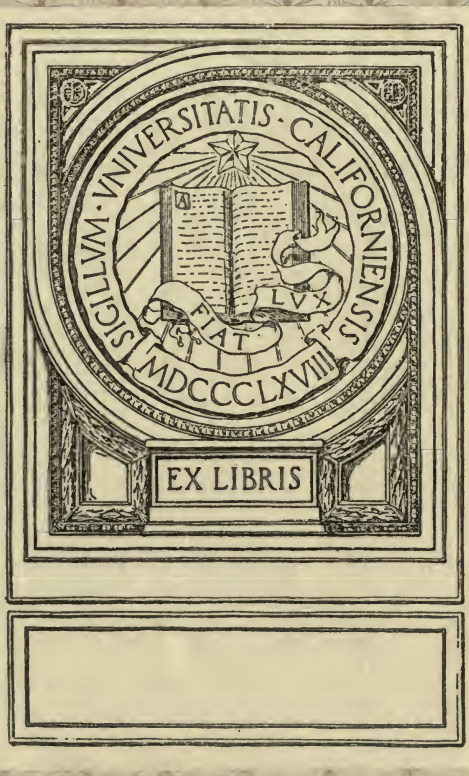
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FRENCH RAILWAYS

BY

LORD MONKSWELL

ILLUSTRATED

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PREFACE

The following notes on the Railways of France are put together from information collected during a series of years, in which, through the kindness of many of the Managers and Officials, I have had opportunities of seeing much of these railways that was interesting.

My most sincere thanks are due to a large number of gentlemen connected with the various French railways—particularly the Nord, P.L.M. and P.O. Especially must I refer to Monsieur Rudloff of the Chemin de fer du Nord, his unvarying kindness on the innumerable occasions on which we have made expeditions together and the great interest of the information he has given me.

M.

September, 1910.

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FRENCH RAILWAYS.

CHAPTER I.

When about eighty years ago railways became an accomplished fact, it became at the same time evident that a revolution in the ways and habits of mankind was imminent. The whole consequences of the introduction of railways could not of course be foreseen, but it was soon apparent that the problem of their control and management was one which interested the public in the highest degree. From that time onward that problem has been under constant consideration; and the different methods adopted by different countries, together with the fact that no system yet evolved escapes denunciation by some, often considerable, body of opinion, while its defects are, at the same time, obvious to its best friends, show clearly enough that no sort of finality has been reached. Railways from their very nature—their great extent and the extreme desirability of every

detail of their working fitting in with every other detail—made necessary a centralization of authority more complete than anything previously known, and were themselves the first example of the modern tendency towards great business agglomerations, the establishment of which they so much facilitated. And this centralization, together with the universal dependence upon railway transport that soon became felt, gave the persons controlling the railways powers so great that it was seen to be necessary to bind them by very strict rules to ensure that their undertakings should be carried on in the interest of the public. At the same time the great expense of building railways and the inability or unwillingness of Governments to embark in immense new financial operations, the results of which could by no means be relied upon to be successful, had the effect of throwing the construction and working of railways largely into the hands of private individuals or corporations. When railways had been some time in existence and their success was assured, the objections to their being taken over and worked by the State became less; indeed, in many cases, the eventual desirability of this course had, from early times, been contemplated, and arrangements made accordingly. But while

everywhere, as the importance of railways increased, the conditions imposed upon them became more stringent and the supervision exercised by the State more complete, actual State ownership has been resorted to only to a limited extent, and the relations between the State and the railways vary considerably in different countries. The whole tendency of the times being in favour of the amalgamation of many small concerns into a few big ones, there is in theory no particular reason why this process should not be carried a step further and all the railways of any country united under one management, which, under the circumstances, could hardly fail to be that of the State. Neither can the stimulus supplied by enlightened self-interest be expected to influence the working of privately-owned railways more beneficially than it influences that of State-owned railways, as the officials, who really manage the railways and are the only people who feel this stimulus, can be given the same powers and emoluments and be treated in the same manner under the one system as under the other. If, therefore, considerations of a practical kind, connected for the most part with the imperfections of human nature, did not intervene, there could hardly be any doubt but that complete State

ownership of the railways would everywhere be the best solution of the question.

France was not a country where the construction of railways was very early pushed on. In some ways this has been a great advantage to her, as it was possible to take stock of the situation and profit by the mistakes of other countries before railway building in France was seriously taken in hand. From the beginning, the State took an active interest in the railways, and if this had the effect at first of checking their construction, the final result is that they are among the best planned in the world. So late as 1842, it was still possible to determine in what direction the principal lines should be built, and in that year a law was passed settling this question once and for all in so satisfactory and comprehensive a manner that the uneconomical duplication of railways between the same points has been almost entirely avoided, and in nearly every case each railway serves its own well-defined district, from which all other railways are excluded.

About the year 1845, concessions were granted for a good many of the lines which were to form the main lines of the different great companies; and that year may be taken as approximately the time at which most of these companies began

their existence. It is interesting to note that many British names occur among the lists of the original concessionnaires.

For a time the construction of the lines which promised good returns on the capital invested in them proceeded with fair rapidity, the State, in some cases, granting pecuniary assistance, and in some other cases itself carrying out part of the work.

It was not till 1857–59 that uniform agreements regarding the working of the railways were made between the Government and the six great companies — Nord, Est, Ouest, Paris-Orléans, Paris-Lyon-Méditerranée and Midi — which, by this time, had absorbed all the important lines in France. These agreements (Cahier des charges) brought the relations of the State with each of the companies into line. They are all similar and are divided into six principal headings treating respectively of :—

1. The location and construction of the railway ;
2. Maintenance and working ;
3. Duration and expiration of the concession and State purchase ;
4. Rates and fares and conditions of transport ;
5. Various public services to be rendered by the railway ;

6. Miscellaneous matters.

Under heading 1, it is laid down that no work can be undertaken without the previous sanction of the Minister of Public Works. The gauge of the line is to be 1·44–45 metre and there must be a distance of two metres between two parallel lines. The maximum gradients and the minimum radius of the curves are fixed. No national or departmental roads are to be crossed on the level if this can be avoided. The railway must be enclosed by hedges or walls or in some other manner authorized by the Government.

Under heading 2, the company is bound to submit for the approval of the Government all their regulations for the working of the railway. The Minister of Public Works is to receive the company's proposals as to the speed and time of transit of all trains and to decide with regard to them. The company is to be placed under Government control and supervision in all matters connected with the maintenance and repair of the railway and all its appurtenances and the working of the line.

Heading 3 deals with the duration of the concession, which is, in every case, ninety-nine years in all, though the dates vary from which the different concessions began; at the expiration

of this period, the Government is to become possessed of the railway and all its fixed appurtenances. If either party wishes it, the Government is to take over all the rolling stock, stores, and other movable property of the railway at a valuation, except that the Government need not take stores more than sufficient to last six months. The Government is given power to buy up the railway on the basis of paying the company every year till the date at which the concession would have expired a sum equal to the average net profits of the best five years out of the last seven years or to the net profits of the year preceding the purchase by the State, whichever is greater.

Heading 4. All rates and fares are divided into two parts—tolls and transport charges—only the former being leviable if the transport is undertaken by some outside agency. The fares for the three classes (exclusive of any Government duty) are fixed not to exceed 10, $7\frac{1}{2}$ and $5\frac{1}{2}$ centimes per kilometre, children under three travelling free, and between the ages of three and seven at half price. Each passenger to be entitled to 66 lb. of luggage free, each child travelling half price to 44 lb. The rates comprise those for live stock, express goods and ordinary goods, and various special tariffs. Any change in rates or fares has

to receive the sanction of the Minister of Public Works and be advertised a month before coming into force. If fares or rates are reduced they cannot be raised again for three months and one year respectively. Discriminations in fares or rates to the advantage or detriment of any person or persons are forbidden generally, but the Government may receive preferential treatment, and the same may be granted to necessitous persons. Goods for the same destination must be despatched in the order in which they are received and without loss of time. The company is bound, if desired to do so, to collect and deliver goods in all places where the population is of a certain density.

The clauses under heading 5 deal with the arrangements between the company and the Government. Soldiers and sailors are to be carried at a quarter of the ordinary fare. The company must provide one train each way daily over the whole line free of charge for the carriage of the mails, and give other facilities. There are also stipulations regarding telegraphs.

Under the miscellaneous clauses (heading 6), the right is reserved for the Government to grant to other concessionnaires concessions for the prolongation of the company's line or for branch lines to connect with it, and certain rules are laid

down regarding the interchange of traffic between the company's line and any such connecting lines. There are regulations as to the construction and working of sidings to serve industrial establishments along the line, one stipulation being that goods wagons are not to be detained more than six hours for loading or unloading (unless the siding is more than a kilometre long, when a certain extra time allowance is given). The company must pay 120 francs (increased later to not more than 150 francs) a kilometre yearly on account of the salaries of Government inspectors and officials appointed to supervise the working of the railway.

France is a country containing only a few big towns and large centres of population, and the routes likely to prove profitable were clearly marked out. There had therefore at first been no great difficulty in finding capital for railway construction till the obviously profitable lines had been completed. But these lines were by no means sufficient for the requirements of the agricultural population, which is spread evenly over almost the whole of France, and the necessity soon became apparent of finding means to extend to the country districts the benefits of easy railway communication. Under these circumstances it was thought desirable to place upon the

concessionnaires, who had been given the right of building and working the profitable lines, the duty of undertaking those also, which, though offering less opportunity of profit, were nevertheless required by the country. With this object in view, Conventions between the Government and the six great companies were drawn up and were signed in 1859.

The main provisions of the Conventions were :

The acceptance by the companies of a number of new lines, for the construction of which subsidies were, in a few cases, to be received from the State.

The division of all the companies' lines, built, building, or to be built, into an " old system," and a " new system," the former, generally speaking, comprising the lines already built, the financial prospects of which were, as a rule, satisfactory, and the latter comprising the new lines, many of which, at first anyhow, were not likely to pay.

The accounts of the two systems were to be kept separately. Interest at 4 per cent. and sinking fund, calculated at the same rate, on the capital invested in the lines of the " new system " were guaranteed by the State for a period of fifty years from 1865, subject to the following conditions :

The net profits on the capital invested in the "new system" was, if sufficient, to be employed for paying interest on that capital. If not sufficient, the amount required was to be made up from any surplus that might remain over after the net earnings of the "old system" had reached a certain specified sum, which was to be reserved as profits on that system. In case the amount available from these two sources was insufficient to pay the guaranteed interest, the State was to supply the difference. Any advance for this purpose made by the State was to be repaid with simple interest at four per cent. as soon as the net profits from the "new system," together with any surplus there might be over and above the reserved profits on the "old system," were more than sufficient to furnish the guaranteed interest on the capital invested in the "new system."

The State guarantee on each particular line of the "new system" was to begin only on its opening for traffic. Before that any deficit incurred in connection with it was to be paid out of capital.

When any advances which the State might have made had been paid off, the companies were to be allowed to retain their whole earnings till the net profits were increased up to a further

point (the arrangements regarding which differed for the different companies). After this the net profits were to be divided equally between the company and the State.

In the case of the Midi only, dividends on the capital invested in the "old system" were also guaranteed by the State.

In case the advances made by the State had not been completely paid off at the expiration of the concession, the amount still owing was to be deducted from the payment to be made to the company for the purchase of their rolling stock and other movable property, which the State was bound to take over at a valuation.

At the time of the signature of the Conventions of 1859, 5000 miles of line were open for traffic; after this construction proceeded, with some help from the State, steadily for many years, except for a short break during the Franco-German War. After the war, those of the lines belonging to the Est which lay in the territory ceded to Germany (462 miles open for traffic and a few lines under construction), were purchased from the French Government by the German Government for 325 million francs, and it was arranged that the railway company, in consideration of the loss which they had sustained, should

receive an annuity of 20,500,000 francs from the Government till the expiration of their concession.

Various new agreements were from time to time made between the Government and the different companies, and in 1878, the State bought up a number of minor companies in the west of France which had got into financial trouble, and formed of them a system of State railways. Meanwhile, the rate of progress in railway construction throughout the country did not satisfy the Government (there were 15,000 miles open in 1878), and in 1879 a bill passed the Chambers authorizing the construction by the State of a very large number of completely new lines; they were, for the most part, intended to serve remote country districts, and their financial prospects were consequently poor. A certain number of these lines were actually built or begun by the State, but it soon became apparent that they could better be constructed and worked by the companies, for handing them over to whom, therefore, arrangements were shortly made, on terms as little onerous to the State as possible, but at the same time onerous enough.

