of six-coupled wheels, 3-ft. and of leading and trailing wheels 2-ft.; heating surface, 1268·7 sq. ft.; weight in working order, 57 tons 2 cwt., of which 38 tons 8 cwt. rest on the coupled wheels; capacity of water tank 1520 gallons, and of bunker 70 cub. ft. We illustrate a four-coupled passenger locomotive, fairly typical of the engines in ordinary use on the Imperial Government railways.

In carrying the rails over the Usui Pass it was necessary to construct twenty-six tunnels in the short distance of 2¾ miles. In traversing tunnels the engine is placed behind the train to obviate inconvenience from the heat and smoke. Further, to ensure the comfort of the passengers, as soon as a train has entered a tunnel a curtain is drawn across the lower end, thus preventing the smoke being sucked up along the tunnel by the moving train.

Japanese railways are built to 3-ft. 6-in. gauge, which time and experience prove to have been a mistake; and it has been decided to widen the gauge to 4-ft. 8½-in. The first line to be altered is the

Shembaski–Bakan, the main artery from Tokyo to the south of the island of Niphon, but other important sections will be tackled in due course, especially the Northern Railway from the capital to Aomorie, which will give the central island a wide-gauge service from north to south, while the widening of the section between Marbara and Tsuruga will accomplish the same from east to west. At present Tsuruga plays an important part in the traffic between Vladivostok and Japan, but with the diversion of the European traffic to the Korean route important changes naturally will follow.

Japanese railways suffer much from earthquakes. On October 28th, 1891, the whole of Central Japan suffered from convulsions

4–4–0 PASSENGER LOCOMOTIVE
(Imperial Japanese Railways)

of uncommon severity. Tokyo experienced comparatively slight effects. "From the outskirts of a district covering the Nagoya-Gefu plain, which, roughly speaking, lies half-way between Tokyo and Osaka, news came fast," said *The Times* correspondent; "but as it came it grew more terrible. From the district itself, although it was covered with towns and cities, and through it the trunk line of Japan passes, for some time nothing could be learnt. All was silent. Trains did not appear, and as telegraphic communication had ceased, their whereabouts was unknown. Next we learned that several bridges had been destroyed; then that cities had been shaken down, that many were burning, and that thousands of people had been killed.

"Leaving Tokyo by a night train, early next morning we were at Hamamatsu, 137 miles from Tokyo, on the outside edge of the destructive area. Here, although the motion had been sufficiently severe to displace the posts supporting the heavy roof of a temple, and to ruffle a few tiles along the eaves of houses, nothing serious had occurred. At one point there was a sinkage in the line, and we had to proceed with caution; but farther along the line signs of violent movement became more numerous. The general appearance was as if some giant hand had taken rails and sleepers and rubbed them back and forth in their bed of ballast, piling the sand and gravel into bolster-like ridges. At places where the sleepers held too tightly to their bed, the rails themselves yielded and had been bent into snake-like curves.

"The ground is cracked and thrown into huge waves, whilst near the bridges the embankment has been shot from beneath the sleepers so that the rails remain suspended in the air. The huge masonry piers have almost invariably been cut through near the base, and have then been danced and twisted from their true position. Cast-iron columns and huge cylinders have been snapped in several pieces, much as one might snap a carrot. For twenty-eight miles no stations remain; only platforms and floors, hummocked and thrown into waves, mark their places. For five years the railway works withstood traffic, typhoons, and floods. When they succumbed it was not only to the unexpected, but to the application of forces practically irresistible."

OTTOMAN RAILWAYS

Asia Minor is destined to play a part in railway developments that will prove of far-reaching effect, since the Bagdad Railway may form an important link in an all-rail route from Europe to India. Originally the scheme was known as the Euphrates Valley Railway. A Select Committee of our House of Commons inquired into the subject in 1872, but notwithstanding the expression of a qualified approval the project was allowed to drop. Meanwhile a German company constructed a system of railways from the Asiatic shore of the Bosphorus far into the interior, acquiring the old Smyrna and Cassaba Railway, which was built with British capital. In due course the German concession was ratified allowing for the construction of the railway from Konia to Bagdad, with a view to an extension to Koweit on the Persian Gulf.

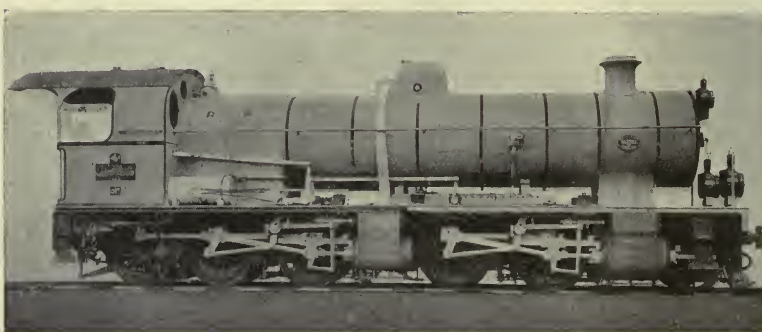
The gauge of the Bagdad Railway is standard 4-ft. 8½-in., and it will need only a tunnel under the Strait of Dover, a bridge across the Bosphorus, and a railway along the shore of the Persian Gulf and across Baluchistan to Kurrachee, for it to be possible for through cars to run from London to the latter city. Unfortunately at the frontier of India a break of gauge would occur, but modern railway engineering would overcome that difficulty, so that a London–Bombay express may yet be possible. By an all-rail route there would be less than ten days between our fellow-citizens in India and the capital of the Empire, the total distance being approximately 6000 miles.

It is quite evident that the Bagdad Railway is the thin end of the wedge that in the end will give Germany possession of Turkey in Asia. Great Britain is not vitally concerned with what Germany does in the western and central portions of the Turkish territory, but that an eastern section of the railway should be under German control is utterly opposed to British interests. "The unfortunate Turk," says *Eastern Engineering*, "though owner of the territory where this conflict of international interests is going on, is little more than an onlooker. . . . If Germany owns and controls the railways and the commerce of the country and fills it full of German residents, railway officials, and no doubt, later on, police, she reckons—and possibly with reason—that she will gain such an ascendancy over the place that she will have obtained actual possession before the lethargic Turk has realised the situation."

In at least one respect the Imperial Ottoman Hedjaz Railway, when completed, will be the most remarkable line in the world, since it is the only railway constructed from purely religious motives. Its sole object is to facilitate pilgrimages to Medina, where Mohammed's body is supposed to lie undecayed, and to Mecca, the metropolis of Islam, which it is the bounden duty of every true Mohammedan to visit at least once in a lifetime. The holy city of Mecca, undrained, unpaved, and filthy, has been for ages a focus of pilgrimage. The great Mosque is capable of holding 35,000 persons, and in the centre of it is the Káaba, which Mohammed declared was built by Abraham. Close at hand is Zemzem, a sacred well, once probably tepid mineral water, but in modern times so largely contaminated by sewage matter, that the Powers demanded that the Sublime Porte should clean out the well, or close it, since European scientists fixed upon it as a source of cholera, which the pilgrims spread over vast tracts of the Old World.

The Hedjaz Railway between Damascus and Medina, a distance of about 800 miles, traverses a region that is mostly desert, and where religious fanatics, opposed to the innovation, are to be added to the serious natural obstacles. The chief stopping-places *en route* are Ma'ân, Tebuk, and Medain Saleh. South of Ma'ân the line descends 500-ft. by means of a long looped curve with a minimum radius of 336-ft. and with gradients ranging from 1 in $55\frac{1}{2}$ to 1 in $62\frac{1}{2}$, followed by a series of curves and gradients less severe. Beyond Tebuk there is a rise with similar gradients. We illustrate an articulated four-cylinder compound locomotive built for service on this hard road, and append particulars of some leading dimensions: cylinders, high-pressure $12\frac{1}{2}$-in. by $22\frac{1}{8}$-in., low-pressure cylinders 20-in. by $22\frac{1}{8}$-in.; coupled wheels, 3-ft. $6\frac{1}{2}$-in. diameter; total heating surface, 1747·01 sq. ft.; weight of engine in working order, 52 tons 3 cwt.; tender with 3960 gallons of water and $4\frac{3}{4}$ tons of coal, 37 tons 18 cwt.

The construction of the Damascus–Medina line was accomplished with more economy and dispatch than is usual with Turkish undertakings, thanks principally to the religious zeal of the workers; and the subscriptions that come in from India, Egypt, and other Moslem lands for the pilgrim railway are expended to the best advantage in the face of many difficulties. Concerning the working of the line, so far as it is completed, matters are more open to criticism. The engine-drivers and mechanics are drawn almost exclusively from the Turkish navy. The desire to employ only Moslems on the railway is quite intelligible, but, nevertheless, is costly.



ARTICULATED 4-CYLINDER COMPOUND LOCOMOTIVE
(Imperial Ottoman Hedjaz Railway)

"The average Turkish engine-driver," says a correspondent, "though sober and fearless, has certain grave defects—a recklessness or fatalism, which has been known to inspire him to descend steep gradients at full speed, or to attempt to jump boulders placed on the line by fanatic tribesmen, whose unwelcome attentions necessitate the establishment of blockhouses for the defence of the railway officials. Generally there is a deplorable untidiness and carelessness in all that concerns machinery, with the result that about twenty per cent of the locomotives on the line are usually under repair, and often expensive machines are irreparably damaged after a life of from six months to a year."

The Turks are engaged in another difficult task in the construction of the first railway in the Yemen, Turkish Arabia, the line being meant for strategical purposes, especially keeping in order various turbulent tribes, against whom hitherto it has been difficult to send troops. It is proposed to build the line from Hodeidah on the coast of the Red Sea to Sanaa, the capital of the Yemen. As far as Hujjeilla, about half the distance of 150 miles, there are no great engineering problems, but the engineers will then be faced by precipitous mountains nearly 10,000-ft. high ; and it is practically certain that a long detour to the south will be necessary to avoid enormous expense and the severest of grades.

Of the 2900 miles of railways in Asiatic Turkey, probably the Jaffa–Jerusalem line of 54 miles is the most interesting to Western nations on account of its Biblical associations. Jaffa (Joppa) was given to Dan in the distribution of the land by Joshua, and Jerusalem is dear to the whole of Christendom.

"East is east and west is west, and never the twain shall meet," sang Kipling, but sufficient has been said in the present chapter to show that the poet was too dogmatic. Railways have made East meet West literally, and more links are in the forging. Morally the iron road already has had an immense effect on the attitude of the Asiatic towards the outside world, ever tending to federate peoples widely different in colour, race, and religion.

CHAPTER XXVIII

RAILWAYS OF AFRICA

THE evergrowing railway conquest of Africa presents features altogether different from what the railway engineer experienced in Asia, since except on the Mediterranean seaboard there were no nations with any pretensions to civilisation. Even as late as the end of the eighteenth century little was known to Europeans of Africa except Egypt and several Moorish kingdoms in the north, a few white settlements chiefly on the West Coast and the Cape of Good Hope. To a large extent the map of the interior remained a blank until three-fourths of the nineteenth century had expired, when various European nations set about the conquest and colonisation of the "Dark Continent" in real earnest, with the result that when the twentieth century dawned, ancient and little Abyssinia was the only kingdom in the whole of the continent that retained its independence.

The Dutch and the British established themselves at the Cape and gradually acquired immense tracts of territory northwards; and finally, when the Boer republics were absorbed in 1902, the British possessions extended in unbroken continuity from Table Bay to the southern end of Lake Tanganyika. Meantime, Egypt had come under British domination, and except for one comparatively small link, British interests extended from the Cape to the Mediterranean; and thus Cecil Rhodes dreamt of a railway from the Cape to Cairo, an idea that speedily caught the popular patriotic fancy.

It would be too much to say that but for Western nations there would never have been any railways in Asia, but it is practically safe to say it of Africa with the exception perhaps of Egypt. In previous pages much space has been devoted to locomotive construction, types, etc., but the present chapter may be devoted chiefly to the consideration of how immense areas are being opened up by the iron road to serve commercial and political needs. Only about a hundred years ago the principal link between Christendom and the Dark Continent was the slave trade, with which our own connection is one of the most hateful of national memories; but the railway already has done much to atone for it; and the Briton

PLATE XIV.

Egyptian Train-de-luxe—Cairo-Luxor Express.

is foremost in laying down the metal strands that promise happiness and comfort to teeming millions, whose forbears knew only barbarity in its most hideous forms. If the continent be taken section by section, noting the railway progress already effected, the reader will be able to estimate what the railway engineer will have accomplished in the not very distant future.

EGYPTIAN AND SUDAN RAILWAYS

It was one of the romances of modern progress for the locomotive to invade the "Land of the Pharaohs," to speed over the sand-drift of the desert beneath which lay the material glories of an ancient empire, just as its political greatness was buried under the debris of the heaped-up ages.

The main line of the Egyptian Government Railways from Alexandria to Cairo is double throughout its distance of 130 miles, and is the only stretch whereon run real expresses. Various sections of the line were opened in 1852, but unbroken traffic was not possible until Stephenson had completed some of the larger bridges over the Nile. It is said that in the meantime these breaks in the connections afforded the Viceroy excellent opportunities of ridding himself of objectionable Pashas by means of special trains that "accidentally" omitted to stop at the river.

From Benha, 29 miles from Cairo, there is a secondary main line to Ismailieh and thence onwards to Suez; while from Tantah, 53½ miles north of Cairo, there is another line to Damietta. Formerly there was a more direct line to Suez, following a fairly straight course across the desert, and forming part of the old "overland route to India and the Far East." Breaking bulk at Alexandria, Cairo, and Suez and camel transport across the desert meant delay and expense which were finally obviated by the construction of the Suez Canal, and this early desert railway reverted to a camel track.

South of Cairo there is one long line as far south as Shellal, a few miles beyond Assuan, but the 4-ft. 8½-in. gauge terminates at Luxor, and thence onward is 3-ft. 6-in. Troubles with the Sudan province made a railway eminently desirable, and the Khedive commenced a new line at Wadi Halfa with a view to the rapid transport of troops to cope with the Dervishes. But when 33 miles of line had been constructed an exhausted exchequer called a halt. At a later period, when the Nile Expedition was in progress, sufficient funds were raised to push the metals a further 53 miles to Akasha. As events turned out it was a pure waste of money, for as soon as the British forces left the Khedive to his own devices the Dervishes "scrapped" most of the track, and Sarras again was left staring into an immense area of blackest barbarity and religious fanaticism, where the Mahdi's sway appeared invulnerable.

It fell to the task of Lord Kitchener to break the power of the Mahdi, and one of the chief agents employed to crush the wily foe was the Sudan Military Railway, which Sir Percy Girouard, a Canadian engineer attached to the Sirdar's staff, pushed across the 234 miles of desert from Wadi Halfa to Abu Hamed. The desert being fairly level and the sand affording a workable foundation, the laying of the steel sleepers necessitated very little ballasting; and the rails lengthened at an average rate of 2 miles a day. The navvies were fellahs raised by conscription, who shovelled for

THE SUDAN EXPRESS

their country while British troops and the Egyptian regulars fought for it.

At Abu Hamed again the Nile was touched and followed by the railway for 149 miles, to where the Atbara joins the great river. Particularly was it required to get the rails past the series of rapids known as the Fifth Cataract, some 20 miles short of Berber, so as to fit together the sections of three gunboats, which were to be utilised in the final advance on Omdurman, the fastness of the Khalifa. Gordon was avenged with the fall of the Dervish stronghold, Mahdism was broken, nay, wiped out, thanks largely to the railway machine which Girouard forged for the Sirdar.

The swelling of the Nile by the flood waters of the Atbara necessitates a particularly strong bridge to carry the railway across the wide and turbulent stream. For campaign purposes a wooden structure served temporarily, but when the time arrived for extending the railway a 1000-ft. steel bridge was an absolute necessity. As first specified, no British firm would undertake to complete the bridge in less than two years, and consequently tenders were invited for a simpler type of bridge with rapidity of construction a vital item. A Philadelphia firm secured the contract at £11 a ton and the work to be completed in 14 weeks, as against the lowest British tender of £15 a ton and 20 weeks. In many quarters there was a loud outcry against British lethargy and

BLUE NILE RAILWAY BRIDGE

conservatism that allowed Yankee hustle to discount our engineering reputation and incidentally our patriotism. Eleven years later, however, when the weight of trains called for a heavier bridge, the American structure was replaced by one of British build.

The railway reached Khartoum in 1899, and in due course the Blue Nile was bridged and Sennar became railhead. From this point the line was carried eastward over the White Nile to El Obeid, in order to tap one of the chief centres of the gum trade; and the bridges at Khartoum and Sennar were triumphs of British engineering in which American bridge-builders had no voice. It must be remembered that the southernmost point of the Egyptian Government Railways is at Shellal, a day's express journey from

Alexandria. Between Shellal and Wadi Halfa the Nile is the traffic artery, entailing breaking bulk and a steamer passage of 40 hours with consequent delay and expense, which led the Government of Upper Sudan to construct a line of 300 miles in length from Atbara to the Red Sea coast. The seaboard terminus is Port Sudan, which has railed connection with Suakin, 50 miles further south. The crossing of the coast mountains where heavy-rain "washouts" caused continual damage, and the desert where water practically was non-existent, caused the engineers equal trouble; but the greatest drawback was the scarcity of native labour, and

TRAIN DE LUXE AT LUXOR STATION

consequently Egyptians familiar with the work had to be imported and housed almost under military conditions.

The railway as a civilising agent finds an excellent proof in its influence on the Sudan, which only fifteen years ago was described as "a monotone of squalid barbarism"; and now Khartoum has been brought within eight days' journey of London. A trip to the city where Gordon perished has become a commonplace, and the Northern Sudan is fast becoming a popular health resort.

The traveller from Cairo to Khartoum has choice of two routes, the "Nile" route and the "Red Sea" route. For sightseeing the former is preferable, but it entails a river journey from Shellal to Wadi Halfa. During the tourist season sleeping and dining cars are attached to all tourist trains on the Sudan Government Railways, and there is every provision to ensure the maximum of comfort. The cars are dust-proof; smoked-glass windows moderate the glare of the sun; and electric fans and special air-cooling apparatus temper the desert heat.

The locomotive history of the Egyptian Government Railways, or the Egyptian Railway Administration as it is called, is of special interest from the fact that the ruler of Egypt in our middle railway era not only largely adopted the best British ideas and methods, but also chose Englishmen for the leading officials.

The first period (1852–70) witnessed the employment of nearly 250 engines, which constituted the most marvellous assortment of types and classes ever collected by one railway. There were British engines from the Midland, London and Brighton, Great Eastern, and Caledonian Railways, with others suspiciously resembling Great Northern and Great Western patterns; four French railways contributed various specimens; Belgian State and Germany had a representative each; America supplied a couple of nondescripts; and then there were other classes designed and built by a number of British makers, which apparently had no counterparts elsewhere.

Stephenson and Co. supplied the first half-dozen six-wheeler engines four-wheels coupled. Five of them were broken up previous to 1890, but No. 1 in 1884 was sent to work on a short length south of Assuan during military operations. It certainly never came north again, and was probably annexed by the Dervishes.

Said Pasha visited the Great Exhibition in London in 1862 and purchased a mixed assortment of engines without any particular regard to their suitability for Egyptian service. One of the most noticeable was a Caledonian 8-footer, which the Pasha required to carry him at 80 miles an hour; but even if the engine were capable of that speed, it is quite certain the Egyptian permanent way would not permit it to be put into practice. Neilson and Co. supplied a couple of similar outside-cylindered locomotives, although it was obvious that inside-cylinders and double frames were best to cope with the frequent sandstorms, that caused endless trouble with the crossheads in the exposed slide bars. In some of his engines Said Pasha gave full play to a pretty taste in decoration regardless of expense, as shown in the illustration of a combined engine and saloon built for His Highness by Messrs. R. Stephenson & Co. in 1862. The engine was a single-driven bogie tank, with the saloon carried on a four-wheeled bogie. Forty years later this machine was still employed to convey the Khedive between his summer residence at Montaza and his palace at Alexandria.

In 1863 Ismail Pasha, a new Khedive, was largely under the influence of Napoleon III and M. de Lesseps, and a year later no less than thirty-three French locomotives were put into service, not a few of them being taken from their work on the Paris, Lyons, and Mediterranean Railway.

From 1870 to 1888 the English heads of the locomotive department enjoyed no sinecure. Not only were no new engines purchased during that period, but Ismail's financial extravagances left little margin for even a few spare boilers. The Egyptian authorities viewed breakdowns or explosions with the utmost equanimity, quite satisfied with the belief that any mechanical contretemps must perforce be the wish of Allah.

Even at the best of times the district superintendents were always at loggerheads with Oriental ideas of punctuality; it was nothing uncommon to have half a dozen engines in steam with only a couple of crews ready to go out. A complaisant native doctor

ROYAL ENGINE AND SALOON
(Egyptian Government Railways)

would give a driver a medical certificate for a bad toe; another would have married a wife—and the Mohammedan's matrimonial ventures occur more frequently than with his British confrère; another afflicted with a plethora of relatives would bury one at inconveniently frequent intervals. Religious excuses were always forthcoming, and it was not wise for an exasperated foreman to interfere in such cases. The engine-cleaners, too, would far rather say their prayers in a dark corner of the running shed than wipe down a locomotive; and half an hour after sending out a dirty engine, would be in the office asking for an increase in wages.

But the British occupation of Egypt speedily reacted on the railways, and Mr. F. H. Trevithick left the Great Western Railway to straighten out matters in the Land of the Pharaohs. In 1889 eighteen new engines were delivered, half a dozen of them being for fast express service between Alexandria and Cairo; they were but larger editions of Mr. Armstrong's "Sir Daniel" class on the Great Western Railway.

In 1898 the increasing sugar and cotton traffic called for forty-five new engines, but as they could not be delivered until autumn, twenty American "Moguls" were ordered from Baldwin's. Although the order was not given until February, fifteen were delivered in June; these American engines were somewhat similar to the "Moguls" subsequently bought by the Midland Railway Company. In 1900 a number of experimental engines were built for the Egyptian Railways; two of them were of the "Atlantic" type, one American-built, and the other by Dübs and Co., of Glasgow. The American engine had an interesting feature in that it could be converted easily from a four-wheels coupled "Atlantic" with 6-ft. 6-in. wheels to a six-wheels coupled "ten-wheeler" with

4-4-2 PASSENGER LOCOMOTIVE "SIRDAR"
(Sudan Government Railways)

5-ft. 9-in. or 5-ft. wheels. The British product had outside cylinders, 20-in. diameter by 26-in. stroke; coupled wheels, 6-ft. diameter; Belpaire firebox, and a total heating surface of 2008 sq. ft.

Of various fine engines designed by Mr. F. H. Trevithick a notable one was the "Lady Cromer," built by a German firm in 1907. It formed one of a series intended for fast trains between Cairo-Alexandria and Cairo-Port Said; and which were modifications of a number of four-coupled bogie tender engines supplied by Messrs. Neilson, Reid, and Co., of Glasgow, in 1901. The "Lady Cromer" was double-framed; cylinders, 18-in. by 26-in.; driving wheels, 6-ft. 3-in.; bogie wheels, 3-ft.; working pressure, 180 lbs. per sq. in.; weight of engine in working order, 55 tons 16 cwt.; tender, 34 tons 16½ cwt. A novel feature provided for pumping the water through a series of heaters, raising it to a temperature of 250° Fahr. before passing into the boiler.

Some powerful passenger locomotives are employed on the Sudan Government Railways, of which No. 110, "Sirdar," is a capital example. This engine was built by Messrs. Robert Stephenson & Co., Ltd., to the designs of Mr. C. G. Hodgson, chief mechanical engineer of the system, whose head-quarters are at Atbara. The gauge is 3-ft. 6-in., and the engine is of somewhat unusual arrangement and proportions for that comparatively narrow gauge. Owing to the sandy nature of the country a relatively low factor of adhesion is permissible; hence the 4–4–2 design as contrasted with the 4–6–2 arrangement so usual at the southern extremity of the African continent. Weight of engine in working order, 53 tons 6 cwt., of which 30 tons 15 cwt. are available for adhesion. The tender, with 9½ tons of coal and 4575 gallons of water, 51 tons 11 cwt.

SOUTH AFRICAN AND RHODESIAN RAILWAYS

The Cape territory originally was settled by Dutchmen in the middle of the seventeenth century, being a place of call for vessels trading between Holland and Batavia; but the colony was ceded to Great Britain in 1814. The British and Dutch settlers did not live amicably together, and at various times the discontented Dutchmen, or "Boers," "trekked" further inland and eventually established the two Boer republics, the Orange Free State and the Transvaal. Natal, as a British settlement, dates back to 1824.

In due course the British and Dutch colonists commenced to construct railways, Natal being the first to enlist the iron horse in the development of its resources in 1860. In the troubled history of South Africa the war of 1899–1902 was an epoch-marking crisis which eventually ended in the annexation of the Boer republics by the British. The Boer railways in particular had been built for their own territorial needs and without any pressing desire to facilitate connections with their neighbours, whereas under the new regime the four great colonies have been united, and thus have brought under one control nearly 10,000 miles of railways with administrative head-quarters at Johannesburg.

The railways of South Africa serve a territory of about 450,000 square miles, while Southern Rhodesia alone is 144,000 square miles in extent, and thus the distances from the coast to important inland centres are very great: Cape Town to Johannesburg, 956 miles; Cape Town to Buluwayo, 1362 miles; and Port Elizabeth to Pretoria, 740 miles.

An entire absence of navigable rivers and the expense of road-making across immense stretches of sandy, waterless country have made railway construction in South Africa a matter of supreme importance. For many years the various colonies adopted a type of line heavier and more expensive than the volume of traffic was likely to warrant; for example, the railways of Cape Colony cost £10,000 a mile, and those of the Transvaal, Orange River Colony, and Natal, £15,000 a mile.

The railway system of Cape Colony consists of trunk lines starting from the principal ports and aiming chiefly for Kimberley, the great mining centre, but sending a branch to the Orange River Colony, and thus on to the Transvaal. Railways were introduced into the last-named state later than elsewhere, and though there was communication with Cape Colony and also with Natal, the chief outlet of the country was a line from Pretoria to Lourenço Marques on Delagoa Bay in Portuguese East Africa.

