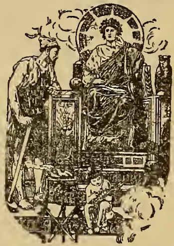
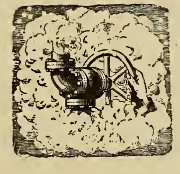


Cassier's Magazine

Engineering Illustrated

Volume XXVII

November, 1904–April, 1905



The Cassier Magazine Company
3 West 29th St., New York
33, Bedford Street, Strand, London

INDEX TO VOLUME XXVII.

ALBERT WILLIAM SMITH

THE NEW DIRECTOR OF SIBLEY COLLEGE, CORNELL UNIVERSITY

SEE PAGE 78

CASSIER'S MAGAZINE

Vol. XXVII NOVEMBER, 1904 No. 1

THE WORLD'S OCEAN-GOING TRADE

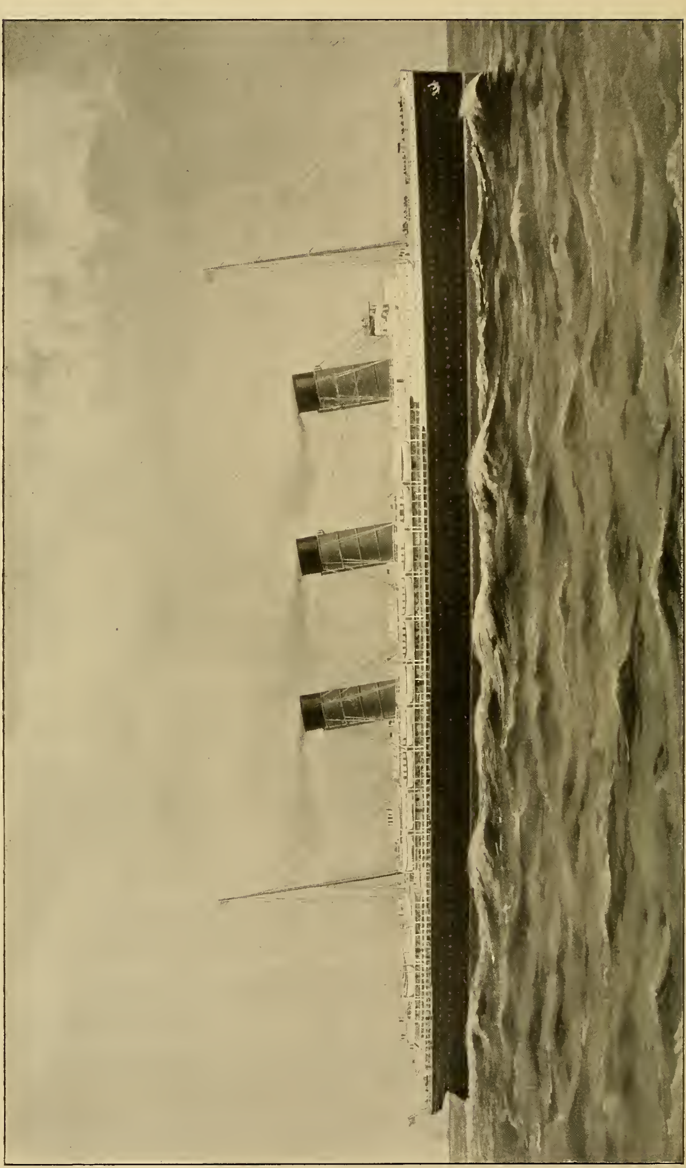
WITH SPECIAL REFERENCE TO BRITISH SHIPPING

By Brysson Cunningham, B. E., Assoc. M. Inst. C. E.

THE maiden voyage of the *Baltic*, the launching of the *Caronia*, the building of the *Carmania* and the placing of the orders for the new 25-knot turbine Cunard Line steamships are events of sufficient moment in the annals of the mercantile marine to direct attention to the present position of Great Britain and the continued expansion of her policy and operations. That there is, and has hitherto been, a marked preponderance of vessels flying the British flag upon the great ocean routes, is a matter of such common knowledge as to render the observation commonplace. But it fails to sum up the whole situation and, moreover, gives only an inadequate idea of the state of affairs in the maritime world. The object of the present article will be to throw some definite light upon the past history, the present position, and the future prospects of British oversea trade.