So in 1883, new Conventions were made between the State and the companies. In virtue

of these, all the companies took over from the State a number of lines already open for traffic and accepted concessions for a number of new lines. (The Paris - Orléans Company, besides, handed over to the State certain lines necessary for forming into a compact system the lines acquired by the State in 1878, and they received in return certain of these latter lines which were not necessary for the formation of a compact State system.)

In most cases, the construction of these new lines was to be paid for by the State, except that the companies were to contribute a sum of 25,000 francs a kilometre. The companies were to provide the rolling stock. The State's share of the capital required for the construction of the lines was to be raised by the companies acting for the State. The State was to repay the companies by annual payments so calculated that the debt would be extinguished at the expiration of the concessions. Those companies which were in the State's debt on account of advances made to them for the guarantee of their interest extinguished their debts in whole or in part by undertaking the construction, at their own expense, of new lines which would otherwise have been paid for by the State.

The distinction between the lines of the "old system" and "new system" was abolished. A single set of accounts was to be kept for all the lines of each company.

In the cases of the Est, Ouest, Paris-Orléans and Midi, the State guaranteed the interest on all the capital invested—the full amount on the debentures and a certain lump sum on the ordinary shares. In the cases of the Nord and Paris-Lyon-Méditerranée the guarantee of the State extended only to the interest and sinking fund necessary to meet the requirements of a certain specified amount of debenture capital.

The limit of time for which the guarantee should continue remained for the Nord and Paris-Lyon-Méditerranée (as fixed by the Conventions of 1859) the end of the year 1914. For the Est it was extended to 1934, for the Ouest to 1935. For the Paris-Orléans and Midi no limit was specified.

The stipulations regarding the repayment of advances made by the State on account of the guarantee of interest were in principle very much the same as in the Conventions of 1859. After all fixed charges had been fully met, any advances which might have been made by the State had been repaid with simple interest at 4 per cent. (in

the case of the Midi the rate of interest was subsequently reduced to 3 per cent.), and the sum reserved for the benefit of the ordinary shareholders had been increased to a specified amount, any remaining profits were to be divided, two-thirds going to the State and one-third to the companies.

Before 1883, neither the Nord nor the Paris-Lyon-Méditerranée ever had recourse to the State guarantee; but since then all the companies, except the Nord, have had to make extensive use of it, and it is only since 1898 that certain repayments have been made to the State. The Paris-Lyon-Méditerranée have, however, now made a beginning of paying the State its share in the profits.

In 1908, after a long parliamentary battle, a bill was passed authorizing the purchase by the State of the Ouest. At the time of writing, the details of the purchase scheme have not been settled, and till this is done a provisional arrangement for working the line is in force, under which it still preserves its individuality and has not been merged in the existing State system. It will therefore be more convenient to continue to refer to it under its old name.

In 1909, the total length of line open in France

was nearly 30,000 miles; there was something over 10,000 miles of double line.

While exercising a very close supervision over every branch of railway working, the State, by granting concessions to private companies, has secured the construction, as far as possible by private capital, of a complete system of railways, which, at the termination of the concessions, will automatically become its own property. The less profitable concessions, however, have involved heavy outlay by the State in subventions and heavy financial responsibility for the guarantee of interest, from neither of which burdens has it so far received much direct advantage, though it has gained from the preferential treatment which it receives from the railways and from the taxes which it levies on them.

The French railway companies are limited liability companies. The original capital was provided by the issue of a certain number of shares of 500 francs each (except in the case of the Nord whose shares are of 400 francs). Funds beyond those provided by the original issue of shares have in almost all cases been procured by the issue of debentures, of which by far the larger proportion of the capital invested in French railways consists. The interest on the ordinary

shares is divided into two parts. There is first of all the statutory interest at a fixed rate, generally 4 per cent., and then the supplementary interest which is dependent upon the amount of the surplus remaining over after all the fixed charges have been met.

The whole capital must be paid off by the time fixed for the expiration of the concession by means of a sinking fund provided out of the earnings of the line or the State guarantee.

Every year, after the date fixed for the beginning of the repayments, a certain number of shares, drawn by lot, are so paid off. When a share has been paid off in this manner the statutory interest upon it ceases, but the supplementary interest continues to be paid until the expiration of the concession upon a certificate, which is given in exchange for the paid off share.

The railways are administered by Boards of directors, elected by the shareholders. The qualification for a directorship is the possession of a hundred ordinary shares. One-fifth of the directors retire by rotation each year and are immediately re-eligible. The Board elect from their own number a chairman and two vice-chairmen. At least one Board meeting a month must be held. Every year there must be at least one general meeting of

shareholders, which should consist of not less than forty shareholders, representing at least one-twentieth of the share capital. In case the shareholders attending the meeting do not fulfil these conditions it is put off till a later date, when its proceedings are valid, however small the attendance.

The arrangements on the Paris-Orléans railway may be taken as an example of the organization of a big French line.

Under the Board is the general manager, who controls directly all the departments into which the service is divided. The three principal departments consist of the Traffic (Exploitation) Department, the Running (Matériel et Traction) Department, and the Way and Works (Voie et Bâtiments) Department — their functions are broadly indicated by their titles. At the head of each is an engineer-in-chief responsible to the general manager. For the purposes of each of these three departments the whole line is divided up into districts, in number and of area suited to the requirements of that department; in each district is a district manager responsible to his engineer-in-chief in Paris. Besides these three big departments, which divide between themselves the whole working of the line, are two others, situated at headquarters, and also under

the general manager, which are concerned respectively with accounts and legal business.

The administrative arrangements of all the great companies and also the State railways are of a very similar nature to those of the Paris-Orléans line.

The number of railway servants employed by the great railway companies and the State railways is, very roughly, 300,000, of which 10 per cent. are women. About 120,000 are employed in the traffic departments, and the rest, except for a few employed in the higher posts, are nearly evenly divided between the running departments and the way and works departments.

The hours of work of the train men are in general fixed not to exceed an average of ten hours a day, with intervals of generally not less than ten hours between each period of work. Drivers and firemen are allowed one complete day's rest (of twenty-four hours) every ten days, or, if they never sleep away from home, one every fortnight. Train men, other than drivers and firemen, who never sleep away from home, may work on an average eleven hours a day with nine hour intervals. They get one complete day's rest a fortnight.

Station men and permanent way men work not more than twelve hours a day, with one whole

or two half-days' rest a month. They are not allowed to be on night duty for more than fourteen consecutive nights.

Most of the railway servants receive pensions on their retirement. Fifty-five is generally the age when a railway servant may retire on a pension, if he has served twenty-five years. Under these circumstances he receives a pension equal, or about equal, to half the average of his yearly wages during the last six years of his service. Greater length of service, and the receipt in some cases of a bonus converted into an annuity, may increase this pension up to a sum not exceeding two-thirds or three-quarters of his wages during his last six years. The funds required come chiefly from payments made by the companies, but the beneficiaries also contribute during their working life sums ranging up to 6 per cent. of their wages. Duly qualified widows receive half the pension which their husbands would have received, and certain payments are made to orphans under eighteen.

In some cases these conditions are somewhat modified to bring them into harmony with a law regarding railway servants' pensions, which was passed in 1909.

CHAPTER II.

The seven great railway systems, which together cover the whole of France, consist of the Nord, Est, Ouest, Paris-Lyon-Méditerranée, Paris-Orléans, and Midi, and the State railways. Regarding Paris as the centre of France, the Nord, Est, and Ouest cover almost exactly those areas which correspond to their names. The Paris-Lyon-Méditerranée cover the whole of the south-east, the Midi a large corner in the extreme south-west and south. The Paris-Orléans serve the country between Paris and the Garonne, and the State railways the region lying between the territories of the Paris-Orléans and the Ouest. The boundaries of the territories served by the different systems are, as a rule, very sharply defined. The only notable exception to this rule is that the line from Tours to Nantes and beyond, crossing the territory served by the State railways and extending right into the Ouest's district in the extreme west of Brittany, belongs to the Paris-Orléans.

As has already been remarked, France is very

largely an agricultural country, and the population is very fairly evenly spread over the whole area. In only five of the eighty-six departments is it less than half the average for the whole country, and, on the other hand, the large towns are not numerous. Consequently a large proportion of the railway mileage serves country districts, and the important through routes with intense traffic are few.

The most prominent geographical features are the hilly country in the south centre, the mountainous regions on the southern and eastern frontiers, and the valleys of the four principal rivers—the Seine, Loire, Rhône, and Garonne. These latter lie in such a manner that it has been found possible to take full advantage of the easy gradients they provide for some of the most important lines in the country. Thus the Seine and the Rhône, with their tributaries, provide a continuous passage from the English Channel to the Mediterranean, except for a narrow ridge which separates the basins of these two rivers, and the main lines of the Ouest and Paris-Lyon-Méditerranée closely follow this passage in either direction from Paris. The Paris-Orléans have an important line down the valley of the Loire from Orléans to the sea, and the Midi make a similar use of the Garonne.

Besides Paris with its population of nearly 3,000,000, there are only three very large towns in France—Marseilles, Lyon, and (if the neighbouring towns of Roubaix and Tourcoing, only a few miles away, are included) Lille. All these contain between four and five hundred thousand inhabitants. Bordeaux, with a quarter of a million, comes easily next. The lines, therefore, connecting Paris in three different directions with these four places form the principal arteries of internal traffic, and their importance is increased by the fact that a great part of the international traffic follows the same routes for a greater or less distance. The main line of the Nord from Paris to Lille is utilized for various distances by the traffic for England and for Belgium, and that of the Paris-Lyon-Meditérranée to Marseilles by the traffic for Switzerland, Italy and the Mediterranean, while the main line of the Paris-Orléans from Paris to Bordeaux is part of the most direct route to Spain. The Ouest and the Est do not connect Paris with any of the very largest towns, but the international traffic conducted by the Ouest with England over the main line through Rouen, and by the Est over their two main lines from Paris to Germany and Switzerland, entitle all these routes to be considered as of first-rate importance. The

Midi forms the continuation to the Spanish frontier of the Paris-Orléans line from Paris to Bordeaux, and is also connected with Spain at the eastern end of the frontier. One of its principal lines runs from Bordeaux via Toulouse to the coast of the Mediterranean. Otherwise the importance of this line is chiefly local. The same may be said to a greater degree of the State system, which, although possessing a line from Paris to Bordeaux, does not, at least as regards the passenger service, effectively compete with the Paris-Orléans route.

In some cases the main lines, instead of passing directly through certain important towns that lie on their route, pass them by at some distance, and the passengers are set down, or carriages detached, as the case may be, at a station well outside, from which the town itself is reached by a short branch line. There is an arrangement of this kind for both Orléans and Tours on the Paris-Orléans, the main-line trains avoiding both of these places, and stopping at Les Aubrais outside Orléans and St. Pierre des Corps outside Tours. This arrangement removes from the main line the traffic which is purely for the town, and in this manner renders the through trains much less liable to be delayed. It involves,

of course, a certain amount of delay and inconvenience for passengers for the places in question, and though well suited for middle-sized towns, to and from which the traffic is not very great, could hardly be used in the case of very large cities.

The principal arteries of internal traffic were completed long ago and there are now none left to construct, but with international traffic the case is different, and important works are under consideration for improving the means of communication with Switzerland, and an agreement has been come to with Spain for constructing three new railways across the Pyrenees. One of these lines is to be across the western half of the chain, and is to start from Oloron ; the other two, across the eastern half, are to start respectively from Ax-les-Thermes and Saint Girons. The first two lines are to be completed shortly, and the third will be taken in hand later.