In 1889 the Cape Colonial Railways extended no further north than Kimberley, 647 miles from Table Bay; and it was at this point that Cecil Rhodes entered upon his great Trans-African railway scheme.

Transcontinental railways such as those of America or the great Russian line across Siberia are of world-wide interest, since they bring the ends of the earth closer together; and they impel

SIX-COUPLED TANK ENGINE, "PRESIDENT KRUGER"
(Pretoria and Pietersburg Railway)

admiration because of the real and immediate sacrifices that have to be faced in order to gain a remote and sometimes problematical benefit. Russia made immense sacrifices to push an iron road across Asia, but as a matter of fact the British Empire profited enormously by the construction of the line. It provided a quicker mail route between England and her territorial dependencies in the Far East and the Pacific; it cut down the time for travelling round the world from 65 days to 33 days—a vitally important factor to the British race, whose possessions girdle the whole globe. But a great trunk line from the Cape to Cairo could be of no material benefit to any part of the world except Africa, for even if a train could steam from Table Bay to the Mediterranean, London would still remain 4 or 5 days distant from Cairo, and the railway route would occupy 15 or 16 days, as against 17 or 18 days by ocean passage. "The two ends of the African continent," wrote the late Mr. W. T. Stead, "have absolutely nothing in common, except that they are both African, and that both are at present under the shelter of the British flag. There is no interchange of commodities between British South Africa and the dominions of the Khedive. If there were any trade the goods would go by sea. As for the mails, the gain of a day or two would not counterbalance the wear and tear and risk of transhipping and of other drawbacks of the land route. It is extremely doubtful whether the line would earn a dividend, or could ever be worked except at a loss."

But Cecil Rhodes had no illusions on these points; his great mind saw more than the mere joining of the two ends of the African continent. Said he: "My railway would be the backbone and spinal cord to direct, consolidate, and give life to the numerous systems of side railways which will connect the vast central road with the seas on either hand."

The first step was the extension of the line northward from Kimberley to Vryburg, a distance of 127 miles. In this enterprise Mr. Rhodes secured the services of an engineer who realised that economy and rapidity of construction were of the first importance in the development of a new country by means of railways. The specifications were designed for a 3-ft. 6-in. gauge line which would be capable of conveying traffic at a speed of 12 miles an hour, and leaving it easy to improve the standard of the road at a later period, when the volume of traffic called for it. Consequently an even surface was followed wherever possible, and ballasting was used only in sections where the rainy season would tend to make the track boggy. The line was unfenced except in the vicinity of stations and near a few farms traversed by the railway. Shallow rivers were not bridged, but the metals were carried across over a ford, until at a later period steel bridges could take the place of such temporary crossings.

Exclusive of the Vaal River Bridge the 127 miles of line between Kimberley and Vryburg were laid in less than twelve months at a cost of £4500 a mile; and when completed the new line was taken over by the Cape Government Railways and added to their main line.

By October, 1894, the line had been pushed on to Mafeking, 196 miles further north. In the meantime the colonisation of Mashonaland had proceeded apace and railway communication became a pressing necessity, which was accentuated by the overthrow of Lobengula and the acquisition of Matabeleland. Early in 1896 railway construction started afresh from Mafeking, for Mr. Rhodes had determined that the railway must reach Bulawayo before the end of 1897. The contractors, Messrs. Pauling and Co., accomplished their task on October 19th, the 492 miles of platelaying having been performed in 500 working days.

While the great line was progressing northwards, railway construction was being carried out in Mashonaland. Salisbury, the capital of Rhodesia, being brought, via Umtali, into railed connection with Beira on the east coast. The 2-ft. gauge line already in existence between Beira and Umtali was widened to the standard 3-ft. 6-in. gauge, so as to avoid the delay and expense entailed in transferring goods at Umtali from one line to the other. Salisbury was connected with Gwelo in 1902, the line being built while the Boer War was raging on the borders of Rhodesia.

The protracted war caused a pause in the northward progress,

RAILWAY CONSTRUCTION IN RHODESIA

but in 1901 work recommenced, and in December, 1903, the Bulawayo-Zambesi line was opened to Wankie coalfield, 1572 miles from Cape Town; and on April 25th, 1904, the rails reached the magnificent Victoria Falls.

The bridging of the Zambesi presented a stupendous task. The spot selected for the structure was 400 yards below the Falls, where the river rages through an awful gorge only a hundred yards wide at the bottom. The bridge comprises a single arch of 500-ft. span at a height of 420-ft. As it was impossible to erect any staging in the boiling flood, the two halves of the arch were built out piece by piece from the banks until they met at the centre, the arch being, of course, self-supporting when the junction was made. The transport of material across the gorge was a herculean task, which was effected by means of a wire rope cable, along which, within a period of five weeks, were carried a locomotive and tender, railway trucks in parts, 800 tons of material for the permanent way, and about 2000 tons of material for the bridge. The erection of the structure occupied only six months, and the entire cost was £70,000. The work was undertaken by the Cleveland Engineering and Bridge Building Company of Darlington. When completed the Victoria Bridge was the loftiest in the world, but it has since been surpassed in this respect by a French structure in the province of Puy de Dôme, where the rails are 434½-ft. above the water.

By the time the bridge was completed, railhead was at Kalomo, 1733 miles from Cape Town. In the construction of this section 5¾ miles of track were laid in a working day of ten hours—a result that holds its own with the best performance of the wonderful American mechanical track-layer.

To carry the line to Broken Hill, 280 miles further, was the next stage, and this entailed bridging the Kafue River with a structure 1300-ft. in length, consisting of thirteen spans each of 100-ft. Again in this case the whole of the steel work was British, being prepared in England, shipped to the Cape, and then transported 2000 miles by railway to the river-bank.

Mr. Rhodes had designed the line to reach Kituta, at the southern extremity of Lake Tanganyika; but in the meantime it was found that railway building in a mountainous region would be terribly expensive, whereas the great lake offers a splendid waterway 400 miles in length, and if necessary ferry steamers could be utilised to transport trains from one end to the other. At any rate, the railway has swung westwards to Elizabethville in the Congo State, from whence the rails have been carried to Bukana and doubtless eventually will go north-west to join the existing line at Leopoldville.

Harking back to the more direct northern route, from Usambara at the northern end of Lake Tanganyika, it is 96 miles to Lake Kivu, and there is no serious obstacle to a railway beyond a rise in level of 2000-ft. Lake Kivu is 60 miles in length, and this sheet of water is also surrounded by high and precipitous mountains, so that another break in the line will have to be made and the waterway utilised.

From Lake Kivu to the Albert Edward Lake is another 60 miles, with a further rise of 2000-ft. to the highest point on the whole route. The country to the east of the Albert Edward Lake is so flat that it may be unnecessary to use this fine stretch of water (75 miles in length), as a railway could be built from Lake Kivu, through a rich, healthy, and densely populated country, passing the Albert Edward Lake and down the Semliki Valley to the southern

VICTORIA BRIDGE OVER THE ZAMBESI

shore of the Albert Lake—a distance of 220 miles. The Semliki is in Congo territory, but this is believed to be the obvious route for the railway, with no engineering difficulty but a drop of 1500-ft. before reaching the level of the Albert Lake, while the alternative route through British territory would involve a climb of 2000-ft. and a sudden descent of 3000-ft. Once the Albert Lake is reached there is a navigable waterway to the Mediterranean by way of the White Nile, save for a stretch between Dufile and Rejaf, where the river is broken by about 100 miles of rapids, and which would call for a corresponding length of railway. An alternative route is possible via Abyssinia, the Emperor of Abyssinia, under the Frontier Agreement of May, 1902, having agreed to allow the construction of a railway through Abyssinia territory from the Sudan to Uganda. However, now that the dense tangled mass of vegetation known as "sudd" which obstructed the river between Fashoda and Lake Albert has been broken up, the Nile route will probably be preferred to any other. Since the commencement of 1904 a regular service of steamers has been plying between Rejaf and Khartoum, a distance of 1000 miles, and Khartoum is now connected with Cairo by railway, except for the short stretch between Wadi Halfa and Assuan.

Thus, when once the railway reaches the southern end of Lake Tanganyika, the construction of a further 470 miles of line is all that will be necessary to render steam communication by combined rail and waterway between the Cape and Cairo an accomplished fact, and be it noted, the whole route will lie through territory belonging to Great Britain or under British influence, save for the short section through the Congo Free State. When these 470 miles of railway are constructed Rhodes' splendid dream will have been realised—if not in its entirety, at least as far as the object which he had in view; for it is evident from what he wrote during his life that it was not as a "through line" that the Cape to Cairo Railway appealed to his imagination, but as a feeder line to branch railways running east and west, so that the breaking bulk necessitated by the changes from land to water carriage is no drawback to the general utility of the scheme. Two such branch lines are already in existence—from Beira to Bulawayo via Salisbury, and from Mombasa to the Victoria Nyanza—and others are projected both on the east side in German East Africa and on the west side in the Congo Free State. A line about 243 miles in length is also in course of construction between the southern end of Lake Nyasa and M'Tombi on the Shire River, whence there is a steamer service to the sea via the Zambesi.

In the brief space of ten years Rhodesia has passed from the rule of a savage king and from a country where railways were unknown, to one of premier importance, with a mileage of railways greater than the Natal, Transvaal, or Orange River Colonies;

thanks in a great measure to the genius of the departed statesman and to the broad-minded policy of the engineers upon whom devolved the details of so unique an enterprise. The line once laid, the standard of the road-bed, buildings, and equipments have been improved upon as traffic developed, and the line to-day is in as high a state of efficiency and capability as those of the neighbouring colonies.

Little need be said of the locomotives in use in South Africa, since they embody all that is best in our home products ; and the coaching stock and freight cars are equally good. All couplings are of the central buffer type. A series of 4–8–2 type locomotives, built by the North British Locomotive Company in 1910 for use on the Cape Division of the South African Railways, were among the most powerful ever built for the 3-ft. 6-in. gauge. The following were the chief dimensions : cylinders, 20½-in. by 28-in. ; coupled wheels, 4-ft. 6-in. ; boiler barrel, 20-ft. 2½-in. long and 5-ft. 7¾-in. diameter ; total heating surface, 2317 sq. ft. ; pressure, 180 lb. per sq. in. In working order the engine weighed 82 tons 2 cwt., of which 59 tons were on the coupled wheels. The tender water capacity was 3500 gallons ; coal, 6½ tons. Gross moving load of engine and tender, 125 tons 11 cwt.

The standard Rhodesian locomotives have eight coupled driving wheels of 4-ft. diameter, with a leading four-wheel bogie. Cylinders, 18½-in. diameter, 24-in. stroke ; safety pressure on boiler, 180 lb. per sq. in. ; heating surface, tubes, 1184 sq. ft. ; firebox, 131 sq. ft. ; weight on each pair of driving wheels, 12 tons ; weight of engine and tender, 93 tons, or in running order, about 120 tons ; haulage capacity, 500 tons ; Sheard injector system, fitted below water-level ; tender capacity, coal, 10 tons, water, 27,000 gallons ; average fuel consumption per mile run, 64 lb. Wankie coal.

For covering the great distances over the Cape and Central South African Railways luxuriously equipped corridor day and sleeping car trains are in use. Each train consists of three day and sleeping saloons, one observation car, one dining and kitchen car, a baggage van containing a refrigerator compartment, and a private suite of apartments. The observation saloon, which is placed in the rear of each train, is 15-ft. long. It has large glass windows which can be taken out and curtains substituted if desired. The internal decorations are in mahogany and upholstered in green buffalo hide with embossed gold fleurs-de-lis, the furniture consisting of a couch, two tables, and easy chairs, all of which are removable. From this compartment a corridor leads to five sleeping compartments, all furnished in wainscot oak. At the end of the corridor a bathroom is provided, fitted with shower and needle baths for hot and cold water. From this saloon a vestibule leads to the day and sleeping saloons, of which there are two. These saloons have large compartments in the centre, with folding tables and upholstered easy chairs, which may be used as sitting-rooms. The dining car, decorated in polished mahogany relieved with mouldings and pilasters, affords seating accommodation for thirty passengers. The whole train is lighted by electricity. The exteriors of the vehicles are furnished in mahogany; the roofs are double, and gauge frames are fitted in the ventilators to keep out dust and insects.

When one remembers that Rhodesia is still in its infancy, its charter having been granted little more than twenty-one years ago, it is difficult to realise what has been done to bring it into close touch with the outside world. A few years ago the journey from Cape Town took months to accomplish, while now the traveller may leave London and in less than twenty-one days may be seated

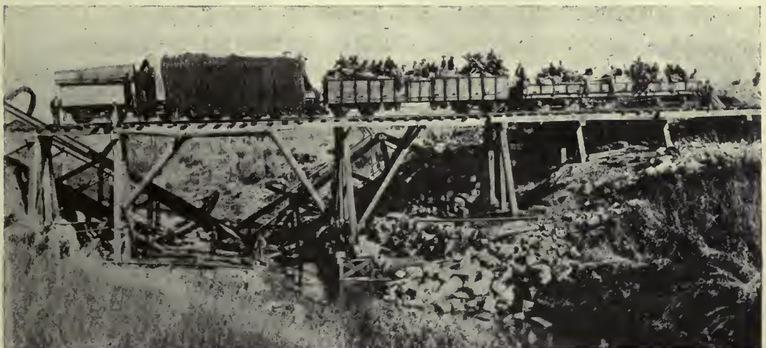
ZAMBESI EXPRESS OUTSIDE BULAWAYO STATION

comfortably in his hotel at Bulawayo, or in three weeks may be gazing at one of the greatest wonders in the world—the Victoria Falls.

The train de luxe leaves the Cape Town Docks after the arrival of the mail steamer on Tuesday mornings, reaching Kimberley on the evening of the following day, where it connects with the Zambesi Express; Bulawayo (1360 miles) is reached on the following Friday, and the Victoria Falls (280 miles from Bulawayo) on the next morning; that is less than three weeks from the date of leaving Southampton.

In addition to this train, there is a through service twice a week between Cape Town and Bulawayo, and a dining car and saloon carriages, with sleeping and lavatory accommodation, are provided.

Railways play an important part in time of war, strenuous efforts being made to keep useful lines intact, while the enemy make desperate attempts to render them unserviceable. In the South African War the railways figured prominently throughout the struggle between Briton and Boer, from the first act of hostility in the derailment of a train by the Boers at Kraaipan to the flight of President Kruger over the railway to Delagoa Bay. In a country where the best roads are either mere dust tracks or bogs, according to the season, and where rain-swollen river "drifts" proved immense obstacles to wagons and artillery, the railways were more than ordinarily important to the combatants; and in addition to the transport of troops, stores, etc., the Engineering Staffs of the Cape Colony and Natal Government Railways rendered immense service to the military authorities. Especially was this the case in



ARMOURED TRAIN IN NATAL CROSSING A TEMPORARY BRIDGE, WHERE THE BOERS HAD DESTROYED THE ORIGINAL STRUCTURE

Natal, where the Railway Department adapted six armoured, and three ambulance trains; found the necessary equipment for the latter; erected the "Princess Christian" hospital train; wired and lamped the hospitals at four different centres, and supplied them with electric current, as well as that used for the X-rays apparatus. Also prepared special carriages for the 6-inch and 4·7 guns; mounted the electric search-light apparatus with engine, dynamo, etc.; supplied 30,000 troops at Colenso with water; found the plant and fuel for condensing water from the Klip River, Ladysmith, for 20,000 persons during the four months' siege; allotted and arranged a portion of the goods-shed as the Base Medical Stores at Durban, and fitted up vans to follow the army with reserve medical supplies. The Department's Engineering Staff speedily restored, or temporarily provided—not only on the Natal lines, but for over 100 miles on the Transvaal system after crossing the Border until the time the two British forces met—72 bridges and culverts, varying in length from 15 to 600 feet, 32 different portions of permanent way, many water-tanks, etc.; effected a clearance through the Laings Nek Tunnel, and constructed several miles of new railway, sidings, and extensive deviations. The Natal Railway Pioneer staff also advanced with General Buller and worked the Netherlands Railway as far as Greylingstad, 100 miles beyond Charlestown, until the line was taken over by the Imperial authorities on the 15th August, 1900.

Hospital trains are a beneficent army equipment in aid of the sick and wounded. They are of three kinds: 1. An ordinary train in which the compartments are made as comfortable as circumstances permit. 2. An ordinary train with special fittings, such as stretchers slung from the roofs of the compartments, which give the wounded a minimum of vibration. 3. A proper Hospital Train comprises all the luxuries and comforts of a Field Hospital with a kitchen wagon, medical stores, and rooms for the medical staff.

Armoured trains are employed in the districts that are in close touch with the enemy. The truck sides are built up with iron plates, while the engine is generally protected with plates and covered all over with roping to make it bullet proof.

UGANDA RAILWAY

As originally constructed to call this British East African line the Uganda Railway was a misnomer, since not a yard of the 580 miles of line between Mombasa on the east coast and Port Florence on Victoria Nyanza was in Uganda territory. In many quarters the construction of the railway was viewed as a huge mistake, the region traversed appearing to promise but little in the shape of profitable traffic. Long before the line was completed its opponents were furnished with plenty of matter for constant cavilling. At the outset wooden sleepers were used only for them to have to be replaced by steel ones, than which nothing less could cope with the ravages of the voracious white ants. The original estimate of the cost of the line was £3,000,000, which fell short of the actual requirements by quite one-half. The physical features of the country presented some extraordinary rises and falls for the railway engineer to overcome. Across the Rift Valley the metals had to wind up the hills on the far side to a height of 8350-ft. There was a rise of 8000-ft. in 500 miles, and a drop of 4700-ft. in 91 miles between Mau and Port Florence.

There were difficulties encountered with the natives, who not only stole tools, but even rails, removing the bolts out of the chairs and fish-plates. A Sikh police force was organised to stop these depredations, but better still the bolts were made practically nonremovable, thus rendering a whole section one solid piece of work. But there were other matters that provided rare excitement, especially at Tsavo, a little over a hundred miles from the coast. The track was laid by thousands of coolies imported from India, who became the quarry of a couple of man-eating lions to such an extent that work on the line was quite disorganised. Camp fires, thorn fences, and iron entrenchments did not stop the marauding beasts, which night after night bore off men, dragging them even out of the tents and carrying them off into the bush. At one stage about 3000 coolies migrated to another portion of the line some miles away, but eventually on December 1st, 1898, the whole of the coolie labourers struck work, claiming that they had come from India to work for the Government under agreement and "not to provide food for devils," it being popularly supposed that in the man-eaters were embodied the spirits of departed chiefs, who once ruled over the land then being conquered by the railway. The lions were at length shot by Colonel Paterson, to whom the grateful coolies presented a silver bowl, bearing an inscription in Hindustani, testifying to the prowess of their deliverer. The bowl is now exhibited in Norwich Museum, together with the heads of the two ferocious animals which had left the bones of twenty-eight coolies, and still more natives, to bleach under the equatorial sun.

The "real" Uganda Railway is the line from Jinga on Lake Victoria to Kakindu on the way to Lake Kioga. This short line is an important link in a route of 3580 miles between Cairo and Mombasa, made up of a series of railways and navigable waterways.

The little-known but prosperous colony of Nyasaland is reached by stern-wheel shallow-draught steamers from the Portuguese port of Chinde, at the mouth of the Zambesi, and up this river and its tributary, the Shire, to Port Herald, a slow journey of about 200 miles. Navigation to the Upper Shire river and Lake Nyasa is prevented by the Murchison Falls. Therefore the British Central Africa Company constructed the Shire Highlands Railway, between Port Herald and Blantyre, a distance of 114 miles. This line has to rise 4000 ft. in this distance, so the gradients are heavy. The standard South African gauge of 3-ft. 6-in. was adopted, and rails weighing $41\frac{1}{4}$ lb. per yard were laid on steel sleepers.

Thirty miles from Port Herald is Chiromo, and here the rails cross the Shire River, by a bridge 420-ft. long. To give a clearance of 30-ft. at high water for the boats that occasionally reach this point, a 100-ft. span is arranged to rise vertically by means of winches, the bridge being balanced by heavy counter-weights.

About 12 miles beyond Chiromo the climb of 4000-ft. begins. The ruling grade is 1 in 44 and the line is one succession of curves up the Ruo Valley until the 64th mile is reached, whence it follows the Tuchili river for 10 miles and then the Luchenza river to the summit at Limbi, 109 miles from Port Herald. The line then falls 500-ft. in the last five miles into Blantyre. The locomotive department head-quarters and repair shops are at Limbi. The railway took seven years to make.

The 4–8–0 engine illustrated on page 649 was built for this line by the Hunslet Engine Company, Ltd., of Leeds. It is equipped with the Schmidt superheater.

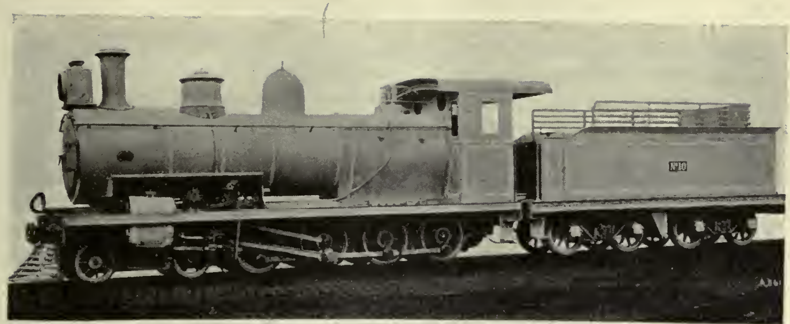
WEST AFRICAN RAILWAYS

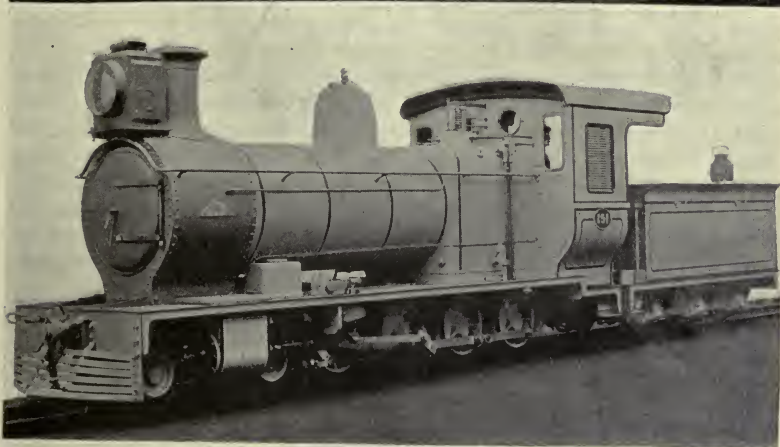
The British possessions on the West Coast of Africa include Gambia, Sierra Leone, Gold Coast, and Nigeria. Gambia is small, only a riparian strip on each side of the Gambia River, which provides ample means of communication and renders a railway unnecessary.

The Sierra Leone Railway is of 2-ft. 6-in. gauge, and reaches from Freetown, the capital, to Baiima, almost on the Liberian border, and just over 220 miles away. The railway thus does not admit of further extension. Its utility has, however, been considerably increased by the construction of short branches, and others will probably be built in the future. The longest branch reaches out to Yonni, and is 21 miles long. Another extends the line from Baiima 7 miles northward ; while a third connects Freetown with the hill station 6 miles distant. The first two branches are in reality tramways, but as they are of the same gauge as the main line the standard rolling-stock is employed on them. There are no prospects of further railway construction in Sierra Leone for some time to come.

The railways of the Gold Coast Colony comprise two principal lines : one of 168 miles from Seccondee on the coast to Coomassie, the capital of Ashanti, and one of 40 miles from Accra to Mangoase. A description of the former line will serve generally for most of the short railways of West Africa, the general conditions being fairly similar. This railway has been pushed through a region of tall trees and tangled undergrowth of forbidding density. " Try to imagine," says Mr. Reginald Higham, " a single line of railway winding along between two green walls 150 to 200 feet high, with occasional clearings for stations, and you will have some idea of the view the line presents " ; and this in an atmosphere in which existence has been compared to " living in a gasometer with the top off."

The railway was commenced in 1898, but the work was hampered by the abnormal rains of 1899 and the Ashanti War of 1900, and consequently the line was not completed until 1904 at a cost of £1,820,000. The gauge is 3-ft. 6-in., and steel sleepers are used almost throughout on account of the white ants. Dislocation of





4-8-0 SUPERHEATED LOCOMOTIVE (Shire Highland Railway)
4-8-0 LOCOMOTIVE (Lagos Railway)
4-6-2 LOCOMOTIVE (South African Railways)

traffic is often caused by trees falling across the line. In one month as many as eighty-three trees have damaged the permanent way or destroyed electrical communication. Heavy rains, too, sometimes as much as 11·14 inches in one day, conduce to frequent "washouts."

Some idea of the difficulties experienced by the officers working the line may be imagined from the fact that, even at the present day, quite one-half of the native staff—pointsmen, porters, plate layers, etc.—and about 80 per cent of the passengers on the railway do not understand English at all, yet English is necessarily the language in which all public announcements and working instructions must be given. The line is equipped with Webb and Thompson's instruments, and to explain the electric staff regulations, in a temperature somewhere round 90°, to a native stationmaster who understands about as much of English as the average English railway official does of French, is a task which white officials feelingly affirm requires a considerable amount of patience, to say nothing of linguistic gymnastics. The Gold Coast has numerous languages and is cosmopolitan; in travelling from Seccondee to Coomassie relying on native languages alone it would be necessary to know at least half a dozen, whereas "pigeon English" will take you through the whole distance.

This railway speedily justified its construction. In 1904 the haulage of native produce amounted to 368 tons, but was twelve times as great at the end of five years, and the native passengers increased from 86,000 to 210,000; and thus the iron road commenced to develop and humanise one of the dark spots of the earth, where wholesale human sacrifices were always in progress, where the very name of the capital meant "Kill them all," and its chief street was called "Never dry of blood."