The number of people who comprehend with any degree of accuracy the exact position of Great Britian in relation to the maritime commerce of the world is probably small. Most people are, of course, aware of certain general facts and conscious of general impressions, from which they augur that it is a position of very great, if not supreme importance. For instance, they are cognisant of the fact that Great Britain maintains the most powerful navy in the world and, in a great measure, this can be attributed to the existence of very valuable interests on the high seas. Then there are the facts of insularity and of a comparatively enormous seaboard, conditions which obviously foster oversea trading, especially when a country is densely populated and incapable of producing internally sufficient supplies for its inhabitants. Lastly, there is the influence and effect of heredity; the Anglo-Saxon race is essentially a sea-loving and a sea-roving race, and in the veins of its present day representatives courses the blood of the Vikings and Berserkers of old.

Thus, by geographical position and inherited instinct alike, there is every reason to expect maritime enterprise of considerable development. This expectation, moreover, is justified and



ONE OF THE NEW 25-KNOT, FOUR-SCREW, TURBINE STEAMERS FOR THE CUNARD LINE. LENGTH, 800 FEET. BEAM, 88 FEET. DISPLACEMENT, 40,000 TONS. HORSE POWER, 75,000, SPEED, 25 KNOTS confirmed by daily experience. The harbours and docks along the British coast are crowded with shipping, mostly of British nationality, and from time to time comes the announcement of the launch from British shipyards of yet another ocean leviathan—"the largest steamship afloat."

In spite, however, of all these data and observations, with their almost inseparable inferences, the average Briton realises only imperfectly the splendid position which his country has achieved and maintained in the international contest for maritime supremacy.

The reason is not far to seek. It is because he has no definite standard of comparison. Without some external source of reference, the judgment must inevitably be at fault. A man may have a giant's stature and yet little appreciation of the fact from a survey of his own image in the mirror.

It is not, indeed, until one comes seriously to the study of international returns, that any true insight into the matter is obtainable. Statistics afford the necessary basis for comparison and a means of estimating the relative importance of the various competitors. It is true that figures are, in general, tedious reading. and it must also be admitted that they rest under the imputation of being more flexible and adaptable than is quite consistent with reliability. Hence, they have come to be regarded with distrust, and even with aversion.

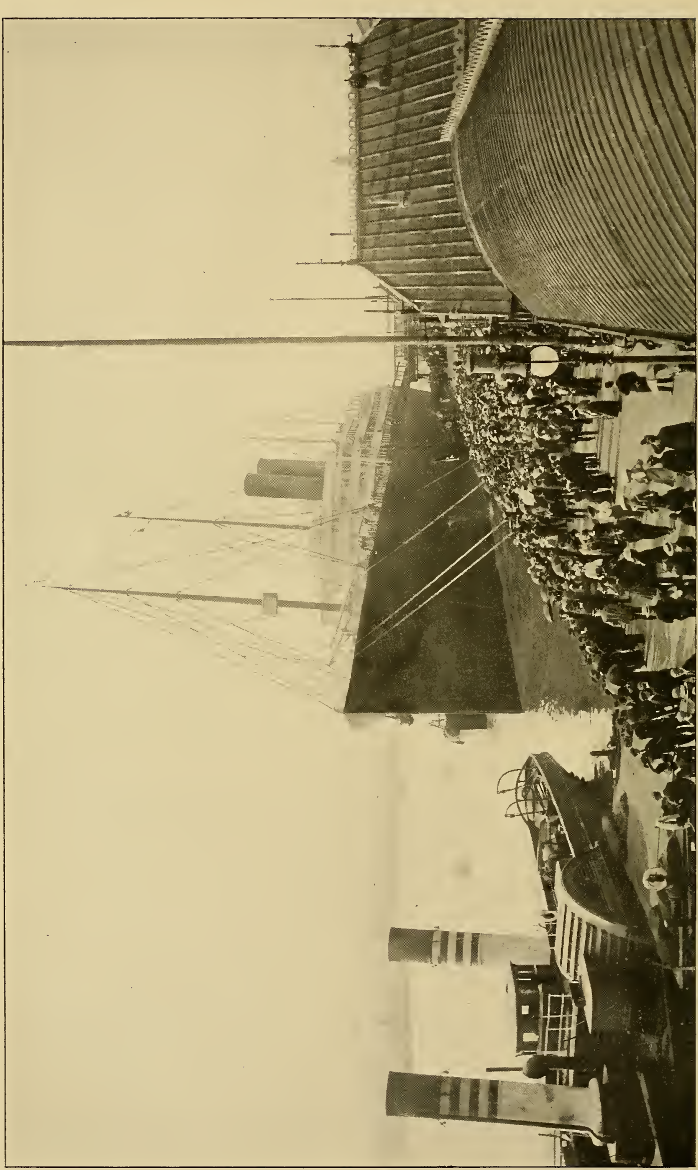
This attitude, however, on the whole is scarcely justifiable. Properly treated and rightly interpreted, statistics furnish most useful and trustworthy information, and he is but an indifferent man of affairs who neglects the lessons they teach. To the thoughtful student they afford a certain charm and fascination, and in presenting in this article a few of the deductions to be derived and the results to be obtained therefrom, an endeavor will be made to give prominence to their more interesting characteristics.