The question of improved communications with Switzerland arises in connection with the opening of the Simplon tunnel. Up to the time when that event took place, there were two great highways of traffic between France and Italy, one direct by the Mont Cenis tunnel, and the other through Switzerland and via the St. Gothard

tunnel. To these the Simplon route has now been added, but, though the Simplon tunnel itself is open for traffic, the approach to it from Paris is not completely satisfactory. There exists indeed a line, which is tolerably direct, except in the neighbourhood of the frontier between France and Switzerland, where it makes a large *détour* via Pontarlier. By building a direct line, some fifteen miles long, between Frasne in France and Vallorbe in Switzerland, where moreover the existing line is of a very difficult nature, a considerable improvement might be effected and fairly adequate provision made for the Simplon tunnel traffic. In many ways, however, it is desirable for the principal line of approach to the Simplon to pass through Geneva, which is much the biggest town and most important railway centre anywhere near the north end of the tunnel. There is at present nothing approaching a direct line from Paris to Geneva, but several slightly different routes have been considered, along which a direct line might be built. The principal difficulty would be the necessity of making a very big tunnel through the Jura near the Col de la Faucille, about fifteen miles from Geneva, and, under any scheme, the piercing of a tunnel would have to be supplemented by the construction of many miles

of completely new line and extensive reconstruction of existing lines. Before such a direct line from Paris to Geneva could be begun, an understanding had to be reached between the French and Swiss authorities as to how the traffic was to be forwarded from Geneva towards the Simplon. From Geneva to the Rhône Valley there exist two routes, one to the north of the Lake of Geneva, lying entirely in Swiss territory, and the other, a shorter one, to the south of the lake, chiefly in French territory, and belonging to the Paris-Lyon-Méditerranée. At the present time there is in Geneva and its immediate neighbourhood no connection between these two lines, and when the Swiss Government allow one to be made, they will facilitate the passage on to the shorter French line south of the lake of traffic from the north, which now follows the Swiss route. The French, on the other hand, might well be reluctant to undertake the great expense involved in making a new line to Geneva if they failed to secure the whole of the advantage which they felt that the new line ought to bring with it. If, moreover, the French were unable to secure acceptable terms from the Swiss Government with regard to the Simplon traffic, it was possible for them, by making a completely new tunnel

through the Alps somewhere in the neighbourhood of Mont Blanc and building the necessary connecting lines, to make for themselves a new route to Italy to avoid Swiss territory altogether. This would, however, be an extremely expensive proceeding, would take a long time to finish, and would also require the consent of the Italian Government, who, being interested in the Simplon route, might put difficulties in the way.

In 1909, therefore, an agreement (the Convention of Berne) arranging about the Simplon traffic, was come to between France and Switzerland. It provided for the immediate construction of the Frasne-Vallorbe line, and laid down the conditions on which the two countries agree to the Faucille line and the link connecting the lines north and south of the Lake of Geneva.

In connection with the Simplon tunnel there arises also the question of the influence on the trend of international traffic which will be exerted by the Loetschberg tunnel, which is now being driven through the mountains on the north side of the Rhône Valley, and, when completed, will provide a direct route from Berne to the Simplon. The Swiss authorities will be glad to direct as much traffic as they can through Berne and the Loetschberg, and it is quite possible for them, in

conjunction with the Est, and by altering some sections of the Swiss lines between the French frontier and Berne, to arrange a new through route from the north of France and from Belgium. In the Convention of Berne, therefore, an agreement is come to for the establishment of this new route also.

The question of improved communication with England by means of a tunnel under the English Channel comes up at intervals, but, owing to the decision of the British Government in 1907 not to allow a tunnel to be made, it is unlikely that much will be heard on the subject for some time to come. From an engineering point of view the difficulties of construction and working are not supposed to be very great. There is under the Channel a stratum of almost impervious chalk, which, from the indications at present available as to its location and thickness, is admirably suited for tunnelling operations. Through this chalk it was proposed that two tunnels should be driven, parallel to one another, each to contain a single line of rails. This arrangement would give greater strength than could be secured by one larger tunnel containing a double line of rails, and would also facilitate ventilation owing to the traffic through each tunnel always moving in one

direction only. The submarine length of the tunnel would be about 24 miles. The traffic through it would, of course, be worked by electricity, the possibility of using this power for the purpose being a most important advantage which has only comparatively lately become available. If the tunnel were constructed in accordance with the latest proposals, the distance from London to Paris would be about 285 miles, which should occupy five hours. It would therefore be possible, with a suitably arranged service, to leave London in the morning, have five or six hours in Paris, and reach London again the same night.

As an alternative to a tunnel it is suggested that the trains might be ferried across the Channel in specially constructed ferry boats. Some arrangement of this kind would possess numerous advantages, without having any effect upon the strategic position of Great Britain; under the most favourable circumstances, however, it could hardly be expected to increase the volume of passenger traffic to the same extent as a tunnel would do, if the hopes of the advocates of a tunnel were fulfilled. But, though not possessing the peculiar advantages of a tunnel, a ferry would save passengers two changes, together with part of the delay attendant upon such changes, and,

as regards the goods traffic, would eliminate all handling of the goods.

Paris itself is provided with a very complete system of railways. There is a whole network of the lines of the electrically worked Métropolitain across and across the city. The Petite Ceinture runs round the city, keeping inside the walls, and the Grande Ceinture forms another ring further from the centre, connecting a large number of the more remote suburbs with one another. Of the big terminal stations, two—St. Lazare, the terminus of the Ouest, and the Paris-Orléans terminus at the Quai d'Orsay—are situated in extremely favourable positions in the middle of Paris; the others are much less central. The Quai d'Orsay station is quite the most remarkable of all. Till nearly the end of the last century the terminus of the Paris-Orléans railway was at the Quai d'Austerlitz, some $2\frac{1}{4}$ miles from the present terminus, part of the site of which was occupied by the ruined remains of the Cour des Comptes. On this very favourable spot the Paris-Orléans set to work to build their new station, which was finished in time for the exhibition of 1900. The continuation of the line from the Quai d'Austerlitz is almost entirely in tunnel, below the level of the streets and houses,

and the platforms of the Quai d'Orsay station itself are therefore some distance underground. The booking-offices and waiting-rooms are, however, on the street level, so that over a good portion of its area the station has two storeys, and a proportionate economy of space is secured. Unlike the other Paris termini, where the platforms used for the main line trains at least are of the ordinary low continental type, the platforms of the Quai d'Orsay are level with the floors of the carriages, a reform which is certainly conducive to the convenience of the passengers.

All the trains which run into the Quai d'Orsay are worked from the Quai d'Austerlitz by electric locomotives, which, of course, have great advantages over steam locomotives for a line running through the heart of the city and very largely in tunnel.

The great floods which occurred in the early part of 1910 brought to light a weak spot in the extension of the Paris-Orléans line from the Quai d'Austerlitz to the Quai d'Orsay. This line, which, as already remarked, is much below the level of the streets, runs close to the Seine all the way, and the river rose to such a height that the water overflowed and converted the course of the railway into a raging torrent. The Paris-

Orléans line was not the only one in Paris that was affected. All traffic over a great part of the underground Métropolitain system was stopped, and many other lines at different points in and around Paris were under water. Neither were the railways by any means the only sufferers from the floods, and the losses and disasters caused by them were so great that it will probably be considered necessary for the sake of the future protection of the city as a whole to establish some elaborate system of regulating the flow of the river during flood time.

The Paris-Lyon-Méditerranée being much the biggest railway in France, their traffic in and out of Paris is perhaps more important than that of any other line. Fortunately, indeed, their suburban traffic is not very large, being nothing like so great as that of several other railways, particularly the Ouest. But the Gare de Lyon being, as it is, the starting-point for an exceptionally large number of important places, its not particularly extensive accommodation is heavily taxed at busy times of year.

The passenger terminus, however, covers only a small part of the area which the Paris-Lyon-Méditerranée require for carrying on their Paris traffic, and for nearly two miles the ground on the

south side of the main line is occupied by the various yards and sidings of the company, and a good part of the north side is similarly utilized also. Nearest to the passenger station are the grande vitesse goods sheds, to and from which

OUTSIDE THE GARE DE LYON.

vehicles arriving and departing by the main passenger lines can conveniently be transferred; the despatching station is on the north side of the main line and the receiving station on the south, corresponding to the down and up sides of the passenger station. A large part of the grande

vitesse traffic coming to Paris is composed of fresh fruit and vegetables. The first new potatoes, for instance, come from Algeria, the next lot from Spain, the gardeners of which country have apparently, during the last few years, rapidly awoken to the advantage which their hotter climate gives them in sending supplies to the northern markets, as against French growers, whose produce can only arrive later.

Beyond the grande vitesse sheds, the main line bears away to the north, while a branch continues straight on through the petite vitesse goods station. Here, as elsewhere, the goods are despatched from sheds situated on the north side of the station, and received at other sheds on the south side. The despatching station for ordinary miscellaneous merchandise consists of an immensely long raised platform, about fifty feet broad, all under cover. The goods to be despatched are unloaded from carts on to this platform at one side, and when all the necessary formalities have been gone through at one of the offices situated at convenient intervals, they are loaded into vans or on to wagons, which stand on a line of rails at the further side of the platform. The platform is divided up into sections, the vehicles standing at each section being for a

different destination, which is marked in large letters on the roof above. In order to make it possible to get loaded vehicles out of the way and to replace them by empty ones, without at the same time moving all the others standing at the platform, turntables are placed at intervals, on to which the vehicles can be run, turned at right angles, and then drawn out by means of hydraulic capstans.

Marseilles is the only point for which the traffic is, as a rule, so great that it is possible to make up whole trains to run straight through. All other trains leaving Paris from this station comprise vehicles for a certain number of different destinations, which involves subsequent sorting.

The south side of the station where the goods are received differs from the north side in that there is a series of short platforms arranged at right angles to the principal lines, and every vehicle has to be turned before it can be drawn in and unloaded.

Here, too, is situated the office of the Customs, where may be seen every variety of package which has entered France by the various frontier stations of the Paris-Lyon-Méditerranée, and been brought to Paris in bond.

Further away still from the passenger station

are various extensive sidings and sheds, where the more bulky and wholesale objects are dealt

STORES OF CHARCOAL AT THE P.L.M. GOODS YARDS.

with. In one place are rows and rows of trucks loaded with charcoal. In another, for moving

heavy timber and large pieces of machinery, is an enormous electric travelling crane, capable of lifting forty tons; and perhaps the most remarkable sight of all is acres of barrels of wine, lying ready to be transferred to the cellars of the

TRAVELLING CRANE.

numerous wine merchants, whose premises lie immediately outside the railway enclosure. The wine is generally brought to Paris in specially constructed wagons; they consist of one or two enormous barrels mounted on a wagon framing;

WINE PLATFORM AT P.L.M. GOODS STATION.

WAGON FOR CARRYING WINE.

one, which I noticed, was capable of transporting seventeen tons of wine. Arrived in Paris the wine is run out straight from the big barrels into barrels of ordinary size, and carted away on the peculiar long carts, with one pair of big wheels, which are used for the purpose.

CARRIAGE SIDINGS (P.L.M.).

Passing on through a sorting yard of rather small dimensions, where only the most necessary sorting is done, the rest being performed at Villeneuve St. Georges, some miles out of Paris, the carriage sidings are eventually reached. Here most of the marshalling and cleaning is done, and a good opportunity is afforded of examining the

carriages of different kinds now used by the Paris-Lyon-Méditerranée. Particularly remarkable is the much greater weight per passenger of the new corridor carriages of 34 tons apiece, running on two bogies, and with only about the same capacity as the older carriages of not much more than a third of the weight. Besides the Paris-Lyon-Méditerranée rolling stock were also to be seen some of the carriages of the International Sleeping Car Company, which are used on the Paris-Lyon-Méditerranée trains, and undergo cleaning operations here at the hands of a party of the Sleeping Car Company's men.

CHAPTER III.

While engines and rolling stock have reached a high pitch of perfection, the same can be said only in a lesser degree of the lines they run over, which still suffer from at least two rather serious defects—one always present, the other always liable to appear. The former arises from the fact that no satisfactory way has been found of imparting to the rail-joints the same strength and stiffness as is possessed by the rail where it is continuous. No matter how tight the fastening may be, there is always, as a wheel passes from one rail to another, a perceptible bump, which no form of joint yet invented seems able to obviate. The latter defect is that railway lines are always liable to sink or become uneven, and unceasing attention and much work are necessary to keep them level. Though the use of a sufficient thickness of good ballast renders movements of the sleepers much less likely to occur, no ballast can ever be depended on to keep them absolutely

fixed and immovable under all ordinary circumstances.