Passing on to Nigeria we come to the scene of by far the most active railway works in any part of West Africa. The Lagos Railway to Ibadan (122 miles), with a branch to Abeokuta, was opened in 1901, but the extension to Tungeru was not completed until 1911. The Baro-Kano line was then commenced, its object being to tap the populous district of Kano, the largest native town in Equatorial Africa. The total length of the railway is considerably over 600 miles, and with a branch of over 100 miles to the Banchi tin-fields, gives to the British West African Railways an aggregate length of roughly 1200 miles.

France is paramount territorially in West Africa. There is not one nation there which does not share at least one frontier with France; and the hinterland of all, with the exception of Portuguese West Africa, is French. Consequently the railways of all the other countries are of local importance only, and are designed for serving their immediate vicinity. One exception, however, should be made: the Benguella Railway (Portuguese), starting at Lobito

Bay, which some day will be of far more than local importance. The French have a number of lines in Senegal, Ivory Coast, Dahomey, and the French Congo, and the Germans have three short lines radiating from Lome in Togoland, and one line in the Cameroons.

The Benguella Railway is destined to cause a great economic change in communications between Europe and South Africa. At the end of 1911 the railway had penetrated 230 miles inland from Lobito Bay, and in accomplishing this the engineers had broken the back of the greatest difficulties to be encountered on the route. This left only 800 miles of line to be constructed before linking up with Kambore in the Katanga region of the Congo State; and as construction proceeded from the Lobito and Katanga ends simultaneously, by the end of the year 1914 passengers and mails should be able to reach Johannesburg in something like five days less than at present. When it comes about this may be detrimental to the interests of the southernmost portion of South Africa, but now that the whole of the former colonies are grouped as States of the Union the advantage to the whole will immeasurably outweigh the disadvantage to the part. Rhodesia would benefit immensely, as that territory would no longer be a railway cul-de-sac, but would form a portion of a main artery of communications between South Africa and the outer world.

The Belgian Railway in the Congo Free State, from Matadi to Stanley Pool, was opened in July, 1898, and was built to aid the Congo River traffic, which was impeded by the Livingstone Cataracts, thirty-two in number. The line was not easy to construct, the country being unexplored and difficult of access. For labour, Chinese coolies were tried, but proved a failure, and consequently recruits were obtained from Senegal, Sierra Leone, etc. Seven thousand workmen were employed at a time. The line is single, 30¼-in. gauge; the gradients are steep and the curves sharp. Express trains from Matadi to Leopoldville (Stanley Pool) occupy twenty hours, or 15 miles an hour. The engines weigh only about 20 tons; wheel base, 6-ft. 7-in.; water capacity, 396 gallons; coal, ½ ton. Owing to the high price of fuel it has been proposed to convert the line for electric traction, the requisite power being supplied by the falls of the Congo.

Having now briefly surveyed the major portion of the railways of Africa we are better able to estimate the most profitable means of effecting transcontinental communications in preference to a route running more or less directly north and south. Algeria is now an integral part of France, and long-standing troubles with Morocco appear to be at an end, and in this portion of Africa railway construction has made rapid progress within the last few years. A really important transcontinental scheme is possible via the French line from Algeria, the Sahara, and the Belgian Congo, i.e. from Algiers via Oran, Igli, Agadiz, Semio, and Stanleyville, from which there could be connection with the Uganda Railway and on to the East Coast, or connection southwards with Rhodesia and thence on to the Cape. It is a huge project, involving the construction of 3000 miles of railway, but it would be an understandable connection between North and South Africa, which would reduce the mail and passenger route between London and Johannesburg from 18 days to about 9 or 10 days. It must be remembered that Algiers is only 2 days from London, via Marseilles, whereas Cairo is 4½ days, via Brindisi. The French line is already through to Igli, and between that point and the Belgian frontier there are no really serious engineering difficulties to be encountered.

By the year 1925 there is every reason to believe we shall have a complete and fairly direct Trans-African Railway from the extreme north to the extreme south, and we shall be able to traverse Africa by a variety of more or less meandering routes from west to east.

CHAPTER XXIX

RAILWAYS OF NORTH AMERICA

North America, for the most part a vast land of prairies stretching oceanwise, is the home of mighty railway enterprises with huge separate systems and a total length of line aggregating about 280,000 miles, of which 25,000 miles are in Canada, 238,000 miles in the United States, and 15,000 miles in Mexico.

The railways of North America have always attracted more than ordinary interest in Great Britain, not only because they are mainly the handiwork of British-speaking people, but because the methods

VICTORIA JUBILEE BRIDGE, MONTREAL
(Grand Trunk Railway)

of railwaymen on the other side of the Atlantic have often been compared with our own, regardless of the fact that the conditions on the other side of the Atlantic make similarity of working almost an impossibility.

In their very inception the railways of North America and those of Great Britain differed widely. In our own case the whole of the country was settled, towns were fixed, and were linked together by an admirable system of well-made highways, which were traversed regularly and safely by coaches and carriers' carts ; manufactures and trade were established on a prosperous basis ; the country was rich, and in supplying the markets of the world was without a serious rival. In Chapter I was set forth how our early railway engineers encountered bitter and expensive opposition by classes whose vested interests might suffer from the threatened innovation ; and Parliament insisted upon lines being built and worked so as to provide the highest degree of safety and comfort for the passengers, and safety and a minimum of inconvenience to the general public.

Excluding only the New England States, the railways of the United States and Canada were the forerunners of settlements and population, and the rise of towns followed in their wake. The iron road did not compete with well-ordered highways, for only a few roads were in existence, and they were scarcely worthy of the name. In these vast territories that awaited opening up there could be only the slowest development without railways. Rapidity and cheapness of construction were the watchwords, little attention being paid to the quality of the lines so long as they would span enormous distances. Especially was this the case in the United States. So long as a train could move safely on the rails, nothing else mattered ; improvements could be effected when there was traffic—and income. It was not that the American railway pioneers had no faith in their undertakings : they quite recognised that they were laying the foundations of valuable properties ; but money was scarce, labour at a premium, and even the most primitive line could commence to earn money. In America the sleepers are called "ties," and for these there was generally an abundant timber supply ; ballasting, except the soil from alongside the track, was avoided wherever possible ; and by laying the sleepers closer together than is the British practice a reasonably solid road-bed could be provided. No iron chairs were used, the rails being spiked directly on the sleepers ; this method was a saving of expense and conduced to rapid laying, and American engineers still prefer this method to the British system. Bridges were generally carried on mere wooden trestles ; fencing, even in towns, was considered unnecessary ; and signalling arrangements were almost unbelievably crude.

In the United States cheap and ill-constructed lines entailed a serious legacy in expensive upkeep ; the timber used in track-building, bridges, stations, etc., meant a constant drain for renewals, often before there were any profits wherewith to meet the demand. Numerous railways consequently fell into a ruinous condition, eventually necessitating almost entire rebuilding. It is reported that an engineer, inspecting a line that was being absorbed by another company, kicked down with his foot one of the four principal supports of a trestle bridge over which trains were constantly passing.

Of course, the best American railroads of to-day have remedied many of their earlier defects. An enormous increase in the population and wealth of the United States has enabled the railway companies to improve the ballasting and metalling of the tracks, while many of the trestle bridges have given place to strong steel structures ; lines through populous districts have been fenced ; better signalling apparatus has been installed ; wooden shanties have been replaced by station buildings of bricks and mortar, although platforms may still be absent. In addition to rapidly swelling traffic receipts, not a few of the American railroads have benefited enormously from the free grants of land, which was afterwards sold to the settlers.

But even to-day, notwithstanding all the improvements, it is not possible to find in the United States a single great railway to compare with the leading British lines for completeness of construction. In the Western States particularly lines still often cross one another or traverse streets on the level, together with various happy-go-lucky conditions that never would be countenanced by the British Board of Trade. Nevertheless, on the whole, one is forced to agree with an American railway official who, after studying British railway systems, said : " British methods are well adapted to meet British conditions, just as American methods are well adapted to meet American conditions, and there is little for either to learn from the other."

CANADIAN PACIFIC RAILWAY

Before the middle of the nineteenth century railways were being built in Eastern Canada, and it was pointed out to the Government that the interests of our North American possessions called for a great highway from the Atlantic to the Pacific. The desirability of a railway from east to west was obvious, since a pack train occupied from May to September to travel from Montreal to Vancouver, even when the waterways were utilised to the fullest extent ; and a rebellion, raised by Louis Riel on the Red River in 1870, would have been quelled with ease if there had been in existence better means for the transport of troops. These arguments, however, did little to further the great railway project. The opening of the Union Pacific line in the United States stirred up the Canadians afresh, but the final pressure came from another quarter : British Columbia would enter the Confederation of Canadian States only if a railway were laid across the continent from the Atlantic to the Pacific ; and the Government undertook to complete the line in ten years.

The surveying of the route was a long and expensive task. The undertaking involved the construction of 2500 miles of new line, 600 miles of which were among the difficult Laurentian ranges round Lake Superior, while the Rocky Mountains, and the Selkirk, Gold, and Cascade ranges in the far western section offered wellnigh insuperable difficulties to the railway engineer. Owing to the wrangling of political parties the actual work of construction did not commence until 1875, and even four years later no progress had been made except at the Lake Superior end. In 1881, however, the Canadian Pacific Railway Company got its charter and commenced work simultaneously at Ottawa, in Winnipeg, and on the Pacific coast. It had been agreed that the Company should receive 25,000,000 dollars in cash, free right of way for the track, and a free grant of 25,000,000 acres of land exempt from taxation for ever. The 700 miles of railway already completed or under contract at a cost of 3,000,000 dollars became the property of the Company, which on its part undertook to complete the line ready for traffic by May, 1891, afterwards altered to May, 1886, in consideration of a Government loan of £6,000,000.

The railway was to be constructed in more substantial fashion than some of the lines in the United States; for example, the track was a few feet higher than the prairie in order to militate to some extent against snow-blocks, and this alone meant earthwork of nearly 20,000 cubic feet per mile even on the level sections. In order to complete the contract within the stipulated time 400 miles of line had to be laid per year, and with a view to facilitate progress the prairie section was let out in about 300 separate sub-contracts. Bridge-making gangs, on day and night shifts, worked some ten miles ahead of the track layers, who laid the rails like clockwork with astonishing rapidity. During the latter part of 1882 the railed track advanced at the rate of two miles a day; the next year 3½ miles was quite a usual daily performance; but on July 28th was set up a record of 6⅓ miles, that has probably never been surpassed in the history of railway construction. A writer in *Engineering* thus describes the record-breaking operations:

"The total number of rails laid that day was 2120, or 604 tons. Five men on each side of the front car handed down 1060 rails, 302 tons each gang, whilst the two distributors of angle-plates and bolts, and adjusters of the rails for running out over the rollers, handled 2120 rails, 4240 plates, and 8480 bolts. These were followed by fifteen bolters, who put in on an average 565 bolts each; then thirty-two spikers, with a nipper to each pair, drove 63,000 spikes, which were distributed by four peddlers. The lead and gauge spikers each drove 2120 spikes, which, averaging four blows to each spike, would require 600 blows an hour for fourteen hours. There were 16,000 ties or sleepers unloaded from the trains, and reloaded on to waggons by thirty-two men, and 33 teams hauled them forward on to the track, averaging 17 loads of 30 sleepers to each team. . . . The first two miles of material were hauled 10 miles along the prairie, and the rest from three miles up, as the usual side-track gang put in a siding 2000 feet long during the day."

While the rails were progressing at a furious rate across the prairie, thousands of tons of dynamite were blasting out a path along

THE IMPERIAL LIMITED"—FROM OCEAN TO OCEAN IN 96 HOURS
(Canadian Pacific Railway)

the northern shore of Lake Superior, in one instance one mile of tunnelling costing £140,000; and at the British Columbia end thousands of Chinese coolies were forcing the track over the Cascade Mountains. The political utility of the railway was proved during the course of its construction, for in the early part of 1885 Louis Riel attempted a second rebellion in the North-West, but thanks to railway transport troops were hurried to the troubled region and the rebellion fizzled out.

The line from Montreal reached the summit of the Rocky Mountains at the end of 1884. From that point the engineers were uncertain which route to select for descending the Pacific slope. By way of the Howse Pass the grading was comparatively easy, but it entailed a 30 miles' longer route than via the steeper Kicking Horse Pass. As time was pressing, the shorter route was given the preference, a temporary line to be provided pending the utilisation of the Howse Pass at a later period. In the 44 miles between the summit of the Rockies and the valley of the Columbia River, the line had to negotiate a fall of 2750 feet; the Kicking Horse Pass was crossed no less than nine times, and 370,000 cubic yards of rock had to be excavated, in addition to 1,130,000 cubic yards of ordinary excavation, exclusive of a great deal of necessary tunnelling. At this time machine rock-drills had not reached their present-day excellence, but as machinery could not be conveyed to the spot, the drilling had to be done by hand.

The eastern sections of the great railway were completed and linked up early in 1885, and there remained only 220 miles to complete between the Selkirks and the Gold Range. This was a terribly arduous section, but on November 7th, 1885, at Craigellachie, the rails from the east and west were joined together and the last spike driven home. In six months less than the contracted time was completed the great transcontinental line, which not only opened up a vast territory that was to become one of the granaries of the world, but was of vital importance to the Empire, since it provided the Mother Country with an alternative route to the Far East, if at any time the Suez Canal was blocked, or the Cape route was rendered dangerous by the privateers of an enemy. The Canadian Pacific Railway thus not only renders inestimable service to Canada in linking the Atlantic to the Pacific, but it binds our world-wide Empire closer together by means of its steel ribbons.

Since its opening the transcontinental line has been improved throughout its entire length, but particularly in the Kicking Horse Pass section, where the grading was so much more difficult than specified, that the Government refused to recognise eight miles of the line, and would pay no subsidy on account of it until the Company complied with the original agreement. Between Hector and Field the eastward-bound traffic encountered an up-grade of 1 in $22\frac{1}{4}$ for more than 4 miles, requiring four engines to haul a train of 700 tons at only 6 miles an hour. After a lapse of thirty years, between October, 1907, and July, 1909, this famous "Big Hill" grade was reduced. Coming from the east the line now first enters a corkscrew tunnel of 3200-ft. in length under Cathedral Mountain. Emerging from the tunnel twist, the track runs back east across the Kicking

THE GAP—EXIT FROM THE ROCKY MOUNTAINS

(Canadian Pacific Railway)

Horse River, and then enters the eastern spiral tunnel under Wapta Mountain, and after describing an elliptic curve emerges again to cross the Kicking Horse westward. The whole thing is a perfect maze, the railway doubling back upon itself twice, tunnelling under mountains and crossing the river twice in order to cut down the grade. Put in brief, the improvement necessitated two tunnels, joint length $1\frac{1}{4}$ miles; 7 miles of cutting outside the tunnels; increase in length of track, $4\frac{1}{4}$ miles. A thousand men were employed; 1,500,000 lbs. of dynamite were used; and the approximate cost of the work was £300,000. The grade was cut down from 4·5 to 2·2, and now two engines haul a train over the still difficult piece of line at 25 miles an hour.

During the tunnel work, for the first time in Canada, steam-shovels were operated by compressed air. Despite the complicated work caused by the spiral shape of the tunnels, they met exactly, and the work was completed with marvellous exactness. It was the greatest piece of tunnelling ever attempted in Canada, and the first introduction of the spiral system of tunnels on the American continent.

No railway outside the British Isles is better known than the Canadian Pacific, so important a factor in our "All Red Route" round the globe. Leaving Montreal, the chief eastern terminus, the line proceeds to Ottawa (116 miles), the capital. For 500 miles the metals traverse a country of forests, meadows, lakes, and ridges, but beyond Missanabie (672 miles) there are 60 miles of track with very heavy rock cuttings through and around the northern shore of Lake Superior, viaducts and tunnels constantly occurring, and often the railway is cut out of the face of the cliffs. Lake Superior finally is left at Port Arthur (992 miles). The succeeding region is wild and broken with rapid rivers and many lakes. Winnipeg (1414 miles), the half-way house to the Pacific, has become a most important railway centre from which branches spread out like a fan. The C.P.R. Royal Alexandra Hotel is one of the finest in the world. The chief workshops of the Company between Montreal and the Pacific are here, and the train-yard contains more than 110 miles of sidings.

Between Winnipeg and the Rocky Mountains lies a vast territory with the richest wheatfields in the world and capable of supporting many millions of people; Brandon (1548 miles) and Regina (1772 miles) are important distributing centres. At Dunmore (2065 miles) the Crow's Nest line leads off westerly through the Rocky Mountains to Kootenay Lake. Medicine Hat (2072 miles) has important railway shops, all operated by natural gas, of which there is an immense flow sufficient to supply the light, heat, and power for the rising city. Near to Crowfoot is a large reservation occupied by Blackfeet Indians, and it is no uncommon thing for Red Men to be found at stations decked in now harmless war-paint, selling polished cows' horns, bead and feather-work, etc. When the railway pioneers first entered this region the Indians took heavy toll of the invaders with arrow, tomahawk, and scalping-knife, but not nearly to the same extent as was the case in the United States. Medicine Hat is at an altitude of over 2000-ft., and at Gleichen (2196 miles) the line has risen to 2900-ft. and the Rocky Mountains are in full view, a magnificent line of snowy peaks. In the next 56 miles the railway climbs 528-ft. and reaches Calgary, the most important city between Winnipeg and Vancouver.

The railway continues a steady ascent, entering the "Gap" at an altitude of 4232-ft.; at Bankhead the pass narrows suddenly, and as the mountains are penetrated the scenery becomes grander and awe-inspiring; just before Banff the line passes along a large corral in which are about a hundred buffaloes, the last specimens of the monarchs of the plains; and at Stephen (2375 miles) the summit of the Rockies is reached at an altitude of 5329 feet. From this point the railway descends 1265-ft. in 13 miles to Field by way of the Kicking Horse Pass (page 658). In the lower canyon of the Kicking Horse the mountain-sides become vertical, rising straight up thousands of feet in a bronze wall crested by a long line of unnamed peaks, and within a stone's-throw from wall to wall. Down this vast chasm go the railway and the river together, the former crossing from side to side to ledges cut out of the solid rock, and twisting and turning in every direction, and every minute or two plunging through projecting angles of rock which seem to close the way. With the towering cliffs almost shutting out the sunlight, and the roar of the river and the train increased an hundredfold by the echoing walls, the passage of this terrible gorge will never be forgotten.

Soon after leaving Beavermouth (2452 miles) at an altitude of 2435-ft. the line commences to climb the Selkirks, and at Bear Creek it rises at the rate of 116-ft. to the mile, and reaches the Selkirk summit, 4351-ft. above sea-level, by way of Roger's Pass, which lies between two lines of huge snowclad peaks, where may be seen at once half a dozen glaciers, one of which, the Illecillewaet, is a vast cascade of gleaming ice falling 4500-ft. from the summit of the snowfield in which it has its source. At Revelstoke (2519 miles) the altitude has fallen to 1475-ft., but in crossing the Gold Range by way of Eagle Pass there is another ascent, and then on the down grade to Vernon, amid vineyards and orchards, the whole country is a veritable paradise. Even now the great difficulties overcome by the railway engineer are very obvious; for example, below Nicola the train runs upon a sinuous ledge cut out of the bare hills, where the headlands are penetrated by tunnels and the ravines spanned by lofty bridges; and in the Thompson canyon, as the gorge narrows and deepens, the scenery is wild beyond description, although the elevation is only 700-ft. At Hope the railway is only 90 miles from the coast, and the rough Indian farms give place to broad, well-cultivated fields; and at last, after four days' journey from Montreal, the train steams into Vancouver (2898 miles), the Pacific terminus of the great railway.

The passenger vehicles used on the C.P.R. are replete with every convenience that long-distance passengers can require. Not the least noticeable are the observation-cars operated through the Rocky Mountains, which are acknowledged to be superior to any vehicles of a similar kind in use in other parts of the world. The progressive character of the management of the Canadian Pacific was evidenced in the summer of 1912, when the Canadian Company built, equipped, and maintained an observation-car service traversing some of the most picturesque and romantic scenery of Austria. The cars are 69-ft. 6-in. long, the longest 8-wheeled passenger vehicles on the Continent. For about four shillings English currency,

GLACIER HOUSE STATION AT AN ALTITUDE OF 4093 FEET
(Canadian Pacific Railway)

in addition to the first or second class fare, a passenger can claim the services of a typist, library, medicine chest, C.P.R. attendants, and an interpreter. Under this arrangement the Canadian Pacific Railway commenced the performance of functions very similar to the operations of the Pullman Company in England and America.

The Canadian Pacific Railway of to-day builds at the rate of 400 miles a year, more than a mile a day ; and apart from its huge main line across the continent its branches reach every district in the country that has been found suitable for successful farming. When the great railway was under construction, the land was ploughed at intervals of twenty miles to ascertain its fertility.

PLATE XV.

FROM THE ATLANTIC TO THE PACIFIC.
The "Imperial Limited" Express crossing the Rocky Mountains. (Canadian Pacific Railway.)

It was the Canadian Pacific Railway Company that introduced hard wheat into the West, irrigated millions of acres of land in Southern Alberta, and established the great fruit industry in British Columbia. No railway company in the world has done so much to develop the territory served by its metals.

Montreal, 600 miles up the St. Lawrence, is not an open port all the year round, the mighty river being frozen during the winter months. In order therefore to give an unbroken railway run from the Atlantic to the Pacific, a line was constructed from Montreal to the ports of St. John in New Brunswick and Halifax in Nova Scotia, a distance of 759 miles, of which 200 miles are in the State of Maine. This line is carried over the St. Lawrence by the magnificent Lachine Bridge.

The connections of the C.P.R. with the United States are of great importance. Montreal is but a day or a night's ride from the principal cities of the States on the North Atlantic seaboard, and there is a choice of several routes to accomplish the journey of 384 miles to New York. There is a through line of 461 miles from Winnipeg to the twin cities of St. Paul and Minneapolis, and thence on to Sault Ste. Marie, or to Chicago.

No account of the Canadian Pacific Railway would be complete without mention of the Soo-Spokane-Kootenay lines from St. Paul to Portland, in Washington State, south of British Columbia. From St. Paul the line goes north-west and at Moose Jaw joins the C.P.R. main line, which is followed as far as Dunmore, from which point there are 392 miles of line to Kootenay Landing. In this section has been completed one of the most gigantic engineering works in Canada, the bridging of the Belly River and the Old Man River, replacing twenty wooden bridges by two immense steel viaducts, one 5328-ft. in length with a maximum height of 314-ft. above the water, and the other 1900-ft. in length with a height of 146-ft. above the bed of the river. The cost of this work exceeded two million dollars. The former is one of the most notable steel structures of the world. It required 645 cars to transport the steel used in the construction of these viaducts, and nearly one thousand cars of material were used in the building of these mammoth permanent structures. After leaving Hillcrest, 193 miles from Dunmore, the mountains rise abruptly in great masses on either side, forming an apparently impassable barrier. The "Gap," however, provides an entrance, and the train swings into this narrow defile between almost vertical walls. The line climbs to the summit of the Rockies, and at an elevation of 4427-ft. crosses the dividing-line between Alberta and British Columbia. In the Crow's Nest Pass the railway descends the valley of Michel Creek, and threads its way along the steep side hill of the mountain. Then comes the "Loop," where the line makes some amazing turns and twists until, finally, after turning up and crossing the south branch of the Michel, it doubles back to within a stone's-throw of itself, and by looking upwards one can clearly discern the railway cutting, a long gash in the mountain, directly overhead. Three miles are covered to make this distance of less than 200-ft. At Loop, as the train swings off to the west again, huge rugged mountains appear on all sides, jagged and naked, their frowning sides and lofty peaks scarred and seamed. At Elko, again, the scenery is wild and the environments grandly beautiful. Here the traveller gets a last glimpse of the projecting angles, frowning precipices, and lofty peaks, lifting their ice-crowned heads far into the sky until lost to sight in a dizzy, uncertain mist. From thence to the journey's end the scenery is as varied as one can desire, but the route presents no special engineering difficulties.

The Canadian Pacific Railway controls railtracks over 16,000 miles in length, and builds at the rate of more than a mile a day; in 1912 the extensions amounted to 707 miles. The locomotives

0–6–6–0 FOUR-CYLINDER MALLET COMPOUND LOCOMOTIVE
(Canadian Pacific Railway)

number 1820; passenger and colonist sleeping-cars, 1840; sleeping, dining, and café cars, 370; conductors' vans, 950, and several thousands of auxiliary vehicles. The freight vans number 61,450. In the year 1912 the passenger trains ran over 19 million miles, carrying 13,590,000 passengers; the freight trains ran 25,640,000 miles, conveying 26,000,000 tons, among which were 112,000,000 bushels of grain, 1½ million head of cattle, and 2,292,000,000 feet of timber. The Company's chief railway works are at Montreal, where 10,000 employes in the "Angus" shops are engaged in building locomotives and railway cars at an average rate of a train a day. Large as is the output of the Company's own shops, not a few locomotives have to be obtained from outside sources. A few years ago sometimes as many as thirty engines at a time were obtained from British locomotive builders, but generally the orders go to the United States. The illustration of the "Imperial Limited" (page 657) shows the standard type of locomotive, 4–6–0 with cylinders 20-in. by 26-in.; total heating surface, 2445 sq. ft.; Boiler pressure, 210 lb. per sq. in.; diameter of coupled wheels, 5-ft. 9-in.; weight of engine, 73½ tons; tender, 54½ tons. For work on the heavy gradients in the western mountainous section, 0–6–6–0 four-cylinder Mallet compound locomotives are now employed.

Coloured Plate XV depicts a train traversing a difficult Rocky Mountain section.

THE GRAND TRUNK RAILWAY

The Grand Trunk Railway was the first railway in Canada, opening a line from Portland (Maine) to Montreal in 1853, from Richmond to Quebec a year later, from Montreal to Toronto in 1856, and thence to Sarnia in 1858. Various amalgamations with other railways followed in due course, notably in 1880 the organisation of the Chicago and Grand Trunk Railway. By the end of the century the "little 20-mile scrap-iron road" had grown into a powerful system, serving not only Eastern Canada, but a slice of the United States; with the longest continuous double track in the world under one management, and with an express train service between Montreal and Chicago that holds its own with any of the greyhounds of the rail to-day. For the running of the "International Limited" the old light road had to be replaced with 80-lb. rails, at a later period rails increased to 100 lb. to the yard; grades have had to be eased, many bridges rebuilt and strengthened; and heavy and speedy locomotives designed and built for the increased loads.