At the present time there exist to all practical intents and purposes two forms of permanent way only. With both transverse sleepers are used. In the most usual form, the bottom of the rail is flat, and either rests directly upon the sleeper, or is separated from it by a metal plate only. In the other form the bottom of the rail is formed into a head of nearly the same shape as the top, and is supported in the jaws of a metal chair, which is fastened to the sleeper. In Great Britain, the second form is universal; in most other countries the first only is used. In France alone, opinions on the subject are fairly evenly divided, some railways using one form of road and some the other. Under these circumstances, it is perhaps safe to conclude that one form is about as good as the other. The one definite advantage possessed by the flat-footed rails is that with them it is possible, without introducing complications, to make use of much longer, and therefore more efficient, fish-plates at the rail-joints than can be done with rails supported by chairs, since with these (unless chairs of special form are used on the sleepers next to the joints) the length of the fish-plates is limited to the clear

space between two adjoining chairs. The number of joints can, of course, be reduced by employing longer rails, and the modern tendency lies in this direction; but the provision of a perfect rail-joint, or of means for the total elimination of rail-joints is perhaps the most important mechanical problem connected with railways that remains unsolved. It is, moreover, a matter that may concern slow at least as much as fast traffic. This was particularly impressed upon me once when I was travelling on the engine of an express train, and some rising gradients were encountered, which reduced the speed to about 35 miles an hour. At this speed, the period of time required to traverse one length of rail (*i.e.* go from one rail-joint to the next) must have corresponded to the periods of oscillation of the springs of this particular engine and tender, with the result that a very serious up and down motion set in between the two. The hind part of the engine kept rising and sinking three or four inches, while the front of the tender sank and rose about the same amount in the opposite direction. When the top of the hill was reached and the speed increased the oscillations almost disappeared.

A very carefully maintained line is the main line of the Paris-Lyon-Méditerranée. This

company use flat-footed rails. These rails weigh 97 lb. a yard. They are mostly laid in 12-metre (39 feet, 4 inches) lengths, but lately, in order to reduce the number of rail-joints, a good many 18 metres (59 feet) long have been employed, and experiments are even being made with 24-metre lengths (78 feet, 9 inches). The ballast is principally broken stone, but gravel is also used to a certain extent. Where the soil is impervious and clayey, very great benefit is secured by using a layer of clean sand or finely divided cinders under the ballast, as it is found that this prevents the soil from working into holes in which water could lodge. Where such a bottom layer is used, gravel ballast is the most suitable, as it does not cut into the sand or cinders as broken stone does. Each 12-metre length of rail rests on eighteen sleepers, between which and the rail are interposed steel plates, which spread the weight of passing trains over a greater area of sleeper than would otherwise be the case, and in this way serve one of the purposes of chairs. The ends of adjoining rails are fastened together by means of long fish-plates, each pair secured by six bolts.

The Paris-Orléans Company is one of those which employ bull-headed rails resting in chairs.

Though the trains are at least as fast and the weight of the rolling stock as great as on the Paris-Lyon-Méditerranée, the rails weigh only 86 lb. a yard ; this, as far as it goes, would tend to show that the chair road is by its form stronger than one laid with flat-footed rails. The ballast used by the Paris-Orléans is either gravel or sand from the river Loire. The principal objection to the latter kind of ballast is that it is extremely dusty. So troublesome was this that formerly the weeds used to be allowed to grow upon the line undisturbed, so as to prevent the dust from rising. At the present time the objection is, to a great extent, overcome by spreading a layer of pebbles over the sand. The greater part of the line is laid with rails 11 metres (36 feet, 1 inch) long, each resting on 14 sleepers. As on the Paris-Lyon-Méditerranée, however, the desirability of using longer rails has lately been recognized, and the standard length of rail has been increased to $16\frac{1}{2}$ metres, while, in extreme cases, rails 22 metres long are used. The strength of the joints has been increased by the introduction of fish-plates much longer than are generally used in conjunction with chairs. These fish-plates necessitate the use on either side of the joint of chairs with jaws wide enough to hold

both rail and fish-plates, thus introducing a certain complication, but the greater support given by the long fish-plates, and also the fact that this method of construction allows the sleepers on either side of the joint to be brought as close together as with flat-footed rails, much more than compensate for the increased complication of the arrangement. The keys used for securing the rails in the chairs are made of steel; they are found more satisfactory than wooden keys, which are liable to work loose in hot and dry weather.

The principal forms of signal employed are:

(1) The red and white chessboard, used at any place where it may be necessary for a dead stop to be made. This signal is a plate, whose surface is divided up into four squares of equal size, two of which are red and the other two white. It indicates "danger" when it is turned towards the advancing train; when in this position it may never be passed, even to the most insignificant extent. If the line is clear it is turned end on to the train. By night "danger" is shown by two red lights arranged diagonally and "line clear" by a white light. Fog signals are arranged to explode when a red and white chessboard signal is passed at "danger."

(2) The green and white chessboard, generally used as a distant signal before the red and white chessboard. This signal sometimes is made so as to give the same indications as the red and white chessboard which it precedes; sometimes

RED AND WHITE CHESSBOARD SIGNALS (NORD).

it is immovable and merely announces the fact that a red and white chessboard will be met with shortly. If less than the normal distance intervenes between this signal and the red and white chessboard which it announces, it is arranged diagonally.

(3) The single semaphore. A signal of this kind is the one ordinarily used at the entrance of each block section. The horizontal position by day and a red and green light by night indicate "danger"; when the line is clear the signal hangs vertically downwards in a line with the

SEMAPHORE, ETC. (NORD).

signal post, and by night a white light is shown. When the signal is at "danger" the train must stop, but may be authorized by the official in charge of the signal to proceed.

(4) The red disc signal. This signal is a round plate, painted red with a white edge. It

is moved in the same manner as the red and white chessboard. By night it shows a red light for "danger" and a white light for "line clear."

RED DISCS AND SEMAPHORES (P.L.M.).

When at "danger" it may be passed, but it indicates that the line is not clear ahead. On some lines, when the train has passed a red disc signal at "danger" it must always stop, after

proceeding cautiously far enough to come under the protection of this signal, but before reaching the first points or crossings, if any such exist; on other lines it is allowed to proceed without stopping, if called on by the signalman or station master. On the Nord there is an arrangement whereby, when a red disc is passed at "danger," the driver's attention is called to the fact by a whistle in the cab, which is set going by means of an electric contact.

(5) Junction semaphores. These consist of fish-tailed semaphores on a single post, in number corresponding to the number of directions in which it is possible to proceed. The top semaphore refers to the line most to the left, and so on. The semaphore corresponding to the line which the train is to take, points obliquely downwards, the others lie horizontally. The former shows a white light by night if no reduction of speed is necessary, otherwise a green light; the latter show violet lights.

On all the principal lines the block system is in use, each section being protected by a semaphore (3), preceded by a red disc signal (4). This latter is, however, not used merely to give the driver timely warning of the position of the semaphore, but of itself when at "danger"

necessitates a stop, subject to the conditions already described.

In other parts of the world the designers of locomotives have generally done their utmost to avoid complications of any sort, but the French

SIGNAL BOX AT THE GARE DE LYON.

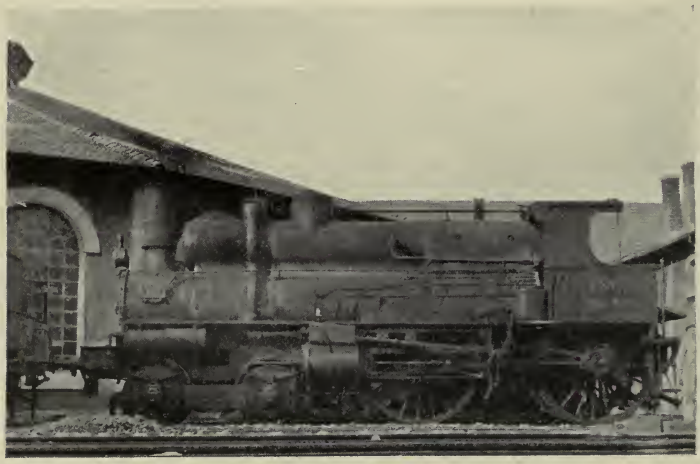
have always been more inclined to make experiments tending towards perfection than to devote themselves to the cult of extreme simplicity. So, while there is quite a remarkable similarity in general design among most modern French locomotives, especially those used for express trains, the four-cylinder compound system, on

which they are generally built, is not a particularly simple one. But this system has so many theoretical advantages that it is not surprising to find that it works with great efficiency in practice. The ordinary arrangement in use in France in both four- and six-coupled engines is to put two high-pressure cylinders outside the frames and two low-pressure cylinders inside, making the former drive the second and the latter the first pair of coupled wheels, thus dividing between two axles the effort which, in an ordinary two-cylinder engine, is transmitted through one. A further and far more important advantage is obtained with regard to the balancing of the moving parts. In an ordinary engine with two cylinders, the disturbing effect produced by the backwards and forwards motion of the pistons and piston-rods, which tends to make the engine swing from side to side, could be neutralized only by introducing complications, to which in practice recourse is never had. All that is done is to put weights into the driving wheels, which, while they diminish the tendency of the engine to swing from side to side, achieve this result only at the price of causing the driving wheels to exert a varying pressure on the rails, which is not at all good for either rails or wheels. In a four-cylinder engine,

built on the French system, it is an easy matter by a suitable arrangement of the cranks to ensure that the high- and low-pressure pistons on the same side of the engine shall, at any given moment, be moving in opposite directions, thereby balancing one another in a fairly complete manner and avoiding the disturbances to which the movements of the mechanism of a two-cylinder engine give rise. Then, in order to extract as much power as possible from the steam on its passage through the cylinders, not only do these engines use it in two sets of cylinders successively, but each set is provided with a complete reversing gear of its own, which enables the driver to vary the admission of steam into the two sets of cylinders independently of each other in the way which experience has shown him is conducive to the best results. There are also, as a rule, complete arrangements for working with high-pressure steam in the high-pressure or low-pressure cylinders alone, or in both sets together, and for admitting a certain amount of high-pressure steam direct into the low-pressure cylinders while the engine is still working as a compound. All these details, as well as others, such as the use of ribbed tubes in the boiler and the employment of mechanism for varying the size of the blast pipe orifice,

undoubtedly introduce complications into the design of these engines; but, in spite of this, the most satisfactory results are achieved with them.