The route of the "International Limited" is from Montreal to Chicago, leaving the Canadian metropolis at 9 o'clock every morning in the year, arriving at Chicago the following morning at 7.42. Toronto is reached at 4.30 p.m., a distance of 334 miles in seven hours and a half. At London on the Thames the train diverges from the main line and reaches Detroit by way of Chatham and Windsor, connecting with the main line again at Durand, thence to Chicago, the terminus of the Grand Trunk Western line.

To make this time the locomotive must be capable of picking up a heavy train between stops and whirling it along at the rate of a mile a minute. The train consists of combination baggage-car, coaches, dining-car, parlour-car, and sleeping-cars. In completeness of detail, artistic finish, and appointments generally the vehicles are equal to anything of the kind yet built in America. The first-class coaches are 68-ft. long with seating capacity for 72 passengers; the dining-cars are over 70-ft. long, the parlour-cars 73 ft. long, and all are fitted luxuriously. The tendency to use steel in the construction of railway cars grows with the increasing scarcity of hard wood and the desire to build for safety as well as comfort. Consequently, steel has been employed in the construction of the latest parlour-cars, which are finished in rich African mahogany with inlaid and marquetry design with trimmings of statuary bronze.

Wilton carpet and hassocks, chairs upholstered in green plush, and those in the smoking-rooms in green leather, with curtains and other draperies of corresponding tints, complete a harmony in furnishing. Each of these cars is equipped with a well-stocked library.

Another famous run on the Grand Trunk is from Chicago to the sea. The route lies across the north-west corner of Indiana to Granger, followed by a 245-mile run in a north-easterly direction through the State of Michigan to Port Huron on the St. Clair River. Port Huron is known as the "Tunnel City" on account of its location at the western entrance to the St. Clair tunnel, which extends beneath the St. Clair River, connecting Port Huron in Michigan with Sarnia on the Canadian side. The tunnel is a marvel of engineering skill and enterprise. It is a tubular structure of iron, bolted together in sections, with its approaches nearly 2 miles in length, and cost £2,700,000. It overcomes the obstacles presented by a navigable stream alive with commerce during the summer and often blocked with ice in winter. The motive power through the tunnel is electricity, powerful motors performing this service quickly, smoothly, and cleanly. From Sarnia the line extends eastward to Niagara Falls via London and Hamilton, and another section of the train proceeds via Stratford to Toronto, Montreal, Quebec, Portland (Maine), and Boston (Mass.).

At Niagara Falls, the ever-famous and renowned natural wonder of the universe, the waters, after their awful plunge over the cliff, rush onward through a gorge to Lake Ontario. Over this tumultuous stream, reaching from bank to bank, there was formerly a suspension bridge, which has been replaced by a steel arch bridge in a single graceful span, second in wonder and sublimity only to the great cataract itself, a worthy companion-piece of man's handiwork to be associated with the great work of nature over which it is placed. The illustration will give a good general idea of the structure and the principles involved in its construction. The highest point is 252-ft. above the water. The span between the piers is 550-ft., and the total length of the bridge, with its approaches, is over 1100-ft. It has two decks or floors, the upper one, 30-ft. wide, occupied by the double railway track, the lower comprising a broad carriage-way in the centre, and footwalks outside of all, making a total width of 57-ft.

Leaving the Falls, via Lehigh Valley Railroad, the route lies through the beautiful lake region of New York State, and the heights and valleys of the Alleghanies in Pennsylvania. Bethlehem is the diverging-point to Philadelphia and New York; in the latter case the train enters Jersey City Station, where ferry or tube trains are taken to the metropolis of America.

Reverting to the section of the train for Toronto, Montreal, Portland, or Boston, at Montreal the St. Lawrence is crossed by the

THE "INTERNATIONAL LIMITED"—MONTREAL TO CHICAGO
(Grand Trunk Railway)

Victoria Jubilee Bridge, which replaced the old Victoria tubular bridge erected by the Grand Trunk Company in 1860. It is one of the longest bridges in the world, being nearly two miles in length, including approaches. George Stephenson was the consulting engineer of the original structure, and he approved the plans of Alexander M. Ross in spite of numerous professional critics, who declared that the piers would collapse under the pressure of the first winter ice-pack. The bridge was a rectangular tube 6592-ft. long by 16-ft. wide and 18-ft. high; weight, 9044 tons; cost, £1,300,000. Stephenson did not live to see the completion of the great work, which defied the St. Lawrence current running at 7 miles an hour and the spring ice floes for three-quarters of a century, until the single track could no longer cope with the enormously increased traffic. It was decided to cut away the old tubular bridge span by span to give place to an open steel truss bridge, weighing 22,000 tons, nearly 70-ft. wide, carrying not only a double railway track, but a roadway for an electric tramline, with space for vehicular traffic and a footway for pedestrians.

The standard 4–6–0 locomotives of the Grand Trunk Railway are very similar to those of the C.P.R.; cylinders, 20-in. by 26-in.; total heating surface, 2415 sq. ft.; boiler pressure, 225 lb. per sq. in.; diameter of coupled wheels, 6-ft. 1-in.; total weight of engine, 81 tons 5 cwt.; tender, 64 tons. On page 672 is illustrated an engine that was built in the G.T.R. shops in 1859, and which hauled the Royal train with the Prince of Wales (King Edward VII) through Canada in 1860.

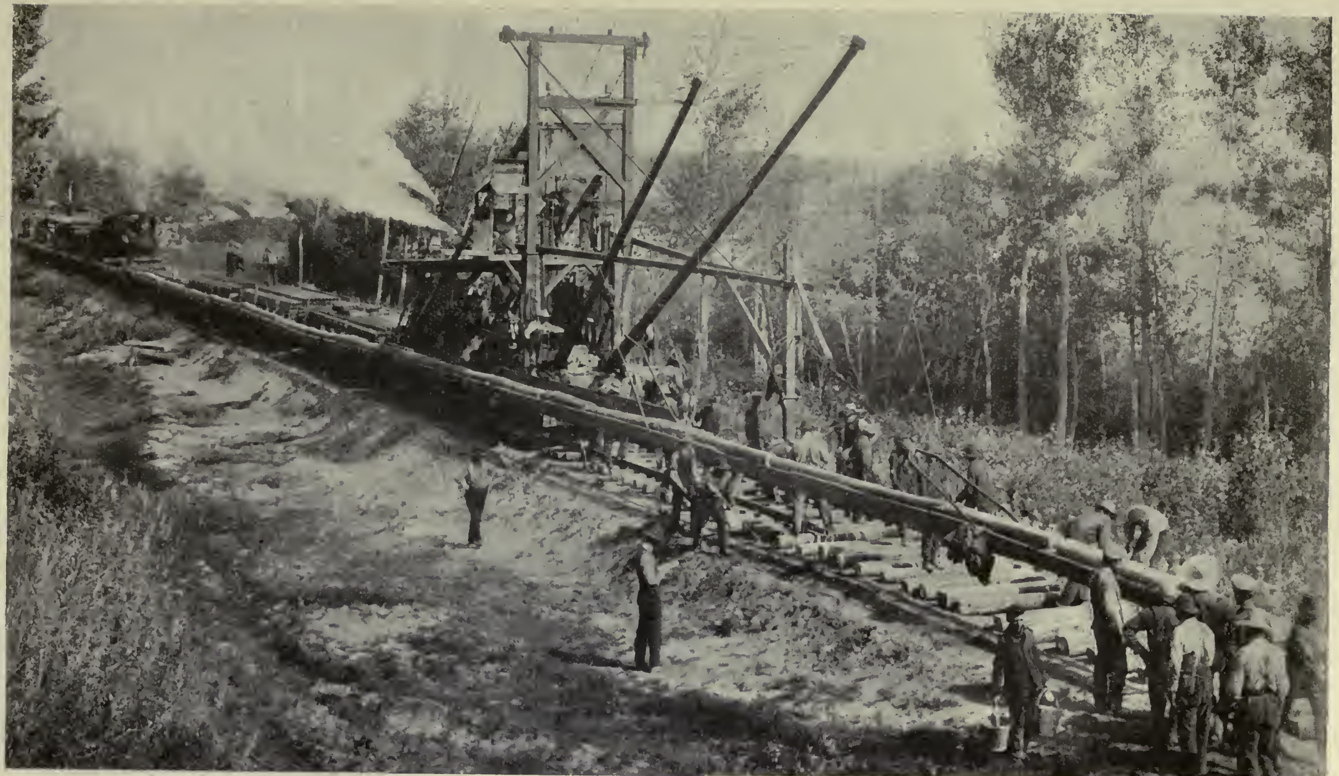
Notwithstanding its importance in the eastern portion of the Dominion, the Grand Trunk Railway never appealed to the popular mind in comparison with the Canadian Pacific and its ocean to ocean service. But early in the twentieth century the Grand Trunk commenced to make railway history, the development of the North-West calling for an additional outlet to the Pacific Ocean. The Grand Trunk Pacific Railway was incorporated in 1906, and at the end of eighteen months 670 miles of new line were in operation from Winnipeg in Manitoba to Wainwright in Alberta; by the spring of 1913 the rails were laid for 1124 miles west of Winnipeg; and from Prince Rupert, the Pacific terminus, 550 miles northwards of Vancouver, 195 miles had been constructed eastwards, leaving only 427 miles to complete the great project, that with the exception of the Great Siberian is the longest railway in the world. This new line across North America was not constructed at the furious rate achieved by the builders of the C.P.R.; the cheap labour of Chinese coolies was not available, owing to the restrictions now imposed upon Asiatic immigrants; and more than that, this great new line to the west was to be solid in construction from the beginning, and every engineering effort was to be made to avoid difficult gradients.

STEEL BRIDGE OVER NIAGARA GORGE
(Grand Trunk Railway)

Nevertheless, even in the actual laying of a good solid track speed was essential, and an ingenious mechanical track-layer enabled metals and ties to be laid at the rate of about 5 miles a day on the plains. "The way having been cleared by the engineering gang with steam-shovel and dynamite, a train is made up with the track-layer in front, followed by half a dozen flat cars loaded with rails, the fussy little engine, which is the motive power of the train, being hitched in here, hauling a dozen cars carrying sleepers, and a car or two laden with fishplates, spikes, various tools, etc." Extending along one side of the train and projecting about 50-ft. in front of it is a wooden trough containing a series of rollers which when set in motion act as a conveyer for the sleepers, which the workers throw out of the cars into the trough to pass along to the other end as fast as the men can place them in position. Very speedily sufficient sleepers are laid to carry the rails, 33-ft. long and 100 lb. to the yard. Projecting over the end of the machine is a couple of booms to which the rails are attached and swung into position on the sleepers. Fishplates are fastened and a few spikes driven home, and the track-layer moves forward to lay down further sleepers, and the next couple of rails. Close behind follows a gang of workers to true up the gauge, tighten bolts, and complete the spiking in readiness for the ballasting train. When the new line has carried a little light traffic the road-bed is equal to any in North America, capable of supporting heavy trains at 50 miles an hour within two months of laying the rails.

A bird's-eye view of the new transcontinental line will afford some idea of the magnitude of the task and its significance to the Empire. It is an astonishing fact that even in the mountain section the engineers have been able to avoid gradients more difficult than a rise of 26-ft. in the mile against eastern traffic and 26-ft. in the mile against west-bound traffic, but this alignment has only been possible at a cost per mile much in excess of any other transcontinental railway. This great world highway commences at Moncton, New Brunswick, where it has the advantage and benefit of its relation to the Grand Trunk Railway of Canada with its 4800 miles of line, on which is situated all the cities and principal towns in Eastern Canada. At Chaudiere Junction, five miles above Quebec, the G.T.P.R. crosses the river St. Lawrence by one of the biggest bridges in the world. The construction of the line entailed heavy work in Northern Quebec, compensated for by 300 miles of almost level land in Ontario, followed by almost continuous rockwork in the Lake Nepigon region, where the line skirts the northern shore of the lake. From Fort William a 200-mile branch to the main line at Superior Junction cost £2,000,000, owing to the frequency of tunnelling through the rocky humps of the broken wilderness to afford the requisite easy grading.

Winnipeg, 1800 miles from Moncton, is roughly half-way to



TRACK-LAYER AT WORK ON THE NEW TRANSCONTINENTAL LINE WEST OF EDMONTON
(Grand Trunk Pacific Railway)

Prince Rupert. The prairie section of 996 miles from Winnipeg to Wolf Creek in Athabasca contains enough valleys and creeks to make the work expensive; for example, Battle River in Alberta, although not a mile wide, necessitates a steel bridge more than a mile long at a height of 186-ft. above the water, and there are notable steel structures over the North Saskatchewan, Pembina, and McLeod rivers. With the crossing of the McLeod commences the real mountain section, wherein the grade is the same as that of the prairie province. This engineering marvel is almost difficult to believe, but it is an established fact that the metals

THE LOCOMOTIVE THAT HAULED THE ROYAL TRAIN WITH THE PRINCE OF WALES (KING EDWARD VII) THROUGH CANADA IN 1860

cross from ocean to ocean, travelling along dark canyons, skirting the shores of great lakes, crossing mighty rivers, and even passing at the foot of Mount Robson, the highest mountain in the Dominion, and all on an easy grade that was formerly thought impossible. In crossing the Rockies the Grand Trunk Pacific encounters only one summit (3712-ft.) as against two on the Canadian Pacific Railway, 5299-ft. and 4308-ft. respectively, necessitating gradients of 116-ft. in the mile; while some of the railways in the United States have to contend with from three to six high summits with gradients as severe as 185-ft. in the mile. The Grand Trunk has to overcome a total ascent of less than 7000-ft.; Canadian Pacific, 23,000-ft., and in the United States the total ascents range from

5000 to nearly 35,000-ft. In the case of the new line the comparative freedom from difficult ascents arises from the fact that the Rockies reach their maximum altitude in the region of the 40th parallel of latitude, gradually receding as they extend northwards.

Of course, the Grand Trunk Pacific Railway is of prime importance as an additional Empire world-route, but it will also be vitally concerned in the ever-increasing crops of the Canadian West; branch lines to Brandon, Regina, Prince Albert, and Calgary will aid in the transportation of the grain; and lines to Vancouver and to Dawson in the Yukon territory will bring their quota of traffic. From Eastern Saskatchewan to Fort Nelson on Hudson Bay there is a new line to aid the wheat traffic to Liverpool; there is a saving of a thousand miles in distance, but Hudson Bay is ice-locked for ten months of the year. The timber, fish, furs, and minerals of the wild region traversed doubtless will supply profitable traffic, but the flow of wheat must be east and west, east in summer and west to the Pacific when winter locks the great lakes in its icy arms.

RAILWAYS OF THE UNITED STATES

At the outset it must be remembered that the United States is a vast country, three million square miles in extent, with a population of ninety millions, chiefly of British descent, "at one with the Mother Country, not only in speech and literature, but in thought and aim and the traditions of a common and glorious historic past." No country in the world has made such rapid strides as the United States; its people are noted for a forceful energy that within but a few decades has caused American progress to be one of the wonders of the modern commercial world.

If Great Britain was in need of steam traction on land to meet the necessities of her increasing trade, the Americans desired it still more to open up vast lands, awaiting only intelligence and energy to come to their aid; and how it was effected has already been briefly described on page 654.

The thirteen States that were then in existence outgrew the control of Britain with the Declaration of Independence in 1776, only seven years after James Watt patented his engine; and some of Newcomen's engines were already at work on the other side of the Atlantic. American inventors speedily were vieing with those of Britain in the harnessing of steam for traction or navigation. In steam navigation the Americans bore the palm, as evidenced by the *Clermont*, launched at New York in 1807; it was not only the biggest steamship then afloat, but the most successful, steaming 152 miles in 32 hours. The first British vessel to attain any real success was the little *Charlotte Dundas*, built in 1801, and employed in towing barges on the Forth and Clyde Canal. The builders of the *Clermont* not only inspected the British vessel, but obtained drawings of her machinery before they drew up their own specifications; and Messrs. Boulton and Watt built for them a new engine without knowing that it was to form part of an American vessel. It was another American vessel, the *Savannah*, that first crossed the Atlantic under steam; the voyage occupied 29 days and for a quarter of the time she was under sail, not through any fault in the machinery, but because sufficient wood fuel could not be carried for steaming so great a distance at only 5 knots an hour. Never-

AN OLD EIGHT-FOOTER
(Camden and Amboy Road, 1845)

theless, the feat marked an epoch in the history of the steam-engine.

Before the year 1830 most of the States in the Union had granted charters for railroads, and not a few of them were in course of construction. The South Carolina Railroad Company commenced their line in 1827, and decided to operate it by locomotives, while the directors of the Liverpool and Manchester Railway were in doubt how to work their line until after the Rainhill tests in 1829. Delays occurred in the construction of the South Carolina Railroad and consequently the Baltimore and Ohio line was first in actual operation, and the first to use locomotives of American construction. But meanwhile, in 1827, the Delaware and Hudson Canal Company had built a short railroad for the conveyance of coal, and it was upon this line that the first locomotive ran on the American continent. Americans claim that their first locomotives were purely original, and that if James Watt had failed to improve the steam-engine, and George Stephenson had never been born, steam locomotion would not have been delayed long in the States. But there is no gainsaying the fact that the Delaware and Hudson's first engine was the "Stourbridge Lion," imported from England. It was of the vertical-cylinder type and weighed seven tons, which proved to be too heavy for the flimsy trestle bridges. In quite recent years the existing parts of this pioneer locomotive were collected and put together, only needing the addition of a few new pieces to form the complete engine, which is now exhibited at the Smithsonian Institute, Washington.

The "Stourbridge Lion" was indeed a quaint-looking machine, greatly resembling Hedley's "Puffing Billy." Americans regarded this British product as a freak, but it appeared no more ungainly than one of the Crampton type that commenced running on the Camden and Amboy Road in 1845. The cylinders were 13-in. by 38-in.; the cast-iron driving-wheels were 8-ft. diameter. The huge chimney and unsightly cab at once attract attention, and at the back of the covered-in tender will be noticed a hood or seat for a guard, who looked back along the train in a similar manner to those originally placed in the same position on the Great Western Railway old broad-gauge engines.

Within the space at our disposal no attempt can be made to describe American railways in anything like detail, and we will content ourselves with a bird's-eye view of the vast network of metals that lie between the Atlantic and Pacific Oceans, drawing attention to anything that is more or less novel to British practice, or that is in some way of outstanding general interest.

In 1830 the length of line in working order in America amounted to 23 miles, and the next year of various lines opened the Baltimore and Ohio line of 61 miles was the longest; and in 1833 the Charleston and Hamburg line in South Carolina had 135 miles in operation, the then longest railway in the world. In 1840 the American railways had a mileage of 2818, which was more than trebled by the year 1850, which was followed by ten years of marked expansion. It was during this period that the world's first trans-continental railway had its birth. A railroad that should join the Atlantic and Pacific coasts was discussed long before engineers were fitted to cope with such a tremendous project, and still more before investors were prepared to find the money. The matter was the subject of a conference held at Dubuque in 1838, but it was not until 1851 that the first sod for a Pacific railway was turned at St. Louis, and even then the scheme proved abortive, the line not getting beyond Kansas City, and eventually becoming the Missouri Pacific Railroad.

It was the private enterprise of a few merchants of Sacramento, California, that originated the first line right across the States from the Missouri to the Pacific. In 1861 they organised the Central Pacific Railroad, which is now part of the Southern Pacific, the object being to carry the metals to the eastern boundary of California, there to meet the line that should extend westward from the Missouri, the track that is now known as the Union Pacific Railroad. The western portion of the undertaking presented formidable difficulties, for it entailed overcoming the Sierras at an elevation of 7000-ft., and the crossing of a desert region where, in one section of nearly 700 miles, there lived only one white man.

. The physical obstacles, mountains, deserts, swollen streams, blizzards, snowdrifts, etc., were sufficiently great almost to daunt even the most optimistic engineer; but to these were added the hostility of the Indians, who waged pitiless war upon the railway prospectors, and later upon the working gangs engaged in opening up the solitudes, hitherto the preserves of the Red Man.

In July, 1862, Congress passed a Bill that assured Government support to the Central Pacific and the Union Pacific companies. Work was commenced in California; but eastwards there was little enthusiasm and sufficient capital could not be collected; and not until a second Bill was passed, which doubled the land grant with a subsidy of 16,000 to 48,000 dollars a mile of track, was a start made at Omaha, on the left bank of the Missouri. Operations were slow, for no railroad had yet reached Omaha, and all material had to come up from St. Louis by water.

The Indians, especially the Sioux, offered a bloodthirsty opposition to the incursion of the railroad into their territory. Large gangs of platelayers frequently were wiped out completely; and at length military guards had to be employed to protect the navvies, who were gradually pushing the rail-head westwards. By the end of 1867 a locomotive could travel over 500 miles west of Missouri. Meantime the Central Pacific workmen had left the Sierras behind them and were attacking the desert of Utah, sometimes accomplishing 10 miles a day. For railing the mountain sections the Government paid extra subsidy, and both companies were eager to obtain the lion's share. Between the workmen themselves feeling ran so high, that in the last section across the plains, when the graders from the east met those from the west, they ignored each other, and overlapped for about 200 miles. But it had already been decided that a junction should be effected where metals met metals, and this point happened near Ogden in April, 1869. On May 10th two silver spikes and two of gold were driven home to complete a task that opened up a new era not only in the history of the United States, but in the progress of the world.

The following year the Northern Pacific Railroad was commenced, but was not completed until 1883, or a year later than the opening of the Southern Pacific Railroad. Since that time the trans-continental routes have been multiplied, until there is a variety of ways by which the continent may be crossed. But it must be noted that

SOUTHERN PACIFIC EXPRESS TRAIN

in the United States there is no single company whose metals run from ocean to ocean as in Canada. Between New York and San Francisco, which naturally are the obvious termini, there are three half-way houses, viz. Chicago, New Orleans, and St. Louis. Between New York and Chicago there are a dozen different routes, between New York and New Orleans a choice of two, and between New York and St. Louis five different routes.

By the year 1860 there were over 30,000 miles of line, or 6000 miles more than there are in the whole of the United Kingdom to-day; 93,000 miles in 1880; 156,000 miles in 1890; 192,000 miles in 1900; and 240,000 miles in 1910. At the time of writing, roughly the length of the railways in the United States is a quarter of a million miles, or 40,000 miles more than in the whole of Europe.

There are more than a score of railway companies with tracks of greater mileage than our Great Western Railway; and there are no less than fifty railroads with more than 1000 miles of line. Among the largest systems are the Pennsylvania Railroad, 11,500 miles; Atchison, Topeka, and Santa Fé Railroad, 10,500 miles; and Chicago, Burlington, and Quincy Railroad, 9100 miles. The Great Northern Railroad—Chicago and North Western—Chicago, Milwaukee, and St. Paul—Chicago, Rock Island, and Pacific—Missouri Pacific—Southern Railroad, each exceed 7000 miles. Some other well-known systems are the Northern Pacific, 6400 miles; St. Louis and San Francisco, 6244 miles; Union Pacific, 3400 miles, but this last-named trans-continental is exceeded in length by the Illinois Central Railroad, New York Central, Baltimore and Ohio, Atlantic Coast, and Louisville and Nashville.

On this immense meshwork of metals there are at work about 66,000 locomotives, 40,000 passenger cars, 14,000 baggage and mail cars, and 2,355,000 freight vehicles of various kinds. The passenger trains run 582,000,000 miles a year, carrying 1,020,000,000 persons; the freight trains travel 642,000,000 miles, transporting 1,817,000,000 tons. The employés of all grades number about 1,700,000, which is only about three times the number of railway employés in the United Kingdom at work on a track mileage ten times shorter than in the United States. In this comparison it must be borne in mind that British railways for the most part traverse well-populated regions, whereas in America there are numerous sections where population is exceedingly sparse, stations far apart, and consequently fewer railway employés necessary. The total capital of the American railways is £4,000,000,000, which works out at about £12,700 per mile, as compared with £54,000 per mile of British railways.

Adverting to the remarks at the commencement of the chapter concerning the primitive methods employed in the early years of American railways, we cannot do better than quote Mr. Edwin A. Pratt: The fundamental differences between British railways and those of the United States "are not fully realised until one has actually travelled in both countries. When the newly arrived traveller from Europe takes his seat in a Pullman car to begin a journey across the American continent, he may think he has reached a country which represents the highest type of railway development. But he will not have got many miles before he revises his judgment. One gets the curious impression that the American railways are both in advance of their times and one or two decades behind them.

At one moment the traveller observes on the adjoining track locomotives and freight cars far surpassing in size and capacity anything he will have found in Europe, and at another he will see the rails he is on cross at right angles the rails of another line; he will find his train passing along the streets of towns and villages;

UNION PACIFIC FREIGHT TRAIN

and he will see country roads, and even the main street of some fairly populous place, go right across the track, sometimes, it may be, guarded by a man with a flag, though in scores of instances between New York and Pittsburg I noticed that the level crossings had absolutely no protection at all, and pedestrians, cyclists, and the drivers of carts, carriages, and even of tramcars had to take care of themselves and keep as best they could out of the way of the passing trains." The foregoing was written only ten years ago. But it was not only through fairly well-inhabited places that the railway ran unprotected, but even through the heart of densely populated cities, as described by another writer. "The number of level crossings inside the city boundary of Chicago is legion, the entire place is flat, and hence the railroads would have to elevate or depress their tracks at great expense. There are no less than 172 crossings of street-car lines or tramways over railroads, one line alone, having four tracks, crosses 17 cable and electric lines on the level. Twenty-three different railway companies run into the city over thirteen separate routes and only four of these really cross the streets on bridges."