The Nord were the first company definitely to adopt engines of this type, but within ten years all the other big companies had done the same,



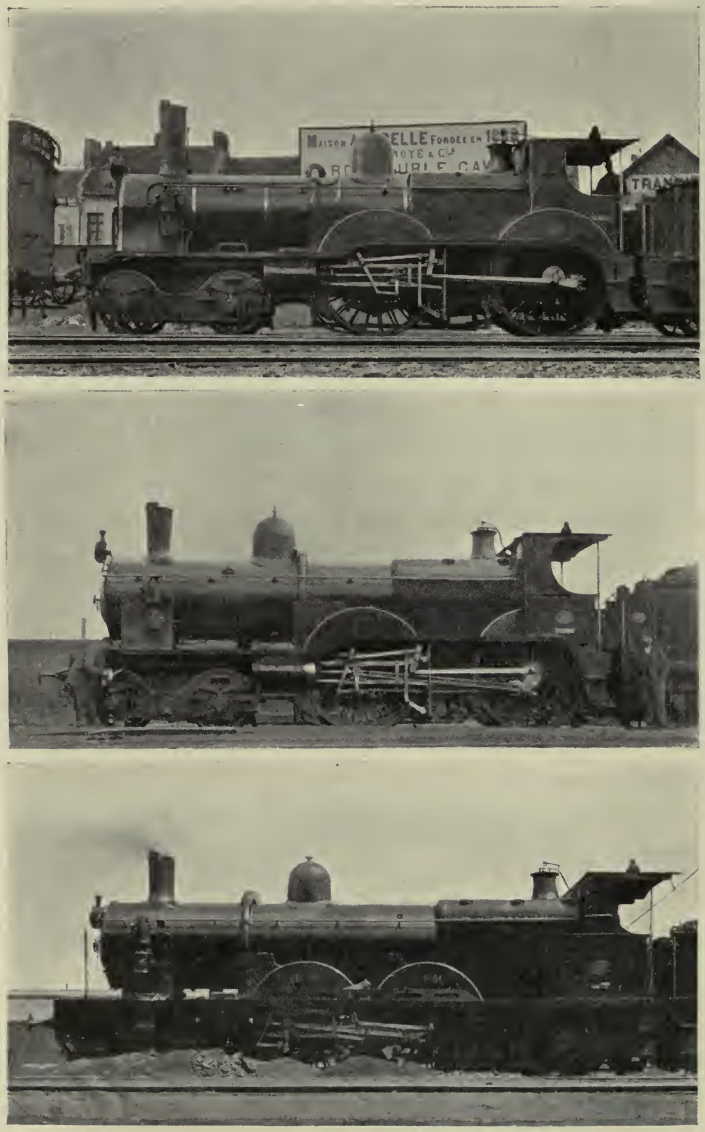
4-4-0 ENGINE WITH FLAMAN BOILER (EST).

and done it with so much uniformity that various other important features, such as the leading bogie and Belpaire firebox had been universally adopted in addition to the four-cylinder compound system. This is the more remarkable in that, except for the fact that they were all four-coupled, very wide differences existed between the express

engines used by the different companies immediately before the adoption of the compounds. The Nord had engines with inside cylinders, a leading bogie and outside frames (4-4-0). The Est engines, with the same arrangement of wheels (4-4-0), had outside cylinders driving the second pair of coupled wheels, inside frames and a special

2-4-2 ENGINE (P.O.).

type of boiler (Flaman) composed of two barrels—the lower one completely filled with tubes, and the smaller upper one for a steam space. The Paris-Orléans engines had outside cylinders placed well forward, driving the first pair of coupled wheels and a small pair of carrying wheels at either end of the engine (2-4-2). The Midi engines



THREE SUCCESSIVE TYPES OF FOUR-CYLINDER COMPOUND EXPRESS ENGINE (NORD).

had six wheels—four-coupled behind and the single pair of leading wheels (2-4-0) placed unusually far forward, well in front of the outside cylinders which drove the second pair of coupled wheels.

The latest express engines on the great French railways are now, in all cases (except for one or two new departures) four-cylinder compound engines with ten wheels ; the considerable diversity that existed not many years ago has been reduced to practically two standard types, and the only important difference between the two types is that the last pair of wheels are sometimes of small diameter and used only for supporting the trailing end of the engine (4-4-2), and in other cases of the same diameter as the two pairs of driving wheels and coupled to them (4-6-0). Though the number of designs which are built to at the present time is so few, there are of course a large number of the older engines of the most diverse types still in service as well as the eight-wheel four-cylinder compound engines with a leading bogie and four-coupled wheels (4-4-0), which were the immediate forerunners of the ten-wheel engines. The pressure of the steam in the compound engines is 14, 15, or 16 kilogrammes per square centimetre (199, 213, and 227 lb. per square inch).

The Paris-Orléans railway have lately introduced a new type of express engine, which, with a pair of wheels more than the express engines previously in use, is considerably bigger than any before seen in France. The power of an engine being chiefly dependent upon the amount of fuel that can be burned in a given time, and this, in

4-4-0 FOUR-CYLINDER COMPOUND EXPRESS ENGINE (P.L.M.).

turn, depending upon the area of the grate, the grates of these engines have been given an area of 46 square feet. The arrangement whereby this is effected is new. The front part of the grate lying between the last pair of coupled wheels has to be of the ordinary width, but the back part, which is not confined in this way, is made a good

deal wider and is spread out above the frames. The roof of the firebox being of the same width

4-6-2 FOUR-CYLINDER COMPOUND ENGINE (P.O.).

throughout, the sides are of rather peculiar form. These engines have a leading bogie, six-coupled

wheels, 5 feet, 11 inches in diameter, (some others have coupled wheels 6 inches bigger) and a small pair of trailing wheels (4-6-2). Without their tenders they are very nearly 44 feet long. Other lines also possess a few of the 4-6-2 type of engine.

The newest Nord express engine (No. 2.741)

NORD ENGINE 2.741.

is chiefly remarkable for the construction of the firebox, which is composed of a series of water tubes of small diameter, to which the water is conducted through large circulating pipes. Advantage being taken of the great strength of the water tubes, the steam pressure has been increased to 256 lb. per square inch. Except that

the trailing end of the engine is carried on a bogie instead of one pair of small wheels, the general arrangement is the same as with the 4-4-2 engines.

NORD ENGINE 2.741 (ANOTHER VIEW).

As with the passenger engines, the goods and tank engines of recent construction are generally much bigger than those which were built a few years ago. A considerable part of the goods traffic is worked by six-coupled four-cylinder compound

engines with a leading bogie and wheels of moderate diameter (4-6-0), which are also used for passenger trains. Several of the railways have adopted goods engines with much the same boilers as the biggest express engines, running on ten wheels, eight of which are coupled (2-8-0). The four-cylinder compound system is employed in these engines,

4-6-0 FOUR-CYLINDER COMPOUND ENGINE (EST).

but the low-pressure cylinders are outside the frames and the high-pressure inside, which is the opposite of the arrangement in the express and mixed traffic engines. These engines weigh over 70 tons ; they are not, however, quite the largest goods engines in France, several companies having some yet bigger machines. The first place is

occupied by some tank engines, employed by the Nord for working their share of the heavy traffic from the northern coalfields. These engines are also four-cylinder compounds, but their design is quite different from the type of four-cylinder compound usual in France. They run on sixteen wheels arranged in two eight-wheel bogies, each of which have six wheels coupled together. Two high-pressure cylinders drive the six-coupled wheels of the rear bogie and two low-pressure cylinders those of the front bogie. The high pressure and low pressure cylinders are arranged back to back. The great difficulty with an engine of this kind is the arrangement of the steam pipes, which have to be jointed or flexible, in order to allow for the movements of the bogies in relation to the body of the engine. The pipes leading the steam from the boiler to the high-pressure cylinders naturally offer the greatest difficulties, as the pressure of the steam is here highest. In some of these engines, the high-pressure steam pipe passes through the pivot of the bogie, where a single joint provides all the freedom of movement required. After the steam has left the high-pressure cylinders, its pressure is so much reduced that flexible pipes can be used for leading it to the low-pressure cylinders and

thence to the exhaust. The extreme length of these engines is nearly 53 feet; they weigh, when full of coal and water, about 103 tons, all but 20 of which rest upon the coupled wheels.

Tank engines, with four- or six-coupled wheels and a bogie at either end (4-4-4 or 4-6-4) enabling them to run equally well in either direction, are used in some cases for suburban traffic, where it is of importance to save the time which would be lost going to and from the turntable.

Lately, a good many engines have been fitted with superheaters. In France, as elsewhere, it is recognized that superheated steam possesses great advantages, principally in that a given amount of fuel will produce a greater volume of superheated than of saturated steam at a given pressure, and that superheated steam is a much more lively and active fluid than saturated steam. The steam, therefore, on leaving the boiler is led through small pipes lodged in the top rows of the boiler tubes (which are made specially large for the purpose), and in this way has its temperature raised before it does its work in the cylinders.

The difference between the appearance of an engine, in designing which care has been taken to avoid excrescences which offend the eye, and of another, on which no thought is given to form,

is very marked. As a pleasing outline costs no more than an ugly one, and as the efficiency of the engine is not perceptibly affected one way or the other, it is strange that the designers of locomotives do not give more uniform attention to this point. Though the exact features which conduce to beauty of form cannot be regarded as settled beyond dispute, it can hardly be contended that a big array of exterior pipes or a sandbox placed upon the top of the boiler are otherwise than ugly. In France, it has always been the custom to devote minute care to the design of all the different parts of the engines, till lately without giving much consideration to the appearance of the finished machine; the result is that many of the older engines look untidy and complicated. Upon the general outline of the newer engines more thought has been bestowed, and some of them (particularly upon the Nord, Ouest, and Paris-Orléans) have a really pleasing appearance.

The loading gauge of the French railways allows carriages about 10 feet wide and 14 feet high to be used. This gives the French designers appreciably more space than British designers have at their disposal, and in the construction of corridor carriages is a considerable

advantage. Up to a few years ago there were very few bogie carriages in France, and except

SIX-WHEEL CARRIAGE (P.L.M.).

EIGHT-WHEEL BOGIE CARRIAGE (P.L.M.).

the dining cars and sleeping carriages belonging to the Sleeping Car Company, most of the passenger

vehicles ran upon four or six wheels. Since then a large number of very fine corridor carriages running on two four-wheel bogies, a great advance in every way upon the stock previously in use, have been built to run on the express trains.

INTERNATIONAL SLEEPING CAR CO.'S CARRIAGES.

The reform dates from the year 1898, when the Ministry of Public Works issued a circular strongly recommending the adoption of corridor carriages. At the present time, the most elaborate vehicles in use are those which the Paris-Orléans Company

have lately built for the day expresses to and from Bordeaux (1st class only). These carriages are of various designs, some being of the ordinary corridor type, while others contain a large open smoking compartment provided with movable armchairs, and others a drawing-room reserved

TWELVE-WHEEL BOGIE CARRIAGE (P.O.).

for ladies. They are 77 feet long over buffers, and run on two six-wheel bogies ; much care and thought has been bestowed upon the internal decoration, which is carried out in a variety of different styles.

The brake most generally in use is some form

of the Westinghouse. The Paris-Lyon-Mediterranée use, in conjunction with the Westinghouse, a non-automatic arrangement, which enables the brake to be applied to any extent and without intermission during the descent of long banks. Some of the goods stock in use in France has the vacuum brake.

CHAPTER IV

On examining the running of the express trains on the different lines, remarkable differences are found, in spite of the engines being so much alike. The work done on the Nord, regarded as a whole, completely outdistances anything else to be found in France, and probably anything else to be found in any other part of the world either. The Paris-Orléans have got three good trains, two of them really fast, in each direction between Paris and Bordeaux, and the best trains of the Ouest, between Paris and Havre, are also fairly fast; but, except with these few trains, the work of the locomotives of neither of the two latter lines is at all remarkable as regards pace. When the Côte d'Azur expresses are running, the Paris-Lyon-Méditerranée are able to boast one really good day train in either direction between Paris and the Riviera, while at this time of the year also there are very creditable night trains between the same points. At other times of the year, the trains of this line are slower throughout. The Est have

accelerated a good many of their trains in recent years and now have a fair number of runs at over 55 miles an hour and one at as much as 58. The speeds of the Midi are quite moderate. (It must not be forgotten, however, that at one time the fastest trains in Europe used to run over this line till an accident took place, in which one of these trains, when travelling at full speed, left the rails with disastrous consequences. The cause of the accident was never made clear, but the speed of the fast trains was reduced to a very moderate level, at which it has remained ever since.) Beyond one good main line train either way, the services of the State railways are of no particular interest.

Far the best services are therefore those of the Nord; their superiority is not due to any physical advantage over other French lines possessed by the Nord, whose engines are, if anything, slightly less powerful than those elsewhere in use, while their gradients, although by no means severe, are quite as hard as those of the principal main lines of most of the other companies.

As the merits of trains must be judged by comparing them with others at present running, the services of the Nord may fairly be called

remarkable, though it must always be remembered that, so far as pure speed is concerned, no trains in Europe are timed at anything like the highest speeds which could be attained by present-day rolling stock over present-day lines. It is quite easy for a train of moderate weight to run at 70 miles an hour, start to stop, over any well laid line, so long as the places where it is necessary to slow down from motives of safety (sharp curves or big junctions) are not numerous and the gradients are not excessively severe. But in practice the very highest start to stop speeds at which the best trains in Europe are now timed is 60 miles an hour or a little more. A few such timings exist on the Nord, which is the only line in France where they are found at all, and the locomotive work in connection with them is the more remarkable for the fact that, if for any reason the trains are delayed, an appreciable amount of time is frequently made up even on the fastest booked runs. This practice of making up lost time is general in France, and, subject to a careful observance of all the speed restrictions, the drivers are encouraged to make it up to any extent and receive premiums for doing so. In order to attain the greatest possible measure of punctuality, some such system is an absolute

necessity. No matter how admirably a railway is managed, delays will sometimes occur, and, when this happens, the only possible way of setting things right again is to make up the time which has been lost. When it is remembered that the unpunctuality of one important train must disorder the working of a large number of others, whose movements are dependent on it and on each other, and must give rise to trouble and annoyance in greater or less degree to perhaps thousands of people, the desirability of making every effort, consistent with safety, to remedy such a state of things is apparent. With regard to safety, too, the making up of time has much to recommend it, as the more nearly in accordance with the time table the traffic is worked, the less likelihood is there of mistakes being made which might cause accidents to take place; this fact has been specifically recognized by the Ministry of Public Works.