Notwithstanding the immense improvements effected in the permanent way of American railroads, only within very recent years have the signalling arrangements been taken seriously in hand. Originally, on the universal single tracks, a train was given an agreed start of another, and it was largely a matter of chance that the second would not overtake the first, or whether a train coming in an opposite direction would reach a provided passing-place in time. The trains in a certain division were directed by a "despatcher," whom the station agents kept informed by telegraph of the position of the trains. When lines were duplicated, the work of the "despatcher" was complicated considerably. In the sparsely populated regions this system still obtains largely, but on the busy lines more or less complete signalling systems have become imperative. On British railways the visual signals are comprised in three simple signs, giving "caution," "stop," and "all right," but these visual signs are only the external safety guards of the block system, which is the prime safety device. In the United States the trainmen have to deal with over a hundred aspects of the signals, a complexity that seems to invite accident. Recently determined efforts have been made to reduce the visual signals to something less than forty; but the block system and automatic signals of various kinds have been adopted on every hand; and the time is not far distant when American railway signalling will be more in accordance with the demands of the increasing traffic.

Railway accidents in the United States are far more numerous than in the United Kingdom, and out of all proportion to the difference in the mileage. In the year 1912, as the result of 5483 collisions, 8215 derailments, and 2045 other accidents, 859 persons were killed and 17,073 injured. Accidents on railways other than those to trains resulted in 9317 deaths and injuries to 60,066 persons, a large proportion of them being railway servants. Altogether during the year 10,585 persons were killed and 169,538 injured. If these figures are compared with the British statistics on pages 174 and 236 the traveller on our railways appears to have much for which to be thankful, great as is the outcry when the error of a signalman leads to disaster, or when the exigencies of fast-express driving cause a driver to misunderstand signals.

The passenger cars in use on American railways may be dismissed in a few words. In a country where long-distance travelling is so common, it was only natural that cars should be provided which would afford the passengers the maximum of comfort. It was in America that the corridor train had its birth; it is the home of the luxurious Pullman, beyond which there appears little to say,

HEAVY PULLING ON THE PENNSYLVANIA RAILROAD

and we will content ourselves with a description of a world-famous train, the "Pennsylvania Limited," the running of which will be described in later pages.

These trains are composed of four cars, viz. a combined parlour, buffet, smoking, and baggage car, with bathroom and barber's shop, a dining-car, a drawing-room sleeping-car, and a compartment-car with observation platform on the rear end, enclosed with bronzed gates and railings. All of these cars are of Pullman equipment, except that a Pennsylvania Railroad dining-car is used. These cars are fitted up in the most approved and luxurious style known to the car builder's art; they are lighted by electricity, and are provided with electric fans to add to the passengers' comfort in hot summer weather.

The American freight vehicles are noted for their great size in order to cut down the proportion of dead weight carried. Previous to the year 1880 the average box-car was 27½-ft. long, 8-ft. wide, and 6-ft. high (inside measurements), weighing 20,300 lbs. when empty, and with a capacity of 16,000 to 24,000 lbs.; whereas nowadays the average is 36-ft. × 8½-ft. × 8-ft., weighing 44,200 lbs. when empty, and with a capacity of 100,000 lbs. Gondola cars have increased from a capacity of 40,000 lbs. to 100,000 lbs. In addition to this growth in size, steel has become the general material for construction instead of wood.

In recent years, indeed, all-steel passenger coaches have come into favour, and in 1906 the Pennsylvania Railroad announced that all future passenger equipment would be built of steel; not only steel frame, but steel throughout and entirely non-collapsible. The new standard coaches are of great strength, and they comprise a steel framing which cannot be affected by fire, and an inside lining which is absolutely unburnable. The Pullman Company, at the instance of the Pennsylvania Railroad, at once commenced designing all-steel parlour and sleeping cars.

At various times accidents to trains on British railways have been accompanied by the firing of the wreckage, largely adding to the death-roll other than by the direct effect of collision or derailment. At such times flying cinders from the engine firebox not infrequently give rise to fire; but the explosion of the gas tanks, by means of which carriages are illuminated, may involve even uninjured carriages in fierce flames that keep would-be rescuers at bay, increasing the horrors of the accident a hundredfold. A notable example was the Aisgill disaster in September, 1913, by which seventeen persons lost their lives and twelve were injured. There was a public demand for some means of decreasing the ever-present risk of fire in accidents to gas-lighted trains, and the provision of ample tools to assist rescuers in removing passengers from among the debris. The outcry was not without result, as seen in a new safety train which the Lancashire and Yorkshire Railway Co. put into service between Manchester and Southport in December, 1913.

"Seen from outside the train looks like any other, but the material under the outer brown paint is steel and not wood. Outside the carriages there is no wood at all beyond the footboards. The frame, the underframe, the bogies, and the sides are of steel. The floorings are all double and are 'insulated' with asbestos. The lighting of the train is by gas, but the gas tanks are separated from the floorings by thick steel plates. They are also encased in steel to protect them from damage. Each gas tank is fitted with automatic valves, and if a gas pipe should be broken these valves at once prevent any further outlet of gas. A novel feature is a large window in the centre of each coach hinged horizontally and opening outwards and upwards. This window is intended as an emergency exit. The train has a central corridor throughout its length of nearly 500-ft. At each end is a large tool rack containing axes, crowbars, fire extinguishers, and other salvage and rescue apparatus."

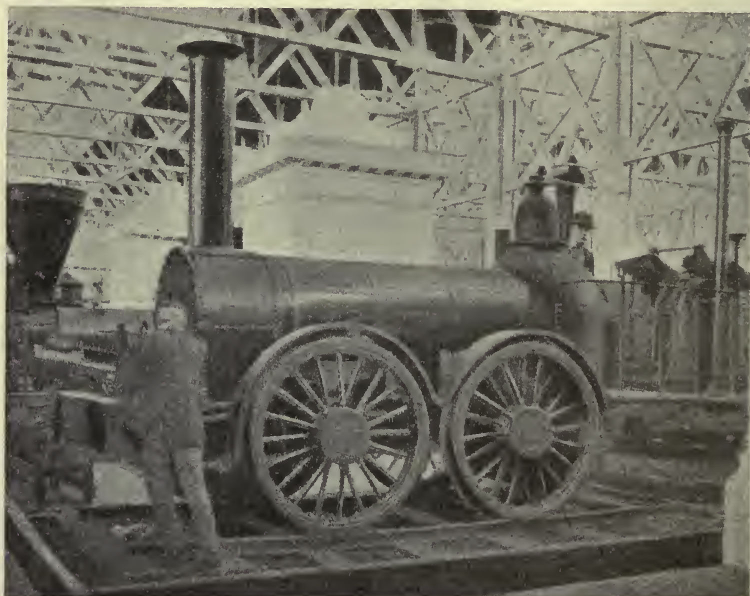
American locomotives are fitted with cowcatchers, an absolute necessity where the tracks traverse vast grazing grounds and cattle on the line are an ever-present danger. Railway-engine headlights in British practice are chiefly for identification purposes by the railway operators, and not to light up the track ahead of the engine-driver in order to detect possible obstacles. Our lines are well fenced in, and under usual conditions travelling at night is as safe as by daylight. In America the tracks are exposed, trees uprooted by gales may foul the lines, boulders may have rolled down mountain-sides, or a sudden flood may have swept across the metals. Consequently large headlights were always the rule, and with the advent of electric light, powerful lamps are provided that will illumine the track and enable the driver to detect an obstruction half a mile ahead.

Whether American engine-builders were beholden for ideas to their British confrères or not, it is a fact that during the first ten years of railway development in the States, more than a hundred engines were sent across the Atlantic by British builders. In the Field Columbian Museum, Chicago, is exhibited the "Rocket," one of a number of locomotives shipped by Messrs. Braithwaite, Milner and Co., of London, to various American railroads, from the year 1833 and onwards. Originally this engine was four-coupled, but was afterwards converted into a single-driver. Its weight in working order was 8½ tons. It was capable of drawing three passenger coaches at 22 miles an hour, or a goods train of 150 tons at 10 miles an hour. It was in service on the Philadelphia and Reading Railroad until 1879, by which time it had run 310,160 miles. It was afterwards partly rebuilt and exhibited at the Chicago World's Fair in 1893.

American engine-builders combated their own difficulties with just the same dogged perseverance that marked British efforts. Traffic conditions on either side of the Atlantic are so radically different that it is impossible to say that what is advisable in one country is equally suitable for the other. On the whole, however, it may be said that the credit for economical railway transport rests with Europe.

Although some of the American railroad companies build engines in their own workshops, the great bulk of the finest locomotives are obtained from outside builders, of which the Baldwin Locomotive Works and the American Locomotive Company are in the very forefront.

Matthias W. Baldwin was a skilful mechanic and engineer whose attention was directed to the railway locomotive when he was asked to build a model engine for use in the Peale Museum, Philadelphia. This effort proving a success, he was asked to build a locomotive for use on the Philadelphia, Germantown, and Norristown Railroad. The Camden and Amboy Railroad had just imported an engine from the works of Robert Stephenson and Co. This locomotive was the famous "John Bull," and the parts, which had not then been put together, were stored in a shed at Bordentown.



ENGLISH-BUILT LOCOMOTIVE, "ROCKET"
(Philadelphia and Reading Railroad)

Mr. Baldwin examined the parts, and from sketches and memoranda undertook to build his first locomotive for actual service on a railroad. The "John Bull" had two pairs of wheels the same size coupled, similar to the "Samson" which was built for the Liverpool and Manchester Railway in 1831. Mr. Baldwin produced the "Old Ironsides," a four-wheel engine with the driving-wheels in front of the firebox, and the carrying wheels close behind the smoke-box. The total weight was 5 tons. The engine was soon at work, and had it not turned out successful, no blame would have attached to the railroad company, who displayed such marked solicitude that they advertised the fact that when the weather was inclement the engine would remain in the shed and the cars would be drawn by horses. From such small beginnings sprang the famous Baldwin Locomotive Works, where 13,000 employés now turn out six locomotives a day. It was to this firm a few years ago that the Pennsylvania Railroad Company gave the largest order on record, viz. 350 engines of various kinds.

It may be asserted safely that American engineers have not only evolved those types best suited to their own varying conditions of service, but that they have in several instances set the fashion in Europe. A noted example was shown in the ten-wheeler (4–6–0), which came into prominence when used in racing trains in America in 1895, and which was the American reply to our East and West Coast rival racing results (pages 48–51). Hitherto British builders had viewed the single-driver as essential for speed, whereas six-wheels coupled and of smaller diameter were quickly adopted for fast traffic.

Another American engine that speedily made its mark was the "Atlantic" type (4–4–2), which was first turned out at the Baldwin Locomotive Works in 1895. The chief advantage in this design lay in the driving-wheels being well in front of the firebox, which thus could be extended laterally to afford a largely augmented grate area. At the same time it must be observed that in British railways there had not been the same need to provide large grate areas as in the United States and on the Continent, where inferior fuel is largely used and heavier trains are the rule.

The ten-wheeler (4–6–0) led to the "Pacific" type (4–6–2), of which the "Great Bear," on the Great Western Railway, was the first in the United Kingdom. Still another American type that has appeared in nearly every country in the world is the "Mogul" (2–6–0), which is a capital engine for fast freight traffic.

During the last two decades the Americans made huge strides in locomotive development; the exploitation of the Western States, and the need for extra haulage power to draw heavy loads over long distances and to overcome difficult grades, led to the production of absolute locomotive mammoths, of which a few are illustrated. Particularly has this been the case with the Mallet engines, which originated in France, but have attained their greatest dimensions in America.

Until a few years ago the "Consolidation" engines of the Pennsylvania Railroad, weighing 98 tons, with a tender of 62 tons, were fairly representative of the heaviest engines in ordinary American practice, and just exceeding the "Baltic" type (4–6–4) illustrated on page 541, as representing the heaviest engine in Europe. But in 1904 the Atchison, Topeka, and Santa Fé Railroad went in for 4-cylinder tandem compound freight engines (0–6–6–0) that weighed about 128 tons each, or with the tender more than 200 tons.

These ponderous machines necessitated relaying portions of the Santa Fé track with heavier rails. In considering the weights of American locomotives, 1 ton=2000 lbs.

Only three years later the Erie Railroad eclipsed all records in weight of locomotives with Mallet articulated 4-cylinder compound locomotive No. 2600, one of three engines (0–8–8–0) for service as "pushers" on the Susquehanna and Gulf Summit section of their system, where the ruling grade is 1 in 77. These engines weighed 180 tons, or with the tender 250 tons. They were built at the Schenectady Works of the American Locomotive Company.

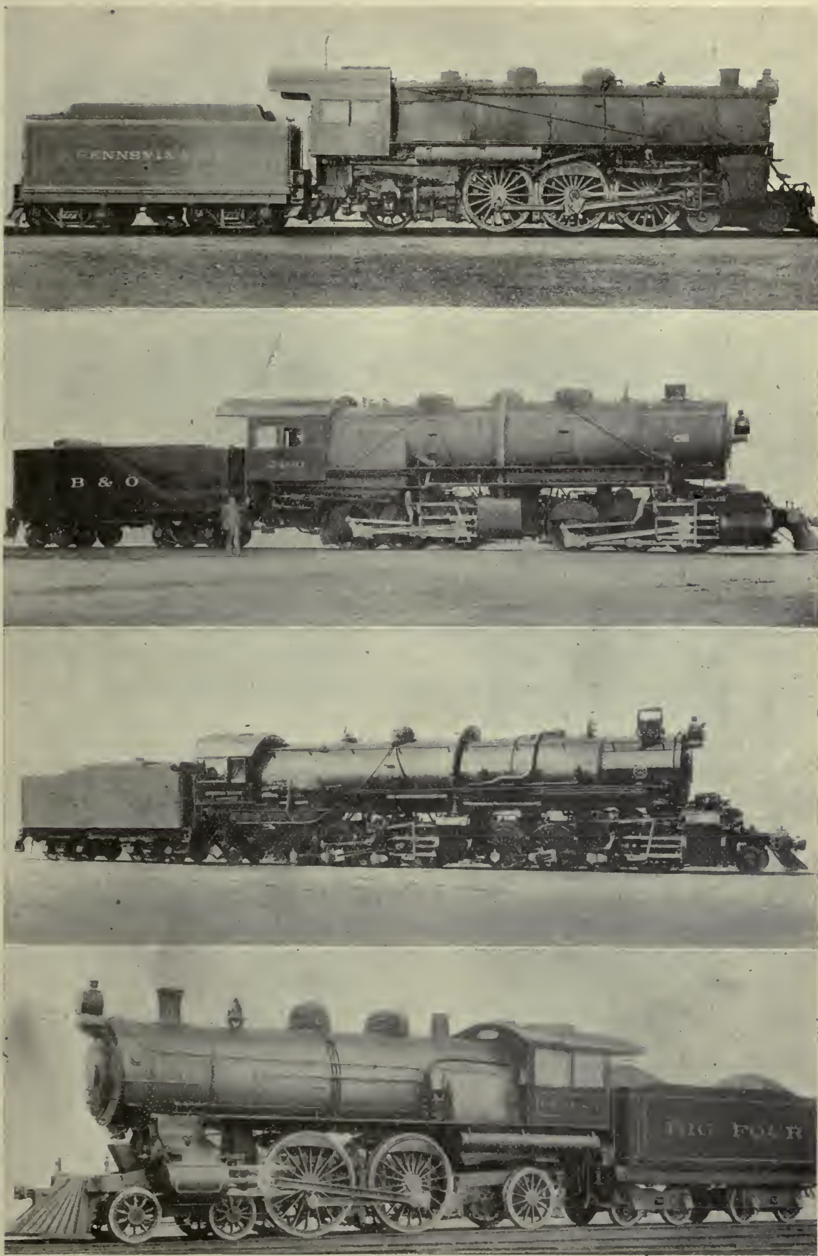
Early in 1909 the Baldwin Locomotive Works regained the record for the largest locomotive by building for the Southern Pacific Railroad an oil-burning engine (2–8–8–2), weighing 190 tons, or with loaded tender over 270 tons. Before the end of the year the same firm put the foregoing engine into the shade with a freight engine for the Atchison, Topeka, and Santa Fé Railroad which weighed 206 tons, with a tender of 104 tons.

The leading dimensions of this articulated compound locomotive (2–8–0–8–2) were as follows: high-pressure cylinders (driving the second group of wheels), 26-in. by 34-in.; low-pressure cylinders (driving the first group of wheels), 38-in. by 34-in.; diameter of radial wheels, front and back, 2-ft. 10¼-in.; diameter of the two series of eight-coupled driving-wheels, 5-ft. 3-in. The boiler of the straight-backed type 7-ft. in diameter, with a wide firebox, carried a working pressure of 220 lbs. per square inch. The firebox: 10-ft. 9½-in. long, 6-ft. 7-in. wide, with a depth of 6-ft. Heating surface of boiler: firebox, 236-sq. ft.; fire-tubes, 4768-sq. ft.; feed-water heater tubes, 1617-sq. ft.; total, 6621-sq. ft; super-heating and re-heating surfaces, 544 and 1201-sq. ft., respectively.

Experience in operating very large engines through tunnels and snow-sheds proved the desirability of placing the engine crew where they could obtain a good view of the track; and consequently some new Southern Pacific locomotives were designed to run with the firebox end first and the tender behind the smoke-stack, a plan that would be impracticable with coal-burning locomotives, but which presents no difficulty when using oil as fuel.

It was at one time thought that there would be a reaction against these monster engines, but in performance they came up to expectations, and the Associated Lines, for example, order them a score at a time.

In 1910 the Delaware and Hudson Railroad received from the American Locomotive Company a huge freight Mallet engine (0–8–8–0), weighing 198 tons; total moving weight with the tender, 273 tons. Though in gross weight it did not equal the engine last described, it was claimed to be the most powerful locomotive ever placed on rails. When working compound its hauling capacity on the level was 10,190 short tons (2000 lbs.), on a grade of 1 in 200,



1. 4–6–2, PASSENGER LOCOMOTIVE (Pennsylvania Railroad)
2. 0–6–6–0, MALLET ARTICULATED COMPOUND LOCOMOTIVE (Baltimore & Ohio Railroad)
3. 2–8–8–2, MALLET ARTICULATED COMPOUND LOCOMOTIVE (Southern Pacific Railroad)
4. 4–4–2, PASSENGER LOCOMOTIVE (Cleveland, Cincinnati, Chicago & St. Louis Railroad)

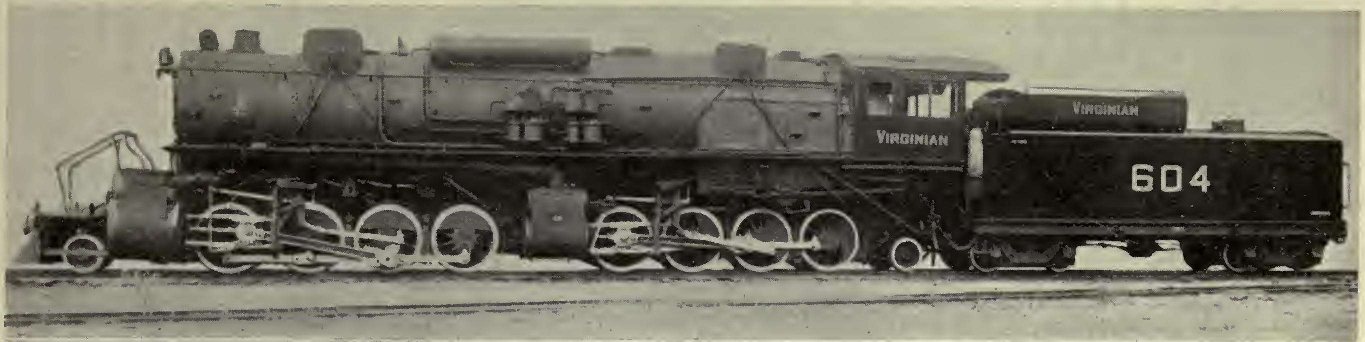
6255 tons, and 915 tons even on a grade of 1 in 25. Engines of this kind are used on the Jefferson branch of the Delaware and Hudson Railroad in operating loaded coal trains from Carbondale to Forest City, a 6-mile up-grade of 1 in 73½, followed by a 14-mile rise to Ararat of 1 in 123. Formerly trains of 2600 tons were hauled from Carbondale to Ararat by "Consolidation" engines with two similar engines to act as pushers. A single Mallet engine now takes the place of the two "Consolidation" "pushers," and so reduces operating expenses.

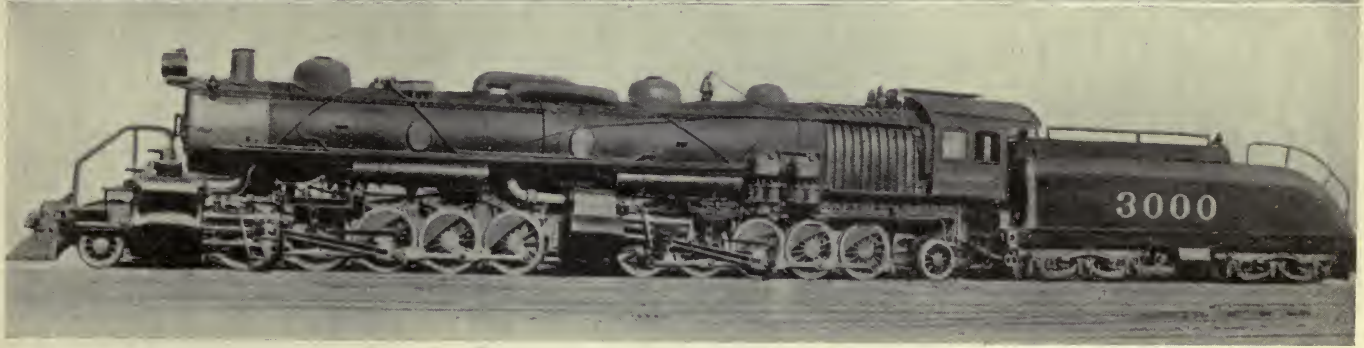
In 1912 the Virginian Railroad put upon their rails the largest and most powerful engines ever constructed. They were Mallets (2–8–8–2), weighing over 241 tons, or 335 tons with the tender. From rail level to the top of the chimney, 16-ft. 6-in.; over-all length of engine, nearly 66-ft. The size of the firebox may be gauged by the fact that it easily accommodates one of the little yard locos. employed at the Schenectady Works. These engines were for use on the Deepwater division of the Virginian Railroad, the crucial point being 14 miles between Elmore and Clark's Gap, most of which is on a grade of 1 in 48, with many bad curves. With two of these new Mallets as helpers, a Mallet of a lighter class will take a train of 3776 tons over this difficult grade.

Of all locomotive giants the 3000 class Mallet oil-fired compounds (2–10–10–2) of the Atchison, Topeka, and Santa Fé Railroad are pre-eminent. The weight of the engine is 308 tons, of which 276 tons rest upon the twenty 4-ft. 9-in. driving wheels. The 12-wheeled tender weighs 117 tons, and carries 12,000 gallons of water and 4000 gallons of oil. Engine and tender together weigh 425 tons and have a length of 120-ft. over all. The high-pressure cylinders are 28-in. by 32-in. and the low pressure 38-in. by 32-in. The firebox is 12½-ft. long, 6½-ft. wide, and 6⅓-ft. deep, giving 294½-sq. ft. of heating surface; there are 377 fire tubes with a heating surface of 3625-sq. ft.; superheated heating surface 3318-sq. ft. Representing the latest developments in engine-heating arrangements, there are also a re-heater and a feed-water heater affording 2659-sq. ft. of heating surface.

These locomotives are for freight service on grades of 90-ft. per mile with average loads of 1900 tons at speeds up to 15 miles per hour. For experimental purposes one of these engines has hauled a train of 4340 tons a distance of 111½ miles in 140 minutes. At a speed of 10 miles an hour the engine develops about 3000 horse-power.

A very interesting experimental train was run by the Pensylvania Railroad to test their H–8–b type freight locomotives, which in working order weigh 198 tons. In this case the 120 loaded cars weighed 6300 tons, and from end to end the train measured little short of a mile. The 127 miles between Altoona and Enola Yard have been regraded so as to give no heavier rise than 12-ft. per





1. 2-8-8-2, MALLET LOCOMOTIVE, NO. 604 (Virginian Railroad)
2. 2-10-10-2, MALLET LOCOMOTIVE, NO. 3000 (Atchison, Topeka & Sante Fé Railroad)

mile, and over this distance one engine hauled the huge load in 9 hours 36 minutes; deducting delays the actual running was at the rate of 19 miles an hour. Owing to the length of the train telephonic communication was fixed up between the driver of the locomotive and the brakesman in the rear van.

What will be the ultimate limit in the size of Mallet locomotives it is impossible to say, but other types are developing in dimensions to a remarkable degree. For example, the Philadelphia and Reading Railroad, in 1913, had built to their own design the largest "Mikado" type freight locomotive (2–8–2) ever constructed. Some of its leading dimensions were: cylinders, 24-in. by 32-in.; boiler, conical type, working pressure, 225 lbs.; firebox, 9-ft. by 12-ft.; grate area, 108-sq. ft.; 504 tubes, 2¼-in. diameter, length 17-ft. 8-in.; heating surface: firebox, 298-sq. ft., tubes, 5210-sq. ft., total, 5508-sq. ft. Driving-wheels, 5-ft. 2½-in. Total weight of engine, nearly 148 tons; gross moving weight of engine and tender, nearly 220 tons.

British engines are increasing in size, power, and weight, but cannot be compared with the American locomotives. The "Great Bear" of the Great Western Railway was never even duplicated; and the latest and largest British engines, such as the "Sir Sam Fay" (engine and tender, 122 tons) on the Great Central, or the "Sir Gilbert Claughton" (engine and tender, 116 tons) on the London and North Western Railway, are but mere dwarfs when placed alongside some of the mammoths that have been under consideration. There is not the slightest doubt that British locomotive builders could construct giant engines equal to any yet built on the other side of the Atlantic, but these monster machines would be impracticable upon our railways, where the limit for width is 10-ft. 6-in, and the height from rail level to chimney top is restricted to 13-ft, these gauges being governed by the height of bridges and especially tunnels. Again, there is no call for abnormally long goods or mineral trains, since in the United Kingdom there are no very long runs such as are common in America; and in any case we have comparatively few sidings that could accommodate the length entailed in a 3000-ton train.