The State railway alone, among the French lines, has laid down water troughs to enable the engines to take water while running, and in this manner they are able to run between Chartres and Thouars (147$\frac{3}{4}$ miles) without a stop. Of the other lines only two—the Nord and the Est—possess trains running as much as 100 miles without

a stop, the Nord performing the Paris-Abbeville (109¼ miles), Paris-Busigny (112 miles), Paris-Arras (119¼ miles), Calais Pier-Amiens (103½ miles) and Calais Town-Amiens (102 miles) runs, and the Est those between Paris and Troyes (103¾ miles), Chaumont and Belfort (112½ miles) and Paris and Chalons (107 miles). The tenders used with the biggest express engines usually carry about 4,400 gallons of water, which, with a heavy train under adverse conditions, is sometimes barely enough for a run of 120 miles.

Some years ago the Nord were seriously considering the question of laying down water troughs, and at least one batch of engines were given tenders fitted with a water scoop. When, however, it came to the point, the question of expense seems to have stood in the way, and the troughs were given up. If they had been laid down it was hoped that the run between Paris and Calais would be performed without a stop in three hours, and, good as the Nord express trains are, they would, no doubt, be better still if the troughs existed.

Besides the speed of the trains, their frequency and the facilities given to 2nd and 3rd class passengers have to be considered. The number of trains, and particularly express trains, is much

smaller in France than it is in Great Britain—indeed for working a considerably greater total length of line there are little more than half as many locomotives. Practically none of the Rapides admit 3rd class passengers, the State

A STATION SCENE.

railway being the only line on which all trains are open to them. The Midi, indeed, take 3rd class passengers in all their trains except the trains de luxe, but the speeds of the fastest Midi trains are very poor. The fastest trains on the Nord and Est (trains de luxe always excepted)

take 2nd class passengers, but on the Paris-Lyon-Méditerranée, Paris-Orléans, and Ouest they are generally excluded.

In this connection we may examine more closely the services from Paris to three large towns situated in different directions—Lille on the Nord, Bordeaux on the Paris-Orléans, and Lyon on the Paris-Lyon-Méditerranée.

The distance from Paris to Lille is 156 miles. The fastest train takes 2 hours 54 minutes, another takes 2 hours 56 minutes, and two more 3 hours. There are two others in less than 4 hours and five more of varying degrees of slowness. Second class passengers are admitted to all the trains and 3rd class to all but the four fastest. There are thus four trains at 52 miles an hour or over.

The Paris-Orléans run nine through trains a day from Paris to Bordeaux (363 miles from the Quai d'Austerlitz to Bordeaux St. Jean, to which station all the good trains run direct). The two fastest (one of them the Sud express, a train de luxe), take only 1st class passengers and occupy 6 hours 43 minutes (54 miles an hour) and 7 hours 11 minutes, respectively, over the journey. There is one other Rapide taking 7 hours 53 minutes, which admits 2nd class passengers only if they are travelling beyond Bordeaux, and four other

trains taking passengers of all classes (3rd class only if travelling a certain minimum distance) and performing the journey in from eight and a half to ten hours.

There are about nine trains a day (winter timing) on the main line of the Paris-Lyon-Méditerranée that will take passengers from Paris to Lyon (318 miles). The fastest, a train de luxe (1st class only), performs the journey in eleven minutes less than 7 hours, but as it arrives at Lyon at 2.44 a.m., it is unlikely that passengers for that city make much use of it. The same remark applies to the next fastest train, the 9.20 p.m. from Paris (1st class only), arriving at Lyon at 4.33 a.m., and to the 7.25 p.m. (1st, 2nd, and 3rd class) arriving at 3.11 a.m. For practical purposes these trains need hardly be considered. After eliminating them and another which, stopping at every station, takes about 18 hours over the journey, there remain five trains only, the fastest of which, the 9.10 a.m. (1st class only) takes 7 hours 50 minutes to reach Lyon—just $40\frac{1}{2}$ miles an hour. Second class passengers can reach Lyon in 8 hours 15 minutes by the 2.25 p.m. from Paris, and 3rd class passengers, by travelling through the night by the 10.35 p.m., in 9 hours 5 minutes. The service between Paris and Lyon

is not nearly so good as that between Paris and the Riviera. The fastest train to the Riviera, the Côte d'Azur Rapide, which does not take Lyon passengers, leaves Paris ten minutes before the 9.10 a.m. express (which is, to all intents, the fastest train from Paris to Lyon), and, making the same stops of only three minutes shorter duration, reaches Lyon 107 minutes in front of the 9.10. Lyon can also be reached from Paris by another Paris-Lyon-Méditerranée route, but the facilities offered by this route are very poor.

So the total number of trains to these three important centres is far fewer than would be found between London and almost any big town in England, particularly if the latter is, as is generally the case, served by more than one company. To Lille and Bordeaux the speed of the best trains is very good, but to Lyon the speed of the fastest train is poor; and the Nord, which run the best trains, also treat 2nd and 3rd class travellers the best. Whether the amount of energy saved by running few trains, as compared with the numbers run under the semi-competitive system in force in England, more than counterbalances the lesser facilities for travel offered to the public, is a question which French railway managers must consider for themselves.

If we try to draw conclusions as to the desirability or otherwise of competition by comparing the services of the French railways, where competition is generally impossible, with those of English lines, where it is generally possible, we find that it is difficult to arrive at any which are at all definite. The French system, by rendering each company independent of every other company, leaves it comparatively free to give a good or a bad service as it thinks fit; the British system, on the other hand, ensures that the different lines running between the same places shall all give fairly equal services in order to retain their respective shares of the traffic; but, while this tends to prevent the services of any one company from being really bad, it tends also to induce the different companies to make agreements with one another to the public detriment not to accelerate trains, and sometimes even to reduce their speed. That the fastest trains from London to Aberdeen should take appreciably longer to perform the journey now than they took in the year 1896, is a most unsatisfactory result of the British system. In fairness, however, it must be said that, though speeds are still far lower than they might be, the express service over a large part of England has been accelerated

during recent years, and that cases of actual deterioration are not very numerous. It will be interesting to watch what the effect will be upon the passenger service of the closer agreements with one another into which so many of the British railways have entered.

Rail motors, which have lately been so widely

RAIL MOTOR (P.O.).

adopted in England, are not nearly so much used in France, and when they are used it is for the service of small branch lines in country districts. As rail motors take as much time as whole trains to pass over a block section and only carry quite a small number of passengers, the French companies appear to think that their use on crowded

lines in the neighbourhood of large towns is not economical.

The fixing of rates and fares is always rather an arbitrary business. The correct principle on which to arrange them would appear to be that each separate tariff should cover the actual expense involved and yield the same percentage of profit. In practice, of course, it is impossible to graduate tariffs with such accuracy. The most that is done with regard to passenger fares is in effect to give a reduction on a quantity by issuing season tickets and granting cheap fares to persons travelling in great numbers, as, for instance, in suburban trains. Goods rates can be, and are, more finely graduated than passenger fares, and in many cases probably represent with considerable exactness the actual cost of the work done together with a fair profit. The principle, however, of " charging what the traffic can bear " also enters in, and there is no doubt that in certain cases more expensive goods are charged more highly, in proportion to the cost of moving them, than less expensive ones—in other words certain classes of goods are subsidized at the expense of certain other classes.

The regular single fares for 1st, 2nd, and 3rd

class (including a Government tax of 12 per cent.), are 11.2, 7.56, and 4.928 centimes a kilometre (1.72, 1.17, and 0.76 pence a mile, if 25 francs are taken as being equal to £1). For 1st class return tickets the fare is ordinarily 25 per cent. less than double fare, and for 2nd and 3rd class tickets 20 per cent. less. Children under three travel free, between the ages of three and seven half price. Thirty kilogrammes (66 lb.) of luggage are allowed for each full ticket, 20 kilogrammes for each ticket issued at half price. Excess luggage up to 40 kilogrammes is paid for at the rate of 50 centimes per ton per kilometre, and after that at 40 centimes per ton per kilometre. Season tickets (1st, 2nd, and 3rd class) are issued by the different companies at prices varying to a certain extent between one line and another. For a ticket between two stations 100 kilometres (62 miles) apart, available for three months, the Nord charge francs 266, 200, and 133 for the three classes, the Paris-Orléans francs 301, 226 and 166. Suburban season tickets are, as a rule, proportionately cheaper than others. If more than one member of the same household takes a season ticket, a certain reduction is made on each ticket after the first, and to school-children and students season tickets are issued at half price.

The goods traffic falls into two divisions—grande vitesse (express goods) and petite vitesse. The basis on which ordinary rates are arranged is that each rate per ton per kilometre is uniform up to a certain distance, which varies according to circumstances, and then for the succeeding length of so many more kilometres is again uniform, but less per ton per kilometre than for the first stage of the journey, and so on. There is one general rate applicable to grande vitesse goods traffic. If the consignment does not weigh more than 40 kilogrammes, the charge per ton per kilometre is 35 centimes for the first 200 kilometres, and 32 centimes for each further kilometre up to 300, with further progressive reductions till, after 1000 kilometres, it becomes 25 centimes per ton per kilometre. For consignments of more than 40 kilogrammes the rate per ton per kilometre up to 100 kilometres is 32 centimes, and it falls progressively till it becomes 14 centimes per ton per kilometre after 1100 kilometres. A special reduction is made in the case of consignments of provisions weighing over 40 kilogrammes, which pay three-quarters of the last-named rate. Each consignment of goods sent by grande vitesse pays a registration fee of 45 centimes.

For the purposes of petite vitesse traffic, all

kinds of goods are divided into six classes, to each of which a separate rate is applicable, the rates for class 1 being the highest and for class 6 the lowest. These rates are not exactly the same on all the different lines, but they are all arranged on the same general principles as grande vitesse rates. To take two examples: the rate charged by the Paris-Lyon-Méditerranée for goods coming under class 1 is 16 centimes per ton per kilometre for any distance up to 100 kilometres; for the part of the journey between 100 and 300 kilometres it is 15 centimes per ton per kilometre; between 300 and 500 kilometres it is 14 centimes; and it then decreases by 1 centime per ton per kilometre for every further length of 100 kilometres. The rate on the Paris-Orléans for goods in class 6 is 8 centimes per ton per kilometre for the first 25 kilometres; 4 centimes per ton per kilometre for the succeeding 75 kilometres; $3\frac{1}{2}$ centimes for each kilometre between 100 and 300; 3 centimes for each kilometre between 300 and 600; and after that $2\frac{1}{2}$ centimes.

For valuables, light bulky objects, explosives and objects of great size, certain exceptions are made to the ordinary scale of rates.

All petite vitesse consignments of less than 40 kilogrammes pay 25 centimes per ton per

kilometre, with the reservation that the total payment cannot be greater than would be due on a consignment of the same kind weighing more than 40 kilogrammes.

Besides the charge for the actual transport of the goods, there are certain supplementary payments which must be made. A registration fee of 80 centimes is levied on each consignment sent by petite vitesse. When the loading and unloading are done by the railway, 1.50 francs per ton (or 1 franc per ton for consignments of more than 4 tons), is charged for these services and terminal fees together ; if the loading or unloading is performed by the sender or consignee, certain reductions on this charge are granted. A fee at the rate of 40 centimes a ton is payable on any consignment of goods weighing more than 40 kilogrammes when it passes from one line to another.

Two clear days are always given the railways to deliver a consignment sent by petite vitesse, and on the more important routes the rule is that if the distance exceeds 200 kilometres, one day more is added for every further 200 kilometres or part thereof. Goods sent over more than one railway are given longer than this.

At large or moderate sized centres, the railways are prepared to undertake the collection and delivery of goods in consideration of a suitable payment.

Besides the six classes of ordinary rates, special rates are granted by the railways in the cases of a very large number of articles, either over the whole line of one railway, or jointly over more than one line, or between certain specified points, and conditions are generally added, such as that a minimum load be despatched at a time and be sent some minimum distance, or that delivery may be delayed beyond the ordinary period. These rates are often very much lower than the ordinary rates. They are sometimes arranged on the same general plan ; for instance, one of the rates of the Est is 4 centimes per ton per kilometre up to 25 kilometres, 3 centimes thence to 50 kilometres, $2\frac{1}{2}$ centimes from 50 to 100 kilometres, and after that 2 centimes. Sometimes the total charge for a minimum distance is laid down, and after that the rate per kilometre for any further distance ; in this way the Ceintures, Est, Nord, and Paris-Lyon-Méditerranée carry coal for francs 9.40 per ton for a distance of not less than 300 kilometres, and after that for $1\frac{1}{2}$ centimes per ton per kilometre. In other cases, a rate is

available only between two fixed points, and the total charge for the whole distance only is given. Persons sending goods from or to stations situated between two fixed points are allowed to pay the full amount of these rates instead of the ordinary rates, if they gain thereby ; and, as a general rule, goods despatched by a route, over only part of which some special rate is available, are for that part of their journey given the benefit of this special rate.

Certain special transit rates are granted in the case of goods crossing French territory by specified routes. French goods of the same kind, intended for export, if despatched from a point on one of these routes, or, if the total distance is not greater, from one within 50 kilometres on either side, can claim the benefit of these rates.

In the special rates, the various fees supplementary to the actual transport charge are sometimes included and sometimes not, according to circumstances ; they are not always the same as for goods sent at ordinary rates.

With regard to live stock, the maximum rate for large animals (oxen, horses, etc.) sent by petite vitesse, is 10 centimes a kilometre ; for middle-sized animals 4 centimes ; and for

sheep and goats 2 centimes. Certain terminal fees are also charged. If sent by grande vitesse the rate is 60 per cent. greater than this for large animals, otherwise 50 per cent. greater.

CHAPTER V

Though it is true that trains of moderate weight could be run a good deal faster than any trains are at present timed, the considerable weight of some of the best expresses, together with the fact that time often has to be made up, may give the engines really hard work to do.

One of the best trains in France is the evening express from Paris to Lille. This train has since been retimed, but for several years it used to leave Paris at 5.25 p.m., and, with three intermediate stops, reach Lille—156 miles—at 8.15 p.m. I saw some very interesting work done with this train between Paris and Arras by engine No. 2.668 ; she is one of the latest built of the ordinary Nord express engines—a four-cylinder compound with a leading bogie, four-coupled wheels, 6 feet $8\frac{1}{4}$ inches in diameter, and a small pair of wheels under the footplate (4-4-2) ; the safety valves blow off at 227 lb. per square inch. She differs only slightly from the first engines of this type, which the Nord, the first of all the French

railways, adopted in 1900, and of which they now possess thirty-five.

On the evening in question, the weather was fine and there was little wind, so the conditions were favourable; but the train, composed as it was of six big corridor carriages, a dining-car and a luggage van, and being moreover full, was no light weight to haul at the speed at which it must run. The French railways compute the weight of the trains very carefully, so the guard was able to inform us that the weight of our train, counting passengers and luggage, was 261 metric tons (say 257 English tons). The weights of the engine (nearly 65 tons) and tender (nearly 42, when full of coal and water at the beginning of its journey), are not included in the guard's computation, so the total moving weight as the train drew out of the Gare du Nord was over 360 tons. The Nord line leaving Paris runs for the first three miles downhill, thereby enabling the train rapidly to gain speed by the help of gravity. Only after full speed is attained is the long bank entered upon by which the train climbs to a summit which is reached just beyond the 27th kilometre post from Paris, between the stations of Louvres and Survilliers. So rapidly did the engine get into speed that kilometre post 11 was passed in

8 minutes 37 seconds from the start, in spite of the fact that the line had already for some distance been on ascending gradients, and after this the whole way to the top of the bank the pace averaged rather over 61 miles an hour, varying only slightly from kilometre to kilometre. The gradient is 1 in 200 nearly all the way, and if the resistance of the train corresponded to the generally accepted tables, the engine must, during this time, have been exerting more than 1500 horse-power. About post 28 the line begins to fall, the descent continuing all the way to Creil. Here very high speeds could be reached, but the permanent way engineers do not like high speeds and the drivers are forbidden materially to exceed 120 kilometres (74½ miles) an hour. No. 2.668 is fitted with a speed indicator to show the driver when this speed has been reached. Through the station and junction of Creil we slowed down, as all trains must do, and then a few miles further on were brought to a stand by an adverse signal, having run 55·6 kilometres (34½ miles) in 35 minutes 14 seconds. As the time allowed for the 78¼ miles from Paris to the first booked stop at Longeau was only 78 minutes, it was now necessary to run well over a mile a minute the rest of the way to ensure a punctual arrival at that station.

Starting again, after we had remained standing three-quarters of a minute, we had in front of us 30 kilometres of generally rising gradients, the ascent at first being gradual, but for the last two-thirds of the distance averaging at least 1 in 300 (and, as compared with a level line, adding about 40 per cent. to the work of the locomotive). Five kilometres from the fresh start we were already making 60 miles an hour; we continued still to gather speed for some distance more on the easier gradients, while the more severe ascent, encountered on the last 20 kilometres before the summit, sufficed to reduce the pace only a little. The regulator was wide open, as is usual with these engines when running uphill, steam was cut off in the high-pressure cylinders at 52 (and towards the top of the bank 53) per cent. of the stroke, and in the low-pressure cylinders at 65 per cent.; but though this meant that we were using steam very fast, the skilful work of the fireman enabled the boiler fully to meet all the demands made upon it. When the summit was eventually passed, it appeared that the average speed up the preceding twenty kilometres had been as nearly as possible 65 miles an hour. Hence to Longeau is a nearly continuous descent, down which we ran easily at something over 75 miles

an hour, and we drew up eventually in Longeau station 43 seconds before time, having performed the run of 43¾ miles from the signal stop at 63¾ miles an hour. After a five minutes' stop, during which the tender was filled up with water, we started off again on the 41-mile run to Arras, for which 42 minutes were allowed. We had not, however, gone many hundred yards before we were stopped by another adverse signal, which caused us altogether a delay of three minutes. When we finally got away it did not take long to get into speed and along an undulating stretch of line, with, however, a distinctly rising tendency, we kept up an average pace of exactly 70 miles an hour. The fire having by this time got a little dirty, the blast pipe orifice had been slightly reduced to increase the draught, without perceptibly impairing the work of the engine. From about kilometre post 148, the line rises more steeply, the gradient, as the summit is approached, being 1 in 200, and the speed gradually fell, but nowhere to appreciably less than 60 miles an hour. After this there are no more difficulties, and 15 kilometres of generally falling gradients brought us to Arras, where we arrived in 42 minutes 35 seconds from Longeau; but the time from the fresh start after the signal stop was only 39

minutes 13 seconds, so we had come thence at over 62 miles an hour, start to stop. We had thus performed two runs of little over 40 miles each at well over a mile a minute with by no means a light train, and without running nearly so fast downhill as we could have run. The driver and fireman were certainly very competent men, but performances of this kind are not exceptional on the Nord.

It may be interesting to give by way of comparison an account of the running of one of the best Nord trains in 1899, the year preceding the introduction of the ten-wheel express engines now in use. The train in question was the Nord express ; it weighed 140 tons exclusive of engine and tender ; the engine was No. 2.163, a four-cylinder compound with four-coupled wheels, 7 feet in diameter, and a leading bogie (4-4-0). This train was, at that time, allowed 102 minutes to perform the run of a little over 95 miles from Paris to St. Quentin. As far as Creil the line is the same as that taken by the Lille trains ; after this it is nearly level for about 47 miles, it then rises at 1 in 333 for 12 miles, and for the last 5 miles into St. Quentin descends, also at 1 in 333. After a cautious start, owing to work that was in progress on the line, we traversed

18 kilometres from post 8 (almost all uphill at 1 in 200) in 11 minutes 2 seconds, which is equal to 60·7 miles an hour, and were then stopped by signal, which fate again befell us just beyond Creil station, near post 51 ($31\frac{3}{4}$ miles). For all that we started off for the third time, 36 minutes 21 seconds after leaving Paris, and eventually reached St. Quentin only 17 seconds late, having done the last $63\frac{1}{2}$ miles, start to stop, in 65 minutes 56 seconds, though we lost quite two minutes on the way through having to cross over on to the up line for a mile or two where the down line was being relaid. In one place we ran 13 kilometres in 6 minutes 59 seconds (69·3 miles an hour), along a practically level road.

Reverting to the subject of the 4-4-2 type of Nord engine, it may be interesting to record a remarkable hill climbing performance by one of these machines—No. 2.656. This engine was working one of the Paris-Calais expresses, which, on the day in question, weighed 295 tons exclusive of engine and tender. Ordinarily good work was performed up to Boulogne, passing which place we were 6 minutes late owing to various delays which we had suffered. Thence to Calais is very much the hardest part of the Nord main lines, this section being almost entirely on rising or

falling gradients of 1 in 125; but, in spite of this, so admirably did the engine perform that the train arrived at Calais Pier at the right time. In one place, for 10 kilometres, beginning at about post 268, there is a continuous rise of 1 in 125 (except for a few hundred yards about a quarter of the way up), and it was here that the most remarkable work of all was done. The ascent was entered on at a speed of something over 75 miles an hour, and the 10 kilometres ($6\frac{1}{4}$ miles very nearly) were traversed in 6 minutes $22\frac{2}{5}$ seconds; for no single kilometre was the speed less than 51 miles an hour. The times of passing the 11 kilometre posts were as follows (from Abbeville):

Posts.	Minutes.	Seconds.
268	56	$20\frac{2}{5}$
269	56	51
270	57	$23\frac{4}{5}$
271	57	$57\frac{4}{5}$
272	58	34
273	59	12
274	59	$51\frac{2}{5}$
275	60	$32\frac{3}{5}$
276	61	$15\frac{2}{5}$
277	61	$59\frac{1}{5}$
278	62	$42\frac{4}{5}$

On one occasion another of the 4-4-2 Nord engines, on which I was travelling, after getting into speed, covered rather more than 70 miles in

the level hour: the load behind the tender was 172 tons.

After witnessing performances of this kind, the question naturally suggests itself—"What is the expenditure of fuel required to effect them?" The answer is that during December, 1906, the average weight of fuel (of only fairly good quality) burned per mile by the whole of the engines of this class (4-4-2) was 49¼ lb., and in the following June, when the weather conditions were more favourable, it was 45¼ lb. It must be remembered that the average weight of all the trains may be taken as 275 tons (exclusive of engine and tender), and that the average speed was probably rather over than under 55 miles an hour.

The new 4-4-4 engine with the water-tube firebox, No. 2.741, did work perhaps superior to any of the older engines. With 298 tons behind the tender she attained 74½ miles an hour on the level, and, with the same train, up the 8-mile bank from Etaples, the last 3 miles of which are at 1 in 133, she did not get below 56¾ miles an hour.

Some of the express trains on the Nord, which stop frequently, are worked by six-coupled engines with wheels 5 feet 9 inches in diameter (4-6-0). That these engines are by no means unable to

run fast was made apparent by one of them—No. 3.515—with a load of 305 tons, attaining a

4-6-0 FOUR-CYLINDER COMPOUND ENGINE (NORD).

speed of 73·6 miles an hour down the bank of 1 in 200 between Survilliers and Paris. But,

as was to be expected, though the engine was in first-rate order and ran with great smoothness, she did not reach this speed so easily as the 4-4-2 engines with bigger driving wheels.