In 1902 the New York Central and Hudson River Railroad commenced running its "Twentieth Century Limited" between New York and Chicago, and the Pennsylvania Railroad put on the "Pennsylvania Limited" between the same two cities. This latter train is illustrated on Plate I. The distance between New York and Chicago is 912 miles by the Pennsylvania and 980 by the New York Central. Both trains were scheduled to accomplish the journey in 20 hours, which time they made regularly every day. On the Pennsylvania the train was required to run at a speed of 45¾ miles per hour; on the New York Central the required speed was 49 miles an hour, exclusive of half a dozen regular stops, changes of engine, and a number of slow downs *en route*, which over a great portion of the distance called for a 60-mile gait or better, in order to run to time.

For convenience sake as well as brevity some of the more notable fast runs in the United States may be tabulated, as selected from *The World Almanac and Encyclopædia*, 1913.

The record for speed is always a great bone of contention among railwaymen, and it is sometimes difficult to adjudicate upon rival claims, and certainly some of the reported American speeds are of the "tall order" variety that will not stand critical examination. But in the United States there are various well-authenticated booked runs that reflect the greatest credit upon the railway

"BLACK DIAMOND EXPRESS"
(Lehigh Valley Railroad)

operators. The length of the run and the gross time occupied are not the sole tests of speed, since the grades must be taken into account as well as single-line working, and various other traffic exigencies. A train that averages but 45 miles an hour for a journey, may lose time in one section and have to travel 80 miles an hour in another stretch to atone for it.

As stated in earlier pages, only booked runs can lay claim to inclusion in any list of meritorious performances. In 1896 the New York Central Railroad commenced running their "Empire State Express" from New York to Buffalo, 440 miles in 8¼ hours, an average run of 53·3 miles per hour. This was nearly a mile an hour faster than the London to Edinburgh run of our East Coast Aberdeen express.

During the next year the Atlantic City Railroad instituted a booked run from Camden (Philadelphia) to Atlantic City, 55½ miles in 52 minutes, or 64 miles an hour. The best record for the whole journey was 46½ minutes, or 71·6 miles an hour.

FAST RUNS OF PASSENGER TRAINS FOR LONG DISTANCES

Date.	Railroad.	Terminals.	Distance Miles.	Time H. M.	Miles per hour.
April, 1895	Pennsylvania	Camden—Atlantic City	58·3	0 45¾	76·5
Sept., 1895	New York Central and H. R.	New York—Buffalo	436·5	6 47	64·3
Sept., 1895	N. Y. Central, "World Flyer"	Albany—Syracuse	148	2 10	68·3
Feb., 1897	Chicago, Burlington, and Quincy	Chicago—Denver	1025	18 52	58·7
April, 1897	Lehigh Valley, "Black Diamond Express"	Alpine, N. Y.—Geneva Junct., N.Y.	43·96	0 33	80
March, 1902	Burlington Route	Eckley—Wray	14·8	0 9	98·7
April, 1904	Michigan Central	Niagara Falls—Windsor	225·66	3 11½	70·7
June, 1905	Pennsylvania	New York—Chicago	897	16 3	56·07
July, 1905	Pennsylvania	Washington, O—Fort Wayne	81	1 4	75·8
Feb., 1911	Pennsylvania	Altoona—Philadelphia	235	3 29	67·2

FASTEST RECORDED SHORT-DISTANCE RUNS

Date.	Railroad.	Terminals.	Distance Miles.	Time M. S.	Miles per hour.
May, 1893	N. Y. Central and H. R.	Crittenden—"Empire State Express"	1	0 32	112·5
March, 1901	Plant System	Fleming—Jacksonville	5	2 30	120
April, 1904	Michigan Central	Crisman—Lake	3·73	2 0	111·9
July, 1904	Philadelphia and Reading	Egg Harbour—Brigantine Junction	4·8	2 30	115·2

A few other remarkable records may be chronicled, chiefly concerned with long distances.

On August 3rd and 4th, 1897, on the Union Pacific Railroad, a special train was worked throughout by the same engine and men from Evanston, Wyo. to Omaha, Neb., a distance of 955·2 miles. This was a remarkable performance, even though the load was only 118 English tons. The average speed for the whole journey was 39·93 m.p.h.; but, deducting time lost in stops, the running time was 20 hrs. 8 min., giving an average of 47·44 m.p.h.

On February 14–15th, 1897, on the Pennsylvania and the Chicago, Burlington, and Quincy Railroads, a train ran from Jersey City to Denver, 1937 miles, in 48 hours at an average speed of over 40 miles an hour.

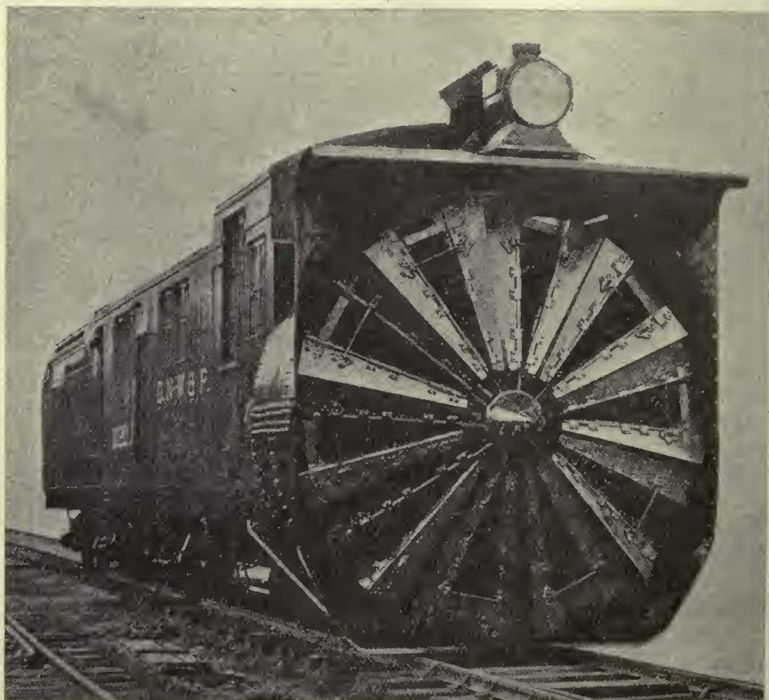
The record price for a railway ticket fell to the honour of Mr. Walter Scott, a Californian millionaire, who chartered a special train to convey him the 2000 miles that lie between Los Angeles and Chicago. If a Londoner desired to emulate the American he might book to Constantinople, for which the ordinary fare would be about £22 for the 74-hour journey. Mr. Scott accomplished his journey in less than 45 hours, an average speed of about 51 miles an hour, for which he paid £1100.

It was not for mere hustling that Mr. H. P. Lowe made a flight across the continent from New York to Los Angeles, but to visit his daughter who lay seriously ill. The entire journey of 2245 miles occupied 73 hrs. 21 mins. From New York to Chicago the anxious parent took advantage of the "Twentieth Century Limited" at 48 miles an hour, but from Chicago he engaged a Santa Fé special that travelled at only 42·8 miles an hour, excluding stops. For the latter portion of the journey Mr. Lowe paid about £900. It proved to be a pathetic but fruitless journey, for the gentleman arrived at his journey's end too late to take a last farewell of his daughter.

Another American special that made railway history in the summer of 1903 became known as the "Safety-Pin Express," its object being to convey a seven-months-old baby to a doctor, in order to remove an unclasped safety-pin which the infant had stowed in its interior anatomy. The journey was from St. Regis Lake, in the Adirondacks, to New York, a distance of 400 miles, which was accomplished in 10 hours. In this case the expenditure of £200 effected the happiest results, for after a two minutes' groping one of the medical staff of the Roosevelt Hospital secured the safety-pin treasure-trove to the great joy of the parents of the erring juvenile.

In concluding this brief and necessarily incomplete account of ordinary railway working in the United States reference must be made to the immense difficulties caused by ice and snow on the exposed sections of railways, especially in high altitudes or on blizzard-swept plains; and in this connection the remarks apply equally to the Canadian railways. On British railways we sometimes experience blockades of snow, but nothing in comparison to the conditions that fall to the lot of the railway operator in North America every year with almost unfailing regularity.

Where the lines traverse actual mountain regions, the metals are often in long sections at a time protected by snow-sheds on a far larger scale than mentioned on page 493 in connection with railways in the Western Highlands of Scotland. Snow-sheds practically are tunnels, usually constructed of wood, to protect the metals from avalanches, which permit a heavy downfall to pass harmlessly over the track and to expend its violent energy in the gorge below. But snow-shedding has its disadvantages in normal seasons, for a lengthy structure holds suffocating smoke, is very subject to fire, and in all cases renders signalling difficult. Engineers are now agreed that snow-sheds should be erected in sections not exceeding 3000-ft. in length, and between the sections there should be a clear interval of open line for a considerable distance. To protect these breaks in the shedding various kinds of fencing are adopted, that tend to split up and deflect a snowslide and at least minimise its obstructive and destructive tendency.



ROTARY SNOW-PLOUGH
(Denver, North-Western, and Pacific Railroad)

But on the storm-swept plains, often of vast extent, snow-sheds are not practicable, and after a heavy fall of snow long sections of line are not only absolutely blocked, but trains are engulfed and have to remain until assistance arrives. The wedge type of snow-plough as used on British railways has been described on page 148, but such an apparatus is quite useless to cope with a blizzard deposit. It was on the Union Pacific, about 1887, that the first rotary snow-plough was put into operation, and speedily it demon-

ROTARY SNOW-PLOUGH AT WORK ON A HEAVY GRADE IN DEEP SNOW (Denver, North-Western & Pacific Railroad) strated its superiority over the wedge type. It effectually cleared away snowdrifts that had baffled all efforts to clear them for weeks before the new apparatus got into operation; during one month it ran over 3000 miles at a cost of only 16½ cents per mile, this including the working expenses of the plough and a pusher engine and the pay of the crews operating them.

Rotary snow-ploughs are now a regular part of the equipment of North American railways; but though there are more than a few on the continent of Europe, there is not one in our country, where fortunately there is seldom a downfall of snow sufficiently heavy to call for its services. The American Locomotive Company has improved upon the first rather crude designs, and provides a machine that represents practical perfection. Briefly, the plough consists of a wheel revolving transversely to the track at the head of a substantially built car, the operating machinery being a pair of horizontal cylinders receiving steam from a loco.-type boiler. The wheel is composed of ten hollow cone-shaped scoops with sharp knife edges, which cut the compacted snow and ice, and it is enclosed within a drum with a square front, the whole capable of being raised or lowered to suit varying conditions. Our illustrations show one of these ploughs at rest and at work; vividly indicating what happens to a snowdrift along a railway track. It is simply cut through by the revolving scoops and thrown away to one side.

In a country so huge and with natural features so varied, it is only likely that there will be a number of lines that are more than ordinarily interesting in their construction or working.

Pike's Peak, in Colorado, is a remarkable mountain thrusting itself from out of a comparatively level plain over 14,000-ft. into the clouds. Its crest commands magnificent views over an area of 60,000 sq. miles, and there was little wonder that American railway engineers desired not to be behind their European brethren, who had conquered various Alpine heights. If a ribbon of steel could be carried to the summit of Pike's Peak, there was little doubt that the project would prove profitable, since some of the joys of mountain climbing would be brought within reach of the masses without peril or untoward demands upon their endurance.

From Manitou Station, on the Denver and Rio Grande Railroad, it was decided to built a cog railway on the Abt rack system, and as Manitou is 6000-ft. above the sea, the engineers had to overcome a rise of 8108-ft., which they accomplished by means of a track nearly 9 miles long, having an average grade of 19-ft. in 100. The work of preliminary surveying was an arduous task, calling for men to be slung by chains over precipitous cliffs amid biting winds, snow blizzards, and heavy rains. Numerous accidents befell the adventurers, but eventually the plans were completed, and the actual work of construction commenced in 1889. Notwithstanding the innumerable obstacles, especially beyond the timber line, the railway was completed in October, 1890, at a cost of £200,000, an average of £22,000 per mile. It is the longest rack railway in the world. The road-bed is from 15 to 22-ft. wide, leaving quite 5-ft. on each side of the cars. To prevent any possibility of the track sliding in its bed, anchors are set into the solid rock at 746 points, varying in distance apart from 200-ft. to 600-ft., according to the grade. For the return journey of 18 miles the fare is 20s., and during the short season each year that the line is open, the ascent is an immensely popular tourist attraction. June 1st is the commencement of the running season, but sometimes even in July snow-clearing tackle has to be employed to remove drifts as deep as 35-ft. The locomotives employed, which are always at the downhill end of the train, are Vauclain 4-cylinder compounds, carrying steam at a pressure of 200 lbs. per sq. in. The cars are of observation Pullman pattern, and accommodate 50 persons each.

From the very foot of the railway the passenger commences to enjoy glorious views, increasing in grandeur, until after a straight climb on a gradient of 25 in 100 to the old Government Signal Station on the summit, the eyes may be feasted on Manitou, the "garden of the gods," and the hundreds of snow-mantled peaks that make up the Continental Divide.

Florida is a large peninsular State in the extreme south-east of the United States, with a chain of small islands curving in a south-westerly direction towards Cuba. The chain terminates in Key West, where is a naval station that figured prominently during the Spanish-American War of 1898. As a result of the war, the United States secured great interests in Cuba, only distant some 90 miles from Key West, to which point it was decided to extend the Florida East Coast Railway a further 45 miles on the mainland to the water's edge, and then carry the metals across the chain of islands to the naval station. The construction of the mainland portion of the extension was a sore trial to the railroadmen, since the route lay through the Everglades, a wilderness of swamps, morasses, and foul mangrove forests, where mosquitoes existed in clouds. Here a great deal of the work consisted in excavating two parallel canals, the dredged-up mud forming an embankment upon which to lay the rails. From the coast the railway called for a series of embankments and viaducts of reinforced concrete, for many of the islands are mere coral reefs, and some of the gaps between them are 2, 4, and even 7 miles wide. Consequently a great deal of this marine section of the work entailed building actually in the sea, one link necessitating a viaduct of 120 arches, each resting on 28 piles and capped with concrete to a depth of 9-ft. Some of the materials employed in this one section consisted of 3,000,000-ft. of timber, 200,000 cubic yards of rock, 300,000 barrels of cement, and 7000 tons of steel reinforcing rods. The rails are laid throughout at a uniform height of 31-ft. above high water; and thus on this railway through the sea, the passengers, looking from the car windows, can see nothing between the railway and the horizon except the waters of the Gulf of Mexico on the one hand and the broad Atlantic on the other.

Alaska, in the extreme north-west of America, was bought from Russia by the United States for $7,200,000 in gold. Until a few years ago the rigorous climate of the region appeared to place it outside the pale of civilisation; and it was left to Indians, Russian

VIADUCT ACROSS AN ARM OF THE ATLANTIC OCEAN
(Florida East Coast Railroad)

half-castes, Eskimos, and a few vagrant Chinese to exploit the scanty resources of the territory as best they could. But the discovery of gold in the Yukon region, and especially in the neighbourhood of the Klondyke River, sent a thrill through the civilised world, and there ensued a "gold rush," the like of which had not been witnessed since the discovery of the precious metal in Victoria over fifty years ago. Spurred on by the hope of gaining sudden wealth, hordes of gold-seekers were on the trail in an incredibly short time, ignorant of the perilous journey to which they were committing themselves to reach a country that for two-thirds of the year is in the grip of winter, with the mercury many degrees below zero.

There are three ways by which to approach the Klondyke:

(1) From Canadian territory by the eastern side of the Rocky Mountains, but a route whose length and general difficulties made it practically impossible. (2) By means of a long sea voyage to St. Michael on Behring Sea, and then by steamer up the Yukon for 1500 or 1600 miles. Here again delays and expense were almost prohibitive. (3) The shortest and quickest way was to enter the country from the south, from either Skaguay or Junea, the best ports of entry. From these towns there are two parallel passes running towards Lake Bennett, from whence boats, which had to be built on the spot, could drift down to Dawson City. Both passes are steep and impeded by glaciers, and in winter the snow accumulates to a depth of 50-ft. Chilkoot Pass is too steep for pack animals, but the White Pass could be negotiated by persons of iron constitution and the most dogged pluck, and provided with a reasonable outfit. Naturally every seeker after fortune could not claim these attributes, and consequently the trail to Klondyke proved a death-trap to a host of victims, who became enshrouded in the frost-bound earth. It is asserted that in one section, within the short space of a mile, there were 3500 dead horses !

The Klondyke region soon proved itself to be a veritable El Dorado, and within two years the White Pass and Yukon Railway was being planned, and construction was commenced in June, 1898. Shortly 2000 men were pushing the metals northwards, but early in August there came a dramatic interference : gold was discovered at Atlin, in British Columbia, and two-thirds of the workmen deserted the line in order to be among the first in the new " rush." But by August 25th trains were running along the first 14 miles of the line, and provided a useful lift towards Lake Bennett. The next six miles of construction presented heart-breaking tasks to the workmen. They toiled with the thermometer ranging from 20° to 40° below zero, on some of the steepest sections having to be " roped " to prevent their being blown away by the icy Arctic blasts, which were so numbing that a man could work only an hour at a time. But gradually all obstacles were overcome, and early in 1899 the first train climbed to the summit of the White Pass, a score of miles from Skaguay, at a height of 2865-ft. above sea-level.

During the succeeding most inclement season of the year the workmen were transferred to the timber-line region at the Bennett end of the line, their communications with the summit being maintained by means of an iced roadway, a capital slope for sledging, both light and heavy, and immense quantities of material went over it in the spring. A 30-ton boiler was conveyed by rail from Skaguay to the summit, and then drawn by twenty horses over the iced road to Bennett, from which point it was floated to Dawson City ; and materials for the construction of steamers to ply on Lake Bennett also went in similar fashion.

At the end of a year the line extended from Skaguay to Lake Bennett, a colossal feat considering that mile after mile of the track had to be blasted out of solid granite on the rocky sides of mountains, and where often the materials for blasting, drills, etc., had to be carried on men's backs. It was necessary to construct three score bridges, but only one tunnel.

From Lake Bennett it is possible to travel by way of the Yukon

Photo] [*E. H. Hegg, Skaguay*

FIRST PASSENGER TRAIN OVER THE WHITE PASS

River all the way to Dawson City, and then on to St. Michael's at the mouth of the river on Behring Sea, a total distance of nearly 2500 miles; but only small boats could traverse the Miles Canyon and White Horse Rapids, and as useful and commercial navigation only commences at the foot of the White Horse section, it was desirable to push on the railway to that point with all speed. In some respects cutting the track through rock was less difficult than dealing with merely frozen earth. Once the rock was conquered the work was done, but in the case of the frozen earth, when spring came, the cuttings and embankments thawed and played havoc with the grading, involving a repetition of work and much extra expense. But engineering skill triumphed over all difficulties, and the last spike was driven in on July 29th, 1900. The line, which is 3-ft. gauge, cost £850,000, of which nearly half was spent in reaching White Pass Summit from Skaguay. During the operations 35,000 men were employed. The locomotives working on this line are among the heaviest narrow-gauge engines in the world ; engine and tender weigh 106 tons, indicative of the power needed to overcome the difficult grades, which in places amount to 1 in 25. As the line was built at a feverish speed, a portion of the work was intended to be only temporary, timber trestles and bridges being requisitioned until they could be replaced by steel structures. Since 1900 the whole of the line has undergone careful overhauling, and it now compares favourably with any line on the American continent. The White Pass and Yukon Railway is not the most northern in the world, as the climatic conditions apparently suggest ; this is claimed by a railway in Sweden between Stockholm and Narvik, on the Ofoten Fiord, which is several degrees within the Arctic circle, whereas the greater portion of the whole of Alaska is outside it.

RAILWAYS OF MEXICO

Mexico is one-quarter the size of the United States, but it has only one-sixth of the population, and its length of railways is still smaller in proportion, namely, one-fifteenth. The country for the most part consists of an immense tableland, traversed and skirted by ranges of lofty mountains, while there are many cross ridges and isolated peaks alternating with yawning canyons. On the Atlantic side the plateau descends steeply to the gently sloping narrow strip of coastland ; in the west the descent to the Pacific is more gradual. The railways of the country owe their inception chiefly to Yankee and British enterprise, and in their construction the engineers met with more than a fair share of natural obstacles.

The National Railways of Mexico account for more than half the railway mileage in the country, throwing out tentacles in every direction from north to south and east to west. This great system, which is controlled by the Mexican Government, is a combination of the Mexican Central, National, International, Mexican Southern, Vera Cruz and Isthmus, Pan-American and various other smaller railroads, with a grand total of nearly 9000 miles of track. The chief line in the whole system, and the greatest on the American continent, outside Canada and the United States, is the Mexican Central Railway, whose main line runs from Mexico City to Ciudad Juarez, on the frontier of the United States, a distance of 1224 miles, branch lines in various directions making a total of about 3900 miles.

The National Railways are linked up by rail with the United States at four points, and it is natural that the locomotives and other rolling-stock should come mainly from the great locomotive and carriage works of that country, although British builders sometimes secure orders in face of the nearness of their American competitors. The quickest way to Mexico from Europe is via New York, with which there are excellent connections over the three great trunk lines from Laredo, Ciudad Porfirio Diaz, and Ciudad Juarez. Among the best-known trains is the "Mexico-St. Louis Limited." Leaving St. Louis every evening, the train runs via the St. Louis, Iron Mountain and Southern, Texas and Pacific, and International Great Northern railroads to Laredo, from which point the route lies over the National Railways to Mexico City, the capital of the Republic. The journey occupies 71½ hours. This train is composed of Pullman cars of the finest type, and as the road-bed of the various railways traversed would compare favourably even with British lines, the passengers enjoy every comfort known to modern railway travelling. The corresponding north-bound train leaves Mexico City at 7.30 every evening.

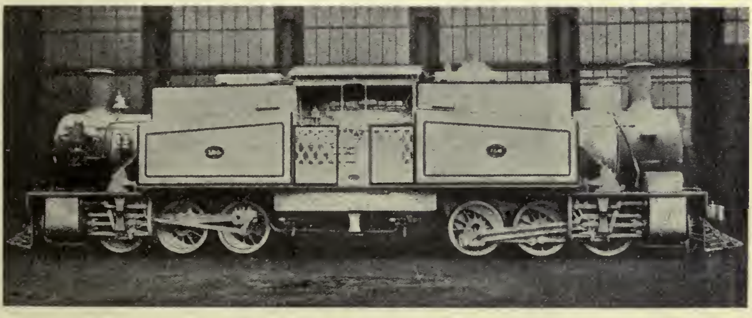
Many of the locomotives employed on Mexican railways are oil-burners, the country possessing vast supplies of mineral oil. For freight traffic on difficult grades Mallet engines are requisitioned largely. Some of them are monster machines, engine and tender weighing 228 tons; the tender with a capacity of 4000 gallons oil fuel and 9000 gallons water.

Of various lines not under Government control one of the most interesting is the Mexican Railway. Practically all the railways of the country start from Mexico City, and as Vera Cruz was always the principal port, a line between these two cities was the first objective of the railway builder; and in 1864 the Mexican Railway Co. was organised to construct the main line, with a branch to Pueblo, 290 miles in all. This first line in Mexico was supported by British capital and laid by British engineers. The chief difficulty was to overcome the steep ascent from sea-level to the great plateau at an elevation of 8000-ft., and this was effected without resort to a rack; and the line remains one of the steepest in the world, relying upon adhesion alone, and has caused it to become better known than any other railway in the country.

The work of construction was slow, for the disturbed state of the country caused ruinous delays, and altogether about 300 miles of line cost £6,000,000. When the railway was opened in 1873 it practically had a monopoly of all traffic between the capital and the outside world, and the owners took advantage of the opportunity to charge 5d. a mile for passengers and £12 a ton for freight; but these excessive rates ceased in 1884 with the opening of the Mexican

Central Railway to El Paso, which gave through rail connection with the United States, and a few years later a competing line between the capital and Vera Cruz was under construction.

The gradients between the coast and the plateau are against fast travelling, the journey of 263 miles occupying from 12 to 13 hours, or only 22 miles an hour ; but the trains stop at all intermediate stations. From Vera Cruz to Orizaba the train is hauled by a 4–6–0, which then gives place to a powerful 12-wheeled Fairlie tank engine to overcome the succeeding very severe gradients. We illustrate one of these locomotives, built by the Vulcan Foundry Co. in 1911. With a total weight of 138 tons, these engines are designed for service in hauling 300-ton trains up gradients of 1 in 25, with curves of only 5 chains radius. Great adhesive weight, cylinder and boiler power, and considerable



0–6–6–0, FAIRLIE TANK LOCOMOTIVE

(Mexican Railway)

flexibility are very requisite factors, and are most satisfactorily obtained in engines of this type.

The scenery is varied in the extreme, gloomy valleys alternating with glorious panoramas as the train zigzags higher and higher, until just before Esperanza is reached the Wimmer Bridge is crossed, a dangerous and awe-inspiring point. Onward, towards the capital, the track traverses flat and sandy plains, where cacti and other thorny shrubs are the chief vegetation, succeeded later by broad fields of maguey, a species of cactus with sword-like leaves, that yield a juice from which is prepared an intoxicating liquid called "pulque." These fields extend for more than a hundred miles, and pulque over 60,000 tons in weight is first in the list of commodities carried by the freight trains.

When the train from Vera Cruz draws up at the Buenavista terminus, Mexico City, it is assailed by a crowd of clamouring *cargadores*, or outside porters, for at none of the stations does the company employ regular porters ; and as the Mexican easily takes offence, the newly arrived foreigner views these importunate gentry with considerable misgiving. Although the carriage stock (only two classes) is modern, dining-cars are not yet known, there being a stop at Esperanza of 25 minutes for dinner. At the intermediate stations peddling Mexican Indians wait upon the train, and open an impromptu market, doing a brisk trade in fruit and eatables.

In Central America, although the Tehuantepec National Railway is only 189 miles in length, it is of the utmost importance, as it virtually forms a bridge between the Atlantic and Pacific Oceans, saving immense distances in the transport of goods, as against the all-sea route via Cape Horn. Another similar ocean distance saver is the Panama Railway, only 50 miles in length. But the completion and opening of the Panama Canal will, of necessity, rob these two railways of at least some of their hitherto great international importance.

CHAPTER XXX

RAILWAYS OF SOUTH AMERICA

THE semi-continent of South America has an area of 7½ million square miles, with a population of 35 millions and a railway mileage of less than 40,000. The countries on the Pacific slope are traversed by the Andes, which contain many enormous peaks, one of them, Aconcagua, being the loftiest mountain on the American continent. Eastward of the Andes the chief countries are Brazil and Argentina, extending to the Atlantic Ocean, while Bolivia and Paraguay are entirely inland countries. Three-fourths of the South American railways are in Brazil and Argentina. Practically all the railways owe their inception and financial support to foreigners, the interest of Britain and the United States predominating. Consequently, in their construction and working, these railways for the most part present nothing that differs from the general conditions which obtain in North America.

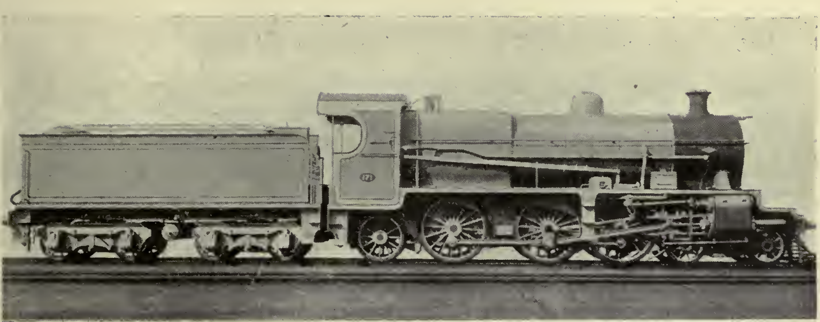
Brazil, with an area of 3,218,000 square miles, is second in size only to the United States, but a great deal of the country is unsettled, and vast areas of tropical forests are even unexplored. The chief commercial regions are on the Atlantic coast, but they are very detached and separated from each other by mountains or plateau escarpments, which make intercommunication a matter of great difficulty. The Maua Railway dates from 1852, and was the first in the country. It was only 10 miles long, running from the head of the Bay of Rio de Janeiro to just below Petropolis, to which the line was afterwards extended on the Riggenbach rack system.

At the present time the railways in Brazil have a total length of about 14,000 miles, controlled by quite fifty companies, not a few of which, however, are concerned with only very short and comparatively unimportant lines. The gauges are very mixed, the metre gauge prevailing. The longest lines are the Leopoldina Railway (1688 miles) and the Great Western of Brazil (1004 miles). The locomotives, carriages, and wagons of the Leopoldina Railway are 200, 250, and 2000 respectively; of the Great Western, 130, 250, and 2000.

In 1905, when the railway mileage of Brazil was 10,600 miles, the number of companies was 94, and the Government controlled 4402 miles of line. Gradually the Government secured control over additional railways, until the State mileage was predominant. But the Government leases its lines to private companies; in fact, it only retains the Central of Brazil Railway, which runs from Rio de Janeiro to the city of San Paulo, and then northward into the interior of Minas Geraes. This railway was formerly known as the Estrado de Ferro Dom Pedro II Railway, in honour of the sovereign who encouraged its construction, and it is for this sentimental reason that the line has not been leased out.

The San Paulo (Brazilian) Railway is one of the most prosperous railways in the country. The company works under a guarantee of 7 per cent from the Government, any profits beyond 8 per cent being divided between the Government and the company. The terminus of the line is at the Port of Santos, and as all the coffee shipped at the port passes over the San Paulo metals, the traffic is heavy and remunerative. The line was exceedingly difficult to construct, especially from the fifteenth to the twentieth mile after leaving Santos, in surmounting five summits, the highest of which is 2300-ft. above sea-level. To effect this between Passaguera and Alta de Serra, a distance of ten kilometres, the line has to be worked by cable traction, aided by locomotives, very similar to the former working of the Cowlairs incline at Glasgow, although the grade is very much steeper, as much as 1 in 12½ in places. But this mountain section probably differs from all other railways in the world in having only three rails for the up and down traffic, which are expanded into the usual four rails at crossing places. This method was adopted to save expense, and thus atone for the cost of the great number of tunnels and the heavy character of the works generally. The three rails, of course, have only the capacity of a single track with crossing places, but as provision had to be made for the up and down cables an ordinary single line was scarcely practicable. Obviously the three rails cost much less than a double track, but considering the enormous goods traffic that is now hauled over the mountain, the saving was a doubtful economy.

The cable incline, 5 miles in length with an average gradient of 1 in 10, is divided into four sections, each 1¼ miles, up which trains are hauled by the stationary engines situated at the head of each section of the incline. The distance from Santos to Alta de Serra is 30 kilometres, and the ascending journey occupies 80 minutes. The cable power plant and most of the locomotives are of British manufacture. At Alta de Serra Station, on the highest summit, the gradients again come within the scope of adhesion locomotives of the side-tank and saddle-tank type, which draw ordinary loads up the steep grades to San Paulo, the capital of the State of San Paulo, and thence to Jundiahy, the inland terminus, 87 miles from the coast. For the heaviest freight trains, powerful 2 – 8 – 0



1. 4–6–2, EXPRESS LOCOMOTIVE (Buenos Ayres and Pacific Railway)
2. 4–6–2, EXPRESS LOCOMOTIVE (San Paulo Brazilian Railway)
3. 4–6–2, LOCOMOTIVE (Central Uruguay Railway)
4. 2–6–6–4, ARTICULATED GOODS LOCOMOTIVE (Antofagasta and Bolivia Railway)

tender engines have been employed in recent years, while for passenger trains 4–4–0 tender engines render capital service.

Argentina, or the Argentine Republic, is little more than one-third of the size of Brazil, and its population about one-fifth; but its railways have a length of over 17,000 miles. The chief systems are:

	Miles.	Locos.	Carriages.	Wagons.	Passengers.
Buenos Ayres and Pacific	2860	570	320	9,700	8,145,000
Buenos Ayres Great Southern	2770	570	840	12,200	18,906,000
Central Argentine	2482	520	550	13,500	15,159,000
Buenos Ayres Western	1365	300	290	6,100	7,489,000

It was in January, 1854, that the first railway concession in the Republic was granted for a line in the Province of Buenos Ayres. The first section, only 10 kilometres long, from Parque to Floresta, was opened in August, 1857, and this little line was the origin of the present-day Buenos Ayres Great Western Railway. The opening ceremony was performed by the President of the Republic, who prophesied a great future for Argentine railways, although he little dreamt of their ultimate magnitude. Whether the first general manager of the line was equally optimistic is doubtful, for it is a fact that he rode on horseback to the opening ceremony at Floresta, rather than trust himself to a train.

How the 5-ft. 6-in. gauge came to be adopted for this line, and to set the fashion for Argentine railways generally, is one of the little romances with which the history of the iron road abounds. The British normal railway gauge was decided by the width of a coal tramline; the Argentine gauge was settled by a chance-bought locomotive, which the contractors used in the construction of the first line. This engine already had shared in making railway history, as it was one of a batch of locomotives that were the first to be used in warfare, being shipped from England to the Crimea to take part in that sanguinary conflict which ended with the fall of Sebastopol. Originally the engines were intended for an Indian railway, and thus these war (iron) horses were of the 5-ft. 6-in. gauge. At the close of the war the engines were offered for sale, and one of them, renamed "La Portena," was transferred to Buenos Ayres, where the contractor fixed upon the 5-ft. 6-in. gauge for his line in order that it might fit his second-hand locomotive.

Only 29 kilometres of line were constructed during the next three years, and in 1863 the Government of the Province of Buenos Ayres took over the railway. Each year the line extended until 1890, when its length was 660 miles, and then, owing to financial difficulties, the Government sold the railway as a going concern, which became the property of a British company. Three sections of the railway were sold to the Central Argentine Railway Co., Buenos Ayres Great Southern, and Buenos Ayres and Ensenada Port

Railway Co. respectively, leaving the new company, the Buenos Ayres Great Western, with only a trunk line of 334 miles. The 124 locomotives in use were products of France and the United States, and the track was laid with 54 and 56-lb. steel rails.

The first year of the new company's history was marked by a national revolution and financial crisis, a state of affairs more or less common to all South American republics, but for which the railway progress would have been much more marked. From 1894 to the present time extensions have taken place almost every year, until the B.A.G.W. Railway has a length of nearly 1400 miles.

AN OLD CRIMEAN HERO
First locomotive in the Argentine

Just as in Canada, the Argentine railways have been pushed into thinly populated and uncultivated districts, where cattle and sheep raising were the only profitable occupations, because the cost of transporting crops was too great for agriculture. A railway immediately opened up country, for even while under construction the land on either side of the track would be broken up for the cultivation of wheat and maize, and by the time the line was completed there was traffic awaiting transport. Taking two items of traffic alone, there are few railways in the world that can show a better record than the B.A.G.W.R. in this respect. In the first year of its existence the company carried 283,000 tons of grain and 237,000 animals; but at the end of sixteen years it was carrying four times the weight of grain and twenty times as many cattle.

THE TRANSANDINE RAILWAY

The western coast of South America has always suffered from the difficulty of communication with the Atlantic Ocean, except by sea round the southern extremity of the continent. Buenos Ayres, the capital of Argentina, and Valparaiso, the chief port of Chili, are less than 900 miles apart, and yet the only really commercial communication between them was by means of a voyage of 14 or 15 days, via Magellan Straits, for which the single passenger fare was £40. But the time came when engineers commenced to scheme and plan to conquer the forbidding Andean heights, that had hitherto forbade the junction of the Argentine and Chilian railways.

In 1874 a concession was obtained for two railways in Argentina, one broad-gauge line from Buenos Ayres to Mendoza, and the other, a metre-gauge track from Mendoza to Las Cuevas, the limit of the Argentine frontier. From the coast to Mendoza the distance is 650 miles, chiefly across pampas plains. As in this long distance the rise is only 2470-ft., the gradients are scarcely perceptible, and one section of 210 miles is in an absolutely straight line—the longest stretch of " straight " line in the world. The line from Mendoza to Las Cuevas forms part of what is now known as the Transandine Railway, which was commenced in 1886. From Mendoza there was an old mule-train trail over the Cumbre Pass into Chili, at the best of times a difficult and dangerous route, and always impassable in winter. Between Mendoza and the Andes winds and twists the River Mendoza, subject to terrible floods from the melting snows. Time after time during the construction of the line sections of the newly laid permanent way were swept away by the treacherous river, which eventually the engineers kept in check by huge artificial embankments, that swallowed up trainloads of immense blocks of stone.

As the line climbed higher and higher, avalanches and snow-slides became an ever-present menace. Danger spots had to be avoided, and where the track lay through sliding detritus immense concrete walls had to be erected to keep the unstable earth in check. No progress could be made except by almost superhuman efforts; blood-curdling gorges and ravines were spanned by steel bridges; drill and blasting powder pushed the track round precipices; morasses were ballasted with brushwood; and piles were driven into unsafe ground to give it stability. But ever the metals crept upward toward the clouds. In the last eight miles to Las Cuevas the line mounts 1414-ft. A halt in the construction of the line was called at Puente del Inca, where the metals were nearly 8000-ft. above sea-level, for from this point normal adhesion trains would be impossible, the difficult grades necessitating the assistance of a rack, and onwards a third rail formed part of the track.

COG-LINE OVER THE ANDES.—SNOWSHED

(Argentine Transandine Railway)

Travelling by the old-time mule-train over the Cumbre involved climbing to an altitude of 12,800-ft. in order to enter Chili ; but the engineers decided in this last stage to cut through the final obstruction rather than attempt to carry the railway over it ; and this entailed boring through about two miles, mostly of solid rock. A small army of 2000 men had to work at a height of two miles in an intensely cold atmosphere, where the fierce blasts were laden with ice particles that stung like bullets. In winter, on the Argentine side, all supplies were entirely cut off, the camp depending for rations, etc., on the forethought with which stores had been provided. The rarefied atmosphere alone was terribly trying, and the men suffered greatly from mountain sickness. But inside the tunnel as the boring progressed, it was warmth from which the workers suffered ; the compressed air driving the drills, and the gasolene flares which afforded light, added to the natural internal closeness of the atmosphere, engendered a heat that was almost unbearable.

The boring was one long succession of difficulties. Work was carried on in 8-hour shifts, night and day without a stop. The rock proved to be volcanic sandstone, hard enough to turn the best drills the contractors had provided, and better apparatus had to be procured. By means of drill and dynamite the workmen resistlessly forced their way, until the volcanic rock gave place to soft claystone for a time. Then they were faced with a section of conglomerate and felspar, where 24 hours would be spent in drilling one set of holes for a blasting charge that would scarcely make any effect on the resisting rock. Moreover, the rock, when exposed to the weather, crumbled, and necessitated lining the tunnel with Portland cement. The average rate of progress was about 7-ft. a day, for under normal conditions it takes from 5 to 10 hours to drill, charge, fire, and clear away the debris, that marks a net progress of only 20-in. But even this slow rate was broken by numerous delays, such as caused by the delvers breaking into fissures from which would pour torrential streams, that washed out the workings ; or sometimes the roof would cave in and allow the descent of loose friable earth to bury the excavators. During the operations, from end to end of the line there were constant accidents resulting in the death of many labourers, unavoidable martyrs to the cause of progress.

On the Chilian side the railway had been laid from Valparaiso to Los Andes, which is only 46 miles from the Chilian end of the tunnel. In this short distance there was a difference of some 8000-ft. in levels to be overcome ; in the last seven miles a rise of no less than 3150-ft. This climb could only be contrived by a series of galleries, which carry the rails along the mountain-sides, the galleries being connected by difficult grades, varying from 6 to 8 per cent, and frequently calling for the aid of the rack.

The boring of the tunnel was commenced at both ends simultaneously in 1906; and on November 27th, 1909, the engineers joined hands in the middle of the mountain, 2630-ft. below the old road over the Cumbre, which the railway would throw into disuse. So exact had been the calculations of the borers that the difference in level between them was less than an inch, and the difference in line was less than three inches.

It was not until April 5th, 1910, that the first train ran through the tunnel, carrying the Argentine Minister of Public Works and Staff to attend the inaugural ceremony on the Chilian side. April 5th is an auspicious day with the Chilians, being the date of the famous battle of Maipo, in which they defeated the Spaniards and gained their independence.

On the summit of the Cumbre, demarcating the boundary-line between the two nations, there is a bronze "Christus" statue, on the base of which is inscribed: "Sooner shall these mountains crumble into dust than the people of Argentina and Chili break the peace which they have sworn to maintain at the feet of Christ the Redeemer." The railway conquest of the Andes, which has brought the Atlantic and Pacific coasts within about 30 hours of each other, is one of the great victories of peace, that will bind the nations closer in social and commercial progress, thus rendering their oath easier to keep.

THE CALLAO-OROYA RAILWAY

Although the railway just described ascends to a height that completely dwarfs the mountain railways of the Alps, and, in fact, is 1500-ft. higher than the highest mountain road in Europe, the Transandine Railway is not the highest in the world. This honour is claimed by the Callao-Oroya Railway, in Peru.

Callao is situated on the Pacific coast, from which the mountains almost immediately commence to rear skywards; and in order to reach Oroya, little over a hundred miles away, as the crow flies, the railway had to overcome a climb of 15,865-ft. It appeared to be almost an impracticable project; but there was a good reward held out in the tapping of the mineral traffic from the rich mines on the elevated inland plateau. Henry Meiggs, a Philadelphia engineer, was a man of mighty ideas; he saw further than the Oroya mines, for under his complete scheme the railway would be pushed on across the continent to a point on the Amazon, from which there was unbroken waterway for steamers to the Atlantic. Meiggs' full plans were never achieved, thanks chiefly to Peru's constant strife and ruinous wars with neighbouring states; but he carried his steel ribbons higher than they had ever been taken before or since, and inscribed his name in railway annals for all time.

The work of construction commenced in 1870, and 20 miles of line were completed within twelve months, while the grading ahead was prepared for another 30 miles. For the first hundred miles the tracks climbs continuously, not a yard of descent in the whole distance. Meiggs zigzagged his metals in a most extraordinary manner, bridging streams at dizzy heights, hewing galleries along tremendous precipices, blasting through formidable rocks. At an altitude of about a mile the engineer was opposed by an almost vertical mountain wall. A tunnel was out of the question, but the existence of a ledge parallel with his track gave the engineer an idea that was absolutely new to engineering. He proposed to lift his track to the ledge by what afterwards became known as the "Meiggs' V-switch." Altogether there are more than a score of these reversing switches, one of them actually being in a tunnel; while others are on perilous ledges, from which the passenger has a view of mountain walls ascending in a perpendicular line 2000-ft. above him, and on the other hand there is a sheer drop over a precipice an equal, if not greater, distance.

Yawning chasms had to be bridged; some of the structures were of short span, but the Verrugas Bridge is 570-ft. in length and 225-ft. above the bottom of the gorge. It is neither the longest nor loftiest bridge in the world, but it is doubtful if any other caused quite so much trouble in its erection. Its situation is at an altitude of 6000-ft., and the centre support of the three which carry it is a solid pier of masonry 50-ft. square at its base in the bed of the ravine. The rails are carried over the intervening space on a slender superstructure of iron, and great care had to be exercised to avoid any of the parts being too large or too heavy for transportation from the coast to rail-head. The bridge cost £12,600, or £22 per foot run, and directly and indirectly was the cause of an astonishing loss of life among the workers. Whilst the structure was only half completed, a mysterious and deadly disease broke out; natives and white men alike were struck down and died within a few hours. Meiggs escaped the epidemic, and as the labourers died like flies, he offered largely increased wages to new men to take their place. The tenacious engineer at length achieved his purpose, but the terrible experience made an old man of him before his time.

As the line progressed upwards, the rocky barriers became more formidable; blasting operations were ceaseless. In one section of 50 miles nearly threescore tunnels had to be pierced. The zig-zagging became heavier and heavier, in some places the metals running on a series of galleries, one above the other, from the topmost of which one can look down upon tier after tier of track, until the eye loses sight of them far below. The Infiernillo Bridge was aptly named. The region was timberless, and consequently the structure had to be built out from the sides. Progress was slow and painful, for the workmen could only swing their tools while

Photo] [*Underwood & Underwood, London*

BRIDGE AND TUNNEL (9472 FEET ABOVE SEA-LEVEL)
(Callao-Oroya Railway)

suspended in cradles, which dangled dangerously at the ends of ropes secured to the rocks above. Nevertheless, Meiggs pushed on with indomitable courage until 1877, when his iron constitution broke down, and he succumbed to the privations and worries that he had undergone. His line of 88½ miles had ascended the Andes to a height of 12,200-ft.; 8000 workmen were then employed, and 500,000 lbs. of explosives were being used per month to push the metals ever upwards. Two-thirds of the gigantic enterprise were completed when the master-mind was called away. For fourteen years there was a total cessation of work, when a new company bought the unfinished railway, and installed William Thorndyke, strangely enough also from Philadelphia, to complete the task to which his bold townsman had given his life.

With the surveys of Meiggs to guide him, Thorndyke carried the line another five furlongs, and then had to tackle the Galera Tunnel, which was hewn through a pinnacle three-quarters of a mile thick. The chief difficulties lay not in the mere drilling, blasting, and excavating, arduous labour as it was; the exceeding rarity of the air at nearly 16,000-ft. above sea-level, and the ravages of mountain sickness, caused heavy mortality among the men, although to a less degree than marked the Verrugas epidemic. But Thorndyke proved a worthy successor to Henry Meiggs, and by unwavering pluck and skill he conquered the last great obstacle. Once clear of the Galera tunnel, the remaining 31½ miles on a downward slope to Oroya were accounted an easy task by men who had braved all and suffered all in conquering Nature in her hitherto inaccessible fastnesses.

The railways of various other mountainous countries in South America—viz. Venezuela, Colombia, Ecuador, Bolivia, etc.—are generally marked by severe grades, that make for difficult working. In not a few cases, not only have the physical difficulties hampered railway development, but frequent revolutions have interrupted ordinary business affairs, with consequent loss to investors, who are chary of finding money for enterprises that bring uncertain returns.

CHAPTER XXXI

RAILWAYS OF AUSTRALIA

Australia and New Zealand, the main portions of the New World of the Southern Hemisphere, were added to the British Empire without trumpet flare or standard flash ; they came under the flag without shedding of blood or the loss of a single life.

For long years Britain misunderstood Australia, and from 1788 to 1840 only used it as a penal settlement. It was the discovery of gold that stirred up interest in the whole continent ; but though gold and silver and other metals have been won to the value of many millions sterling, and mining still remains one of the chief industries, agriculture and stock-raising have occupied increasing numbers of colonists. The whole area of Australia (including Tasmania) is 2,974,565 square miles ; population, 4,555,000 ; and the railways have a length of 18,653 miles (1912).

Australia is smaller than Canada by about three-quarters of a million square miles, but its railways are very similar in proportion to area and population ; in Canada, roughly, there are 0·6 mile of line to every 100 square miles of territory, and 35 miles of line to every 10,000 persons ; in Australia the figures are 0·5 mile and 37 miles respectively. In Canada the land is fertile right across the continent from ocean to ocean ; in Australia the productive areas are chiefly in the east, a portion of the south, north, and west ; while the centre is a vast, little-known, and practically waterless region that offers no attraction to settlers, and thus for a time there was no pressing desire to build a railway across the continent, as in Canada.

The Australian railway mileage is made up, for the most part, of a number of short lines, that were built by the various colonies to meet their own immediate needs. There was no joint building for mutual benefit, and each colony fixed upon a gauge without considering intercommunication with a neighbouring State. In Victoria the gauge is 4-ft. 8½-in., Victoria 5-ft. 3-in., South Australia 5-ft. 3-in. and 3-ft. 6-in., and in Queensland and West Australia 3-ft. 6-in.

The iron horse made its first appearance in Australia in the colony of New South Wales in 1855, when was opened a line from

Sydney to Parramatta. Although railways were projected and commenced here and there, progress was slow, for the settlements were small and sparsely populated; and there was no general appreciation of the railway as a civilising agent and a creator of life and activity. At the end of twenty years the whole of the railways only totalled 473 miles. Then came a marked change. The natural resources of Australia forced themselves into recognition, and settlers commenced to crowd to its shores. The expansion of the railways commenced in real earnest, and during the next 25 years nearly 13,000 miles of line were built, chiefly at the expense of the various colonial Governments. Unfortunately, during this period of progression, each colony adhered to its original gauge, when it would have been a wise policy to "scrap" the earlier lines and fix upon a common gauge for the whole continent. The moral had been pointed in other countries; as in England in the case of the abolition of the broad gauge; and in America after the Civil War, when 10,000 miles of line in the Southern States were converted to 4-ft. 8½-in. in order to conform to the gauge of the Northern States. This variety in the Australian gauges was all the more regrettable in view of the federation of all the colonies into the Commonwealth of Australia on January 1st, 1900.

At the end of 1908 New South Wales was first in mileage with 3472 miles, followed by Victoria, 3401 miles, Queensland, 3359 miles, South Australia, 1279 miles, and West Australia, 1830 miles; but in 1912 Queensland was at the head of the list with 4143 miles, New South Wales, 3799 miles, Victoria, 3543 miles, South Australia, 1460 miles, and West Australia, 2471 miles. The figures show that Queensland and West Australia are building more rapidly than the older colonies of New South Wales and Victoria. Queensland's increased mileage comes chiefly in the construction of two entirely new lines, one of 454 miles along the coast, and one of 1200 miles across the western portion of the colony.

Australian railways on the whole are marked by difficult grades, and in New South Wales particularly the railway builder was confronted by some stiff problems. Running almost parallel with the coast, at a distance varying from 20 to 70 miles from the sea, are various ranges of mountains, which have to be climbed by trains out of Sydney, north, south, or west, to reach the inland tableland. When Bathurst clamoured for railway connection with Sydney, the early line from the coast to Parramatta was extended easily to Penrith, from which point the steepness of the ascent to the plateau above could be overcome only by zigzag grades of 1 in 30; one tier with a dead end obtained by a diagonal cut up the face of the cliff, followed by a similar cut up the flank to another dead end, and so on up to the desired level. Heavy as was this work, it was nothing compared to the task shortly afterwards of descending into the Lithgow Valley, by way of an almost sheer precipice of 600-ft. drop. By means of tunnelling, comparatively easy grades and reasonable curves were possible, but the Governor-General would not sanction the heavy expenditure; and, indeed, this sapient official suggested that horses could draw the trains, if the rails were laid along the mountain road, which had been roughly constructed for cattle drives and wagon traffic. After prolonged negotiations the Governor-General consented to an expenditure not exceeding £20,000 per mile; and the engineer, robbed of his last hope of resorting to tunnels, had to rack his brains to find some other means of conquering the obstacle. The result was the

SYDNEY-MELBOURNE EXPRESS TRAIN AT ALBURY
(New South Wales Government Railways)

famous "Lithgow Zigzag," which, in only three miles of line, on three tiers sawed in the slope, carried the metals downwards a distance of 600-ft.

As the traffic of the colony increased, the slow travelling caused by the heavy grades and the difficult curves of this wonderful piece of engineering proved a bar to the economical working of the line, and reconstruction at almost any cost was advocated. By 1908 the goods traffic had risen to $2\frac{1}{2}$ million tons per annum, and it was decided to provide a new alignment for the section by means of a series of ten short tunnels with a gradient of 1 in 90. The blasting operations were on an enormous scale; one explosion of some 10,000 lbs. of blasting material, chiefly powder and gelignite, shattered 35,000 tons of rock. The excavated material in tunnels and cuttings was used for embankments and to fill up gulches. The total length of the tunnelling was nearly 1¾ miles, and one open cutting through rock was 130-ft. deep; while two others were longer but less difficult. The total cost of replacing one engineering marvel with another was about £350,000.

The new deviation is 5½ miles in length, enabling the through journey to be shortened by 30 minutes, which in the passenger service alone means a saving of nearly 700 hours' running in the year; and double-heading for only moderately heavy goods trains ceased to be a necessity. Coloured Plate XVI depicts an express train between Sydney and Bathurst on a new curve with the Zigzag viaducts in the rear.