On the other French railways, I have never seen anything at all approaching the best work done on the Nord. The fastest booked run of the Sud express on the Paris-Orléans, that from Les Aubrais to St. Pierre, where 72 minutes are allowed for the exceptionally easy length of 69½ miles, I have twice seen done in rather less than the booked time, and on other occasions have been with the trains when start to stop runs of between 55 and 58 miles an hour have been performed. But when I have been present, the loads have always unfortunately been very light. Perhaps the best run on the main line, in which I have taken part, was from St. Pierre to Les Aubrais, with engine No. 3004 (a 4-4-2 machine with 6 feet 8¼ inch wheels), and a load of 213 tons behind the tender. The line is appreciably harder than it is in the opposite direction, as in this direction it ascends the valley of the Loire. The 69½ miles occupied 76 minutes 40 seconds, the usual slack taking place past Blois and ¾ of a minute being lost owing to a signal delay outside Les Aubrais. Along one stretch of 24 miles, where

the line, though nearly level, has a slightly rising tendency, the average speed was 61 miles an hour, but the engine being a very big one, considerably bigger than the Nord engines of the same type, was probably exerting not much more than half her full power. The running of this big engine was admirably smooth.

The Toulouse line of the Paris-Orléans is a great contrast to the main line, the gradients being very severe. The new six-coupled engines with twelve wheels (4-6-2) are used for working the express trains over this line. Early one morning I came from Brive to Limoges on one of them working the 12.29 a.m. train. After falling for a few miles out of Brive, the line ascends for 30 miles on gradients which average 1 in 145 throughout, and are frequently 1 in 100. Here also fairly sharp curves are almost continuous and add considerably to the resistance of the trains. On the night in question our train was composed of 23 vehicles of various descriptions, and weighed 390 tons, exclusive of engine and tender. We stopped at Allassac, three stations from Brive, but the $50\frac{1}{2}$ miles thence to Limoges are run without a stop. After we had got into speed we traversed the $28\frac{1}{2}$ kilometres between the stations of Estivaux and Masseret in 29 minutes 20 seconds,

which is 36½ miles an hour. Steam was cut off at 55 per cent. in the high-pressure and at 65 per cent. in the low-pressure cylinders, and the regulator was half open or a little more. The fireman was kept hard at work putting on, at frequent intervals, charges of about sixteen shovels each of fuel consisting chiefly of briquettes. Once over the top of the hill, we dropped easily down the other side, never reaching so high a speed as 60 miles an hour, and we reached Limoges 74 minutes 7 seconds from the start, having saved about 5 minutes on the booked time. The engine ran very smoothly.

On the Est one of the eight-wheel compounds ran 36 miles with a light train in 37 minutes 57 seconds, start to stop, and another did the 112½ miles from Belfort to Chaumont with 150 tons in 126 minutes 56 seconds, saving 10 minutes in spite of one severe slack. In both these cases the engines must have had a very large store of reserve power.

The six-coupled express engines did considerably better. No. 3124, with 170 tons, was stopped 51 miles out of Belfort, after a long slow down, in 54 minutes 28 seconds, and No. 3131, with 200 tons, did the whole 112½ miles to Chaumont in 117 minutes 43 seconds. We began this

latter run very gently up the ascent of 1 in 200 out of Belfort, then traversed the long descent from the summit tunnel to Vesoul at high speed, several times reaching 120 kilometres an hour. Here a slack takes place, and for the next 50 miles the line is mostly on rising gradients as far as the tunnel between Chalindrey and Langres, whence it falls most of the rest of the way to Chaumont, some 10 miles before which station we had to slow down to 10 miles an hour. No. 3108 on the 10.10 p.m. (now 10 p.m.) from Paris reached Troyes (103¾ miles) in 114 minutes 18 seconds with 300 tons. (This section of the line undulates fairly steeply—sometimes the gradients are as much as 1 in 166—for the first 60 miles, and then rises gently to Troyes, which lies at an appreciably higher altitude than Paris.) Another engine took the same train from Chaumont to Belfort in 125 minutes 22 seconds, saving more than 5 minutes on the booked time.

The best work I have ever seen done by an Est engine was not done on the Est line at all, but on the Nord. The Nord had borrowed from the Est one of their six-coupled express engines (No. 3152) in order to observe the working of the superheater with which this engine is fitted. No. 3152 was working the boat train due to leave

Calais at 1.15 p.m. and reach Paris at 4.45 p.m. We actually got off at 1.26½ p.m.—11½ minutes late. We had 277 tons behind the tender. Owing to the sharp curves which exist for the first mile or two we could not at once begin to run hard, and we took 6 minutes 18 seconds to pass post 292, 5·3 kilometres from the start. Hence to post 290 there is a piece of level line, on which the speed rose to nearly 60 miles an hour, but then come 11 kilometres of 1 in 125 to post 279, unbroken except for a few hundred yards at 1 in 400 past the station of Fréthun, between posts 288 and 287. Kilometre 290–289 occupied 40 seconds, and on the whole ascent no kilometre took more than 44⅖ seconds, so that the speed was nowhere less than 50¼ miles an hour. The following are the times reckoned from the start:

Posts.	Minutes.	Seconds.
290	7	47⅖
289	8	27⅖
288	9	9⅕
287	9	52
286	10	34⅘
285	11	17⅘
284	12	1⅘
283	12	45⅗
282	13	28⅘
281	14	13
280	14	56⅘
279	15	41⅕

Downhill 74½ miles an hour was soon reached, and then steam was shut off most of the rest of the way to the bottom of the descent. Six kilometres from post 274 were run in exactly 3 minutes. The way in which the speed kept almost absolutely constant down 1 in 125 with only a very little help from the boiler for a short

EST ENGINE 3152.

part of the way gives a good idea of the resistance of the train, which must under these circumstances have been a little more than 18 lb. a ton. With steam on the resistance no doubt increases a little, so the generally accepted figure of about 22 lb. a ton at 75 miles an hour must be about right.

One kilometre at the bottom of the descent was run in $29\frac{1}{5}$ seconds ($76\frac{1}{2}$ miles an hour), the regulator here being well open. This was the highest speed which we reached.

EST ENGINE 3152 (ANOTHER VIEW).

Along the undulations to Boulogne and the fairly level stretch which follows, we ran most of the way in the region of 70 miles an hour, 18 kilometres from post 265, taking 10 minutes, and

up the succeeding ascent of 4 miles at 1 in 140, the last kilometre wholly uphill (240–239) took $40\frac{4}{5}$ (not quite 55 miles an hour). Downhill to Etaples the speed soon rose to very near the limit, but for some reason sank slightly below 70 miles an hour for a mile or two just past that station. Then, however, when we were well on to the level we began to run really hard. The regulator was wide open and steam cut off at 58 and 68 per cent. We reached 70 miles an hour at about post 223, and from this point the next 45 kilometres were run at 72 miles an hour. The line is practically level the whole way, generally dead level. The speed varied very little, but for 10 kilometres from post 198 was slightly higher than the average. The times for this piece were (from Calais):

Posts.	Minutes.	Seconds.
198	60 ..	9
197	60 ..	$39\frac{1}{5}$
196	61 ..	$9\frac{2}{5}$
195	61 ..	$39\frac{3}{5}$
193	62 ..	$39\frac{4}{5}$
192	63 ..	10
191	63 ..	$40\frac{1}{5}$
190	64 ..	$10\frac{1}{5}$
188	65 ..	$10\frac{3}{5}$

The average speed for these 10 kilometres was thus 74·1 miles an hour.

We passed Abbeville, $75\frac{3}{4}$ miles from the start, in a few seconds less than 72 minutes. During all this hard running the fireman, although fairly well occupied, was by no means overworked. Neither was the fuel of specially good quality, containing as it did a lot of quite small stuff. It was mostly put on behind, about six or eight shovels at a time. The temperature of the superheated steam was about 320° centigrade. At Abbeville we were about punctual, so after this we did not run so hard on to Amiens, in which station we drew up 99 minutes 44 seconds from Calais ($103\frac{1}{2}$ miles), having done the whole run $13\frac{1}{4}$ minutes under time.

At Amiens we overstayed our time by a couple of minutes, and starting off again took things rather easily for a time and also lost several minutes through the permanent way's being under repair in one place. From post 104, however, 17 kilometres, where the gradients average about 1 in 350 against the train, were run in 9 minutes $34\frac{2}{5}$ seconds, which gives an average speed of $66\frac{1}{4}$ miles an hour. The regulator was wide open and the cut-offs 60 and 68. Downhill towards Creil we were slacked before Clermont, and passed post 51, 50 miles from the start, in 54 minutes 17 seconds. From post 48 to

post 28 the line rises all the way, and is very nearly all at 1 in 200. Here we again began to run hard, and accomplished these 20 kilometres in 12 minutes $15\frac{3}{5}$ seconds, which gives an average of just under 61 miles an hour. This was

P.L.M. FOUR-CYLINDER COMPOUND EXPRESS ENGINE 2608.

about as good as anything we had done. The times were (from Amiens):

Posts.		Minutes.		Seconds.
48	.. .. ..	56	..	$17\frac{3}{5}$
46	.. .. ..	57	..	31
45	.. .. ..	58	..	$8\frac{2}{5}$
44	.. .. ..	58	..	$45\frac{1}{5}$
43	.. .. ..	59	..	$23\frac{1}{5}$
42	.. .. ..	60	..	$0\frac{1}{5}$
41	.. .. ..	60	..	$36\frac{1}{5}$
40	.. .. ..	61	..	12

Posts.		Minutes.		Seconds.
39	.. .. ..	61	..	$47\frac{2}{5}$
38	.. .. ..	62	..	$23\frac{2}{5}$
37	.. .. ..	62	..	$59\frac{4}{5}$
34	.. .. ..	64	..	$50\frac{4}{5}$
33	.. .. ..	65	..	28
32	.. .. ..	66	..	$5\frac{1}{5}$
31	.. .. ..	66	..	$42\frac{4}{5}$
30	.. .. ..	67	..	20
28	.. .. ..	68	..	$33\frac{1}{5}$

P.L.M. FOUR-CYLINDER COMPOUND EXPRESS ENGINE 2608 (ANOTHER VIEW).

After this, nothing particular happened. We were slacked about post 24, and eventually drew up in the Gare du Nord 2 minutes early—88 minutes 14 seconds from Amiens ($81\frac{1}{2}$ miles).

The up and down Côte d'Azur Rapides give the Paris-Lyon-Méditerranée engines their best chance of distinguishing themselves. Coming up

one evening from Dijon with engine No. 2608 (a four-cylinder compound with six-coupled wheels 6 feet $6\frac{3}{4}$ inches in diameter) and this train, we had a load of 262 tons behind the tender. The ascent of the long bank from Dijon (812 feet above the sea) to the exit from the Blaisy-Bas tunnel (1328 feet) was uninteresting, and steam was shut off to descend the steeply falling gradients which are then met with, but, after the more level ground had been reached, $66\frac{3}{4}$ miles from Thénissey to Brienon—the last station before Laroche—were run in $66\frac{3}{4}$ minutes, though we lost 3 minutes through having almost to stop on account of permanent way repairs which were proceeding near kilometre 189. At Laroche, No. 2608 was replaced by No. 2643 of the same type, and we started on our $96\frac{1}{4}$-mile run to Paris, for which the booked time was 105 minutes. After getting into speed, No. 2643 traversed $41\frac{1}{4}$ miles from Joigny to Montereau on an undulating road with a slightly falling tendency in 39 minutes. After this the undulations of the line are rather more pronounced—there is a good deal between 1 in 200 and 1 in 250—and we encountered some slight delays, but we had saved several minutes on the booked time as we ran into Paris. An adverse signal, however, almost brought us to a

standstill a few hundred yards outside the Gare de Lyon, and we only crawled on into the station, where we arrived in 104 minutes 55 seconds from Laroche; the average speed including all delays was thus 55 miles an hour. Work of this kind does not seriously tax the energies of engines so powerful.

The work of the goods engines does not, of

GOODS TANK ENGINE (NORD).

course, present so many points of interest as that of the express engines. I travelled on one of the large Nord goods tank engines when working a coal train over the rather difficult line from Valenciennes to Hirson. We had 51 loaded coal wagons weighing 810 tons, which is rather less than these engines are intended to work; but

on the other hand, though we started half an hour late and were considerably delayed by signals, we arrived at approximately the right time. In places the gradients are steep, and once the engine was put to a severe test, when, having been

A RUNNING SHED.

stopped by signal, she had to start away on a gradient rising at 1 in 84. Steam from the boiler was admitted direct to the low-pressure as well as the high-pressure cylinders, and, after she had skidded violently at the first attempt, at the second this feat was successfully accomplished.