The Governments of the various colonies are fully alive to the necessity of improving the railway facilities to cope with the rising trade and commerce, to open up new and promising districts, and to bring about closer settlement. In New South Wales, for example, existing lines are being doubled, for in some cases congestion of traffic was so great that wheat, held up in sidings, sometimes sprouted through the bags before trucks were available to take it to market. Wholesale improvements are pending, as evidenced by an order placed with the Ebbw Vale Co. in 1913 for 26,000 tons of rails—a record order. Increase in rolling-stock will follow as a natural consequence. Light country lines are under construction, not only to tap new districts, but to bring some of the older settlements into closer touch with each other. One instance in this direction will suffice: a light railway of 90 miles in length will join Coonamble and Narrabri, whereas the former roundabout railway connections necessitated a trip of over 700 miles. In 1912 the Government programme involved an expenditure of nearly £5,000,000, chiefly for duplications and extensions of existing lines.

The engines employed in the premier colony have been of very diverse types, most of them of British build, although Baldwin's, of America, have made additions to the stud at various times. In recent years the leading engines have been built at the Government workshops at Eveleigh. For express passenger and mail traffic 4–6–0 engines (P class) are employed chiefly; they have 5-ft. coupled wheels, and in working order, with tender, weigh 99 tons; and in their trials a speed of 75 miles an hour has been attained. But the conformation of the country forbids any really fast running, except for short distances. In the journey from Sydney to Penrith, the speed in the section between Parramatta and Blacktown, which is like a magnified switchback, varies in every mile of the six, from as low a rate as 37½ miles to as high as 57 miles per hour; but later on there comes a stretch of 5 miles, where the lowest rate is 60 miles and the highest 66 miles per hour.

On the Southern line, which is the high-road to Melbourne and

PLATE XVI.

Express Train on the new line between Sydney and Bendigo, showing the old Zig-zag Viaducts.
(New South Wales Government Railways.)

Adelaide, for the first 53 miles there are no difficult gradients, but in the next 16 miles there is a rise of 1478-ft.; for 5 miles the gradient is 1 in 30, and for one mile it is 1 in 33. This difficult 16 miles the "Melbourne Limited Express" covers in 41 minutes on the outward journey from Sydney, but in 21 minutes on the return. The total distance from Sydney to Albury, on the Victorian boundary, is nearly 392 miles, which is accomplished in 11 hours 26 minutes, or, allowing for stops, an average rate of 37·3 miles per hour.

On the Northern line the distance from Sydney to Wallangarra, where it connects with the Queensland system, is 492 miles. Practically all along the route there are difficult grades, sharp curves, and general undulations that make against fast running.

About the 36th mile out of Sydney the line crosses the Hawkesbury River on a bridge 3000-ft. in length. This iron and steel lattice structure is the largest bridge of its kind in Australia. It was erected by an American firm, and from beginning to end the work

MELBOURNE TO ALBURY EXPRESS TRAIN

(Victorian Government Railways)

was one of great difficulty. In mid-stream the water runs 40-ft. in depth, and the bed of the river was mud to a depth of over 100-ft. To obtain foundations for the seven spans composing the bridge, huge steel cylinders had to be sunk through the mud until solid bottom was reached, the cylinders being filled with concrete. The steel work for each span was put together on the bank and then floated out on a pontoon at high tide, so as to be suspended over the masonry of the two piers that had to support it. As the tide fell the span descended into position. The most accurate judgment was necessary in these operations, and upon one occasion the pontoon broke loose and stranded its heavy cargo, where it had to remain until the next tide permitted it to be floated afresh, and finally placed in position.

From Newcastle (104 miles) the line continues to rise for 299 miles to Ben Lomond at an elevation of 4473-ft., grades of 1 in 33, 1 in 40, and 1 in 50 being quite common; and then follows an easy run of about 90 miles to Wallangarra, during which there is a descent of 1598-ft.

The Brisbane Express performs the journey of 492 miles in 17 hours 50 minutes, but as quite 2½ hours are lost in making 44 stoppages, the average running is 32½ miles per hour. The longest non-stop performance in the Commonwealth is 80 miles between Moss Vale and Strathfield, on the Sydney-Albury run, which the "Limited Express" traverses at 43·6 miles per hour. Against this Victoria can claim a 61¼-mile non-stop, to Seymour out of Melbourne, in 95 minutes during the journey between Melbourne and Albury; the complete run is 190 miles, which is performed, after allowing for stops, slacks, etc., at about 44 miles per hour. Queensland's best performance is done on the 48 miles between Ipswich and Helidon at 30 miles an hour. In South Australia the Melbourne-Adelaide Express runs the 28¼ miles between Bordertown and

MAIN-LINE EXPRESS TRAIN WESTWARDS OUT OF BRISBANE
(Queensland Government Railways)

Keith in 38 minutes, or 44·6 miles per hour. This service is run on a 5-ft. 3-in. gauge line. In West Australia and Tasmania there are no trains that achieve 30 miles per hour.

On the Victorian Railways, for running the "Sydney Express" from Melbourne to Albury, the Government workshops at Newport in 1908 turned out some new 4–6–0 locomotives; cylinders, 21-in. by 26-in.; diameter of coupled wheels, 6-ft. 1-in.; working pressure, 200 lbs. per sq. in.; weight of engine, 67½ tons; loaded tender, 41½ tons. The "Sydney Express" has to negotiate many miles of gradients as hard as 1 in 50 over a curving, hilly road, and a load of 390 tons is sufficient to test an engine's capacity. In the first 33 miles out of Melbourne there is a rise of 1115-ft., which one of these Newport engines will climb at 34 miles per hour, even at the summit of the Glenroy Bank of 3 miles in 50, the speed being 22 miles per hour. In 1911 the Baldwin Locomotive Works supplied twenty 4–6–0 locomotives for passenger, fast goods, newspaper trains, etc. Although constructed in America, they followed British practice very closely. They were smaller than the foregoing, engine and tender weighing only 93½ tons.

On the Queensland Railways in 1912 appeared the finest locomotive that had yet been seen on the 3-ft. 6-in. gauge lines of the colony. It was a 4–6–0, and the first of a batch of twenty built by Messrs. Griffiths at their Southern Cross Works, Toowoomba. The trial run was from Toowoomba to Jondaryan (31 miles) and back. On the outward journey the speed attained was 40 miles per hour, while on the return trip 58 miles per hour was registered.

In West Australia, where the gauge is 3-ft. 6-in., Garratt engines are rendering excellent service; some of them are 69 tons in weight and are of the same general dimensions as those in use on the Darjeeling Railway, described on p. 607. The railways in Tasmania are chiefly 3-ft. 6-in. gauge, but there are some sections of 2-ft. gauge; and here also Garratt engines are employed for both passenger and goods trains.

With the rapid development of the Australian colonies, in recent years has come the desire to link up the railways of the eastern side of the continent with those of West Australia. A transcontinental railway would not only render great commercial service to the Commonwealth, but would prove of undoubted strategic value, and the project had the warm approval of Lord Kitchener when he visited the Antipodes. Western Australia in particular had long desired connection with the chief centres in the east, but, unaided, was unable to finance so great a scheme; but when the various colonies were federated, the chief factor that decided West Australia to throw in her lot with the sister colonies, was the hope that federation would lead to a transcontinental line. It was found not to be a difficult matter to build a railway from Port Augusta, in South Australia, to Kalgoorlie, in the Coolgardie region, except that the line would lie across the edge of the Victoria desert. Surveyors have already inspected and reported upon the route through a region that formerly was considered to be hopelessly sterile. The nature of the country was indicated by the surveying party having to rely on camel transport in order to perform their task; but it was proved that at intervals there are vast areas to which artesian wells and irrigation would bring unbounded fertility. The Port Augusta-Kalgoorlie section is now under construction, bringing nearer the time when the Australian will be able to travel by rail from Perth to Brisbane, a distance of some 3400 miles. True, the differing gauges would entail changing carriages at least five times, but there would be a great saving of time over the present sea voyage to South Australia or Victoria, and thence by rail to Queensland.

RAILWAYS OF NEW ZEALAND

New Zealand, the Britain of the Southern Cross, consists of North Island and South Island, in themselves a thousand miles in length, and various other islands aggregating an area of nearly 105,000 square miles; population, 1,022,000. The country is mountainous in the extreme, especially South Island, and in constructing the 2978 miles of railways that were in working order at the end of 1912, many physical difficulties had to be overcome.

When it was desired to connect Auckland and Wellington, in North Island, 426 miles apart, the population of North Island was very small; and even to-day it is not equal to that of Liverpool or Manchester. The pessimists, who could not discern the possibilities of the country as a new "Britain of the South," ridiculed the idea of such an enterprise as carrying a railway through the terribly broken country. High mountains had to be skirted, gorges were astonishingly frequent, numerous rivers had to be crossed, and for many miles the railway track would be only a mere avenue through dense forests. But railway engineers have ever laughed at difficulties, and ultimately it was decided to build a main trunk line throughout the length of North Island.

The work of construction was heavy throughout; but about midway between Auckland and Wellington, in the neighbourhood of Ruapehu, an extinct volcano, there were two notable engineering operations. The railway skirts the base of the great peak, and the rails had to ascend a mountain-side for some distance, which was effected by a "spiral," during which the line makes four complete turns on a grade of 1 in 50. Another difficulty was presented by the Makatote Gorge, where a precipice suddenly and steeply dips down to a distance of about 320-ft., while it is 800-ft. across the intervening space to the edge of the cliff on the opposite side. Nor was the mere spanning of the gorge straightforward work, for the region was densely forested, and months were occupied in clearing a way in readiness for the building of a viaduct. The engineers decided to prepare the necessary steel work on the spot, and workshops with electrical plant were soon in operation. To carry the structure across the gorge it was necessary to provide a number of huge pedestals, three of them being over 200-ft. in height, the highest of them towering up 270-ft. These were composed of concrete foundations, sunk into the ground to a sufficient depth, and upon them were erected steel towers, comparatively light, but affording the maximum of strength and rigidity. Gradually an excellent piece of work was completed without the loss of a single life, a happy result of which few great engineering feats can boast.

On another line, namely, from Wellington to Napier, the Rimutaka incline called for a grade of 1 in 15, one of the steepest ascents in the world to be worked by ordinary adhesion. For many years locomotives on the Fell system, with an extra pair of horizontal wheels gripping a central or third rail, were employed on this section ; but nowadays large tank adhesion locomotives of the 2–6–0–0–6–2 type render capital service.

In South Island the mountainous nature of the country everywhere offered a strenuous opposition to the advance of the railway builder, as shown particularly well in the Central Otago Railway, which has become known as the "Bridge Line," owing to the

MANGAWEKA VIADUCT
(New Zealand Government Railways)

numerous gorges and fissures that the metals had to be carried across. But one of the greatest feats was performed in connecting Christchurch on the east with Greytown on the west coast, between which points are the Southern Alps, with peaks towering upwards to a height of 12,000-ft. To pierce a track through these great mountain masses meant a continuous succession of bridges, viaducts, and tunnels ; of the last-named there were nearly a score. The piercing of the Otira Tunnel, $5\frac{1}{2}$ miles in length, was a tremendous task that completely balked the company that had undertaken the building of the line ; and eventually the Government had to take over the work.

The railways of New Zealand are worked in accordance with British general practice. A particularly well-appointed train is the "Geyserland Express," which runs each week-day from Auckland to the "Wonderland of New Zealand," as the thermal region of Rotorua is popularly termed. It usually consists of twelve cars hauled by a powerful 4-cylinder compound "Pacific" type locomotive. The cars are of American style, with end doors and platforms. The restaurant-car is situated in the centre of the train; one particular car is intended for observation purposes, and has an open corridor on one side of the first-class compartment. Gas is the illuminant. Out of Auckland there are tunnel and general engineering difficulties on the single line to Newmarket, but it is

GEYSERLAND EXPRESS
(New Zealand Government Railways)

double later to Penrose Junction. From Penrose to Mercer (43 miles) the line runs through a country which reminds one of England, except that wire fencing takes the place of hedgerows, and frequently there are burnt tree stumps, where the forest has been cleared for grazing or agriculture. At Mercer the express stops for 10 minutes for water, after which the route strikes the Waikato River and follows its valley for several miles, finally crossing the stream. The valley then closes in, and the scenery becomes much finer. A run of 11 miles brings the train to Frankton, where the main trunk line is left behind. At Hamilton the Waikato River again is crossed by a fine lattice bridge, and the journey lies through a sheep-rearing country dotted with farms. After water has been taken at Morrinsville (103 miles), a trestle bridge carries the line over a stream and valley, preparatory to a climb to Putaruru (140 miles), 525-ft. above sea-level. Steeper grades follow, and a second engine has to be attached to render assistance up the long ascents that occur with great frequency. In order to distribute the load on the bridges the helping engine is inserted behind the front luggage van. The train continues to ascend to Mamaku (158 miles), which is practically the summit at an altitude of 1884-ft. Next follows a charmingly wooded defile descending to the shores of Lake Rotorua, on the shores of which are situated the famous hot springs and geysers. The train finally runs into Rotorua terminus (171 miles), after a journey occupying a few minutes under eight hours. Although including the stops the average speed attained by the train is less than 22 miles an hour, the traveller is little likely to cavil at the slow rate, which enables him the better to enjoy a marvellous panoramic ride, that in not a few respects cannot easily be surpassed in any other part of the world.

The locomotives in use on the New Zealand Government Railways number 513; carriages, 1300; wagons, 18,550. During a year nearly 12,000,000 passengers are carried, and 5½ million tons of freight.

CHAPTER XXXII

ELECTRIC RAILWAYS—CONCLUSION

Having arrived at the closing pages of the volume our shortcomings are the more impressed upon us. The railways of the British Isles have been described at considerable length, because they represent much of what is best in the railway world ; but the railways of not a few other countries afford matter of information and interest sufficient to fill several separate volumes ; and as we review what has been written, it is comparatively easy to note that there is no mention of numerous difficulties that have been surmounted and problems that still await solution.

But no book dealing with railways could pretend to be complete without reference to the advent of electricity, a force that within but a few years has made rapid strides, while the ultimate effect on traction generally it is quite impossible to estimate.

When electric tramlines commenced to be a commonplace all over the world, even the unobservant could foresee that electric locomotion would enter into competition with the steam-driven machines, which have played so great a part in vivifying the workaday world ; and electric railways have already proved their capacity in certain well-defined directions.

The first electric motor was produced by an Italian about the year 1830. In 1838 Robert Davidson built quite a powerful electric engine, 5 tons in weight, and carrying a 40-cell battery. After the engine had made a few experimental trips on one of the Scottish railways, some jealous employés wrecked it in the sheds at Perth. In the United Kingdom, on the Continent, and in the United States inventors were continually at work. It was in the last-named country that the more notable results were achieved, and in 1887 an electric line at Richmond, Virginia, proved such a success that very speedily electric lines were being installed, not only in the States, but other countries. An electric line at the Giant's Causeway, Ireland, was the first of the kind in the United Kingdom ; but although several more or less unimportant lines followed, it was the Liverpool Overhead Railway, opened in 1893, that first marked the importance of the electric railway in this country. This line is carried on a continuous bridge supported by pillars and piers ;

and thus railway traffic goes on above without any interference with the street traffic below. This method of easing congested street traffic was first adopted in New York. Another notable event also took place at Liverpool, where the railway under the Mersey was the first British steam-driven line to be converted into an electric railway.

Nowhere in the world was there a better field for electric railways than in London. The Metropolitan and District Railways were for the most part underground, but as little below the surface as possible. Although there were open spaces at most of the stations, and ventilating shafts at frequent points, the fumes and smoke from the steam locomotives created a sulphurous atmosphere that was exceedingly trying to the passengers. But with the conversion of these lines, and the opening of various deep "tube" lines, London's electric railways became one of the marvels of modern traction.

Worked by steam, the old "Underground" could accommodate a maximum of less than 20 trains an hour, but with electric traction the number rose to 40 trains, with further acceleration still possible. By reason of its capacity for getting up speed, combined with rapid braking, an electric service for short distances can be run with greater frequency, with the same headway between the trains, thus adding to the capacity of the line; whereas in the case of steam locomotives on a suburban line with frequent stops, by the time the engine has got up to its maximum speed, it is necessary to slacken in readiness for the next pull-up. At terminal stations electricity has an enormous advantage, equivalent almost to 100 per cent. At a steam railway terminus stand-by locomotives are necessary for the trains to proceed in a reverse direction; and quite five minutes are occupied, and two roads are blocked during switching and signalling operations; while the electric train is ready for the return journey as quickly as the motor-man can walk from one end to the other.

It is obvious that running trains one after the other at short intervals entails the most careful signalling arrangements. The human element would be liable to constant failure in signalling for traffic with a headway of only 90 seconds, and therefore automatic signalling is an absolute necessity. As a train leaves a section or block it automatically clears the signals for that block; and if a driver attempted to run against signals the electric current would be switched off and the brakes applied. The system apparently is as perfect as ingenuity can conceive, as proved by the practical immunity from accident.

One of the first ordinary railway companies in the United Kingdom to work trains electrically was the Lancashire and Yorkshire, the steam line, 18½ miles in length, between Liverpool and Southport, being converted in 1904, as the best means of coping with the increasing traffic, while keeping the trains under efficient control. The system selected—known as the continuous current—had been tried for heavy tramway services in several parts of the country, but up to that time had not been applied to heavy main-line traffic. The result quite justified the experiment—the capacity of the Liverpool-Southport line was increased to the required extent; and in due course, not only was the line extended, but two separate lines to Aintree were electrified. Capital examples of dispatch are the electric trains carrying the Aintree race traffic; where a thousand passengers are discharged from a single train, only 90 seconds elapsing between its arrival and departure.

Another successful electric installation is on the London, Brighton, and South Coast Railway, between Victoria and London Bridge, 8¾ miles, which is accomplished in 25 minutes for a single fare of 3½d. This line is worked on the overhead system, similar to that in use on many electric tramways. The Midland Railway has an electric railway, also on the overhead system, between Heysham and Morecambe.

On electric railways it is possible to attain an enormous speed, quite eclipsing all record steam performances. In Germany the 14½-mile military line between Marienfelde and Zossen was specially prepared for electric train trials. In 1901 a speed of 101 miles an hour was attained, but the track suffered considerably, calling for improvement before further experiments were attempted. Not only were heavier metals laid down, but for the greater part of the distance the line was equipped with guard rails, thus minimising the danger of derailment, while adding to the solidity of the track.

The two experimental cars each carried 4 motors, each of 250 horse-power, seated 50 passengers, and weighed 100 tons. The car was carried on two 6-wheeled trucks, the wheels 4-ft. in diameter. Particular attention was paid to the braking arrangements, there being Westinghouse air, hand, and electric brakes.

In September and October, 1903, various trips were made by one car, and the speed gradually rose by successive stages, until the record stood at 128½ miles per hour. This result astounded the engineering world, but a little later the second car eclipsed its rival by putting up a speed of 130½ miles per hour. Although at this remarkable velocity the passengers experienced little vibration, no such rate would be practicable upon an ordinary commercial open-air line; for the draught created by the passage of the train whisked up stones and loose soil that followed the car as in a cyclone.

The electric locomotive for use on ordinary railways made its first appearance in the United States. On the Baltimore and Ohio Railroad, the tunnel under the city of Baltimore, 1½ miles long, was almost unworkable from the smoke and gases given off by the steam engines; and the expense of ventilating the tunnel was prohibitive. The freight trains using the tunnel averaged 2000 tons in weight, and had to be hauled on an up-grade of 42 ft. per mile. Although no electric locomotives had hitherto been put to real practical use, in 1895 it was decided to install some electric locomotives weighing 96 tons each. The experiment proved quite successful, and these electric engines have continued to render good service.

Electric traction on main-line railways has made considerable progress in Europe, especially in Switzerland, Italy, and Sweden, where fuel is scarce, but water-power abundant for the generation of electric current. The largest and most powerful electric locomotives on the Continent are employed on the Loetschberg Railway, not only for operating traffic through the great Alpine tunnel, but on the whole section of 48½ miles between Spiez and Brigue. A locomotive weighing 90 tons will haul a load of 310 tons at 26 miles an hour on a gradient of 1 in 37.

REID-RAMSAY ELECTRO-TURBO LOCOMOTIVE

Electric traction has various proved advantages over the steam locomotive, but the present employment of electricity necessitates the provision of a generating station, and the laying down of conductor rails or wires. Electrical engineers have endeavoured to produce electric locomotives that are practically generating stations on wheels. The Heilmann locomotive, which was tried on the Western Railway of France in the early 'nineties, was an experimental engine of this kind. It carried a boiler and engines, which drove a dynamo, from which the electric current passed to motors coupled to the wheel axles. It ran smoothly, and was easy of control, but its great weight, size, and general complexity caused it to be abandoned.

But when the steam turbine was invented, the electrical engineer seized upon the idea to see whether the turbine could not be adapted to his purpose. It was obvious that the chief difficulty to be overcome was the establishment of some method of electric control between the high-speed turbine and the driving-axle. The North British Locomotive Company in 1909 set to work to design the Reid-Ramsay electric turbine locomotive. A big locomotive boiler supplied steam to a turbine, which drove a dynamo for generating current, which would work motors on four of the axles. Experimental running commenced in 1910, but up to the present time the new engine appears to have made but little practical progress.

To describe the means by which current is supplied to electric trains, etc., would involve technical details for which the reader must consult works devoted solely to the subject. The foregoing remarks concerning ordinary electric railways must suffice, in order that we may consider very briefly one or two phases of electric railway working that are more out of the common.

In many parts of the world there are aerial transporters for working up and down great elevations, where a railed track is not practicable. Roughly the method employed is a development of the overhead trolley system in use at Victoria Station, Manchester (page 386), the aerial line consisting of a steel cable supported by piers, etc. Most of these lines are for the transport of goods and raw materials, but in a few cases provision is made for passengers. Strictly speaking, these aerial cable lines are not railways, but there is a "Hanging Railway" at Barmen-Elberfeld, in Germany. In this case the usual overhead wire carrying the current is replaced by a track rail from which the car is suspended.

The Barmen-Elberfeld line is 8¼ miles long and connects the two important Rhenish towns. For six miles the track is supported over the River Wupper. There are 20 stations, reached from below by stairs. There are numerous steep gradients, often 1 in 22. The cars, each provided with two 36 horse-power motors, are 40-ft. long, and accommodate 50 passengers. A rate of 25 miles an hour is attained, top speed being reached in 20 seconds; and owing to the absolute block system trains can run at two-minute intervals. This is an immense improvement over the ordinary steam railway communication between the two cities. The State Railway line is two-thirds of a mile shorter; but the hanging train performs the journey quite as quickly, with 19 stops, as the steam train making only 2 stops. The line cost £750,000 to construct.

There are various Mono-Rail systems that have been put down and tried experimentally, notably that of Lieutenant Brennan, which attracted much attention at the Japan-British Exhibition held in London, 1910. The engine and car, with the wheels all in line, ran upon a single rail, and no matter how the load might be moved, it was impossible to disturb the balance of the car, which would traverse a sharp curve with ease at a rate of 20 miles an hour. The mechanism employed, though apparently very complicated, is an adoption of the "gyroscope" principle. Gyroscopic tops are well-known and popular toys, which so long as they rotate at a good rate will balance themselves on a single point. In a gyroscopic engine the main feature is a pair of heavy wheels kept revolving from 2000 to 3000 times per minute by means of an electric motor. Revolving nearly horizontally, the wheels, just as in tops, resist any attempt to make them incline or cant over ; and if force be used to make them do so, they endeavour of their own accord to return to their original position. Thus in rounding curves, or if the passengers all move to one side of the car, the gyroscope resists the tipping movement, and restores the equilibrium. It must be understood that the two gyroscopes are geared together with teeth, so that they must work at the same rate of precessional rotation.

BARMEN-ELBERFELD RAILWAY

The principles of gyroscopic action were applied on shipboard quite fifty years ago to give steadiness to telescopes and compasses ; and Mr. Brennan himself invented and sold to the Government a torpedo steered by gyroscopic mechanism. Very practical experiments have taken place to show how the gyroscopic balance-wheel can be utilised to prevent a ship from rolling, without interfering in the least with the steering or the ordinary progression of the ship. Dr. Otto Schlick, on a vessel 116-ft. in length and of 56 tons displacement, has reduced the rolling through an arc of thirty degrees to one degree. But many naval engineers, while agreeing with the practicability of abolishing rolling, maintain that if the gyroscope from any cause broke loose, it would devastate a ship with the same effect as a monster cannon-ball. The possibility of such a catastrophe will cause shipbuilders to hesitate before adopting it for ordinary passenger vessels, but for war vessels one more engine of destruction aboard possibly would not militate against the undoubted advantage of a stable deck from which to fling projectiles at an enemy.

Returning to the mono-rail, there is no doubt it possesses certain advantages over the standard two rails, in lessened friction and side thrusts, with additional speed and smoothness of running—always supposing that the gyroscope wheels keep turning. The inventor claims that if a 100-ton car poised on a single rail be suddenly deprived of its electric power, the balancing wheels, revolving in a vacuum, would by their own momentum continue to turn for two or three days. Even if one of the gyroscope wheels did absolutely stop, owing to breaking loose from its bearings or something equally bad, the other wheel would hold the car steady, unless it chanced to be on a curve at that particular moment. In that case an accident would be inevitable ; but then, it is not claimed for the "gyro-car" that it eliminates all danger, but certainly that it lessens the liability of accident and derailment over the present system of railway transportation.

Mr. Brennan maintains that except in the case of very remote contingencies, accidents to which the "gyro-car" is liable would leave ample time for the engineer to run his train into safety sidings, and where these were not in existence the cars would be provided with adjustable struts for letting down on either side, when the gyroscopes were not in use. When asked for an expression of opinion concerning speed, the inventor declared :

"We shall surpass all that the world has known ; for with friction reduced to a minimum and side-thrusts practically eliminated, there is no reason why our mono-rail trains should not make one hundred and twenty, one hundred and fifty, or even two hundred miles an hour with absolute steadiness and far more safety than is possible on existing trains. I may add that ideal smooth running will be secured by having a continuous line of wheels under each car, a single line, of course, so that the whole train will rest on a solid chain of wheels."

During the 1900 session Parliament passed a Bill for the construction of a mono-railway between Liverpool and Manchester, notwithstanding that railway experts endeavoured to prove that the scheme was a wild dream. The capital required was estimated at £3,000,000, but as the investing public refused to subscribe anything like the amount, the scheme was abandoned.

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