The naval supremacy of Great Britain is a theme, of course, upon which much might be written. With this form of maritime greatness, however, we are not at present concerned. Our immediate purview is the field of commercial enterprise; and we must restrict it to a limited period of recent date; otherwise, we should find ourselves exceeding all reasonable bounds of space.

The early part of the nineteenth century constituted an epoch of supreme importance in the history of navigation, in that it signalised the definite introduction of steam as a motive power. Attempts had certainly been made to propel vessels by this means at much earlier periods; in the first instance by the Spaniards in 1543, then by the French in 1707, and in England in 1736; but it was not until Robert Fulton appeared in America on the banks of the Hudson in 1807, that anything really tangible and effective was realised. Then, in 1812, the *Comet* began her passenger service on the Clyde, and in 1821, the *Aaron Manby*, the first iron paddle steamer, left England for France. At this date, steam propulsion may be deemed to have acquired definite recognition, though it was then still confined to river and coastwise navigation.

The *Savannah*, an American-built ship, had certainly crossed the Atlantic in 1819; but, in her case, steam was simply an auxiliary to sail power, and was utilised on only eighteen out of the thirty-five days during which the voyage lasted. The first British Atlantic steamer was the *Royal William*, built at Quebec in 1831. The first Cunarder, the *Britannia*, came in 1840; the first Allan liner, the *Canadian*, in 1854; the first Anchor liner, the *Tempest*, contemporaneously with the first boat, the *Borussia*, of the Hamburg-American line, in 1856; and the pioneer of the White Star Line, the *Oceanic* (I) in 1870.

The earliest steamers were paddle-wheel ships and they continued in vogue for over half a century. As late as 1862 the Cunard company built the *Scotia*—acknowledged to be the finest vessel of her day, excepting only the *Great Eastern*—of that type. The first vessel fitted with a screw propeller was the *Francis B. Ogden*, built in 1837. Eight years later came the *Great Britain*, the first iron screw steamer to appear on the Atlantic service. Twin screws came



THE WHITE STAR LINE STEAMSHIP "BALTIC" AT HER LIVERPOOL LANDING STAGE. LENGTH, 724 FEET. BEAM, 75 FEET. DISPLACEMENT, 40,000 TONS.
HORSE POWER, 14,000. SPEED, 17 KNOTS

in between 1860 and 1865 to be followed soon after by triple screws, though only with partial favour. The steam turbine passed out of the experimental stage in 1894, and, after trial on the Clyde, has been adopted for the new Allan liner, the *Victorian*, recently launched, for the *Carmania*, to be launched next year, and for the 25-knot steamers now on the stocks.

The year 1858 was, of course, remarkable for the advent of the *Great Eastern* and, without dwelling further upon the vicissitudes and fate of that luckless vessel, whose principal fault was her premature creation, it is interesting to compare her leading dimensions with those of four of the largest vessels of recent date, as given in the following table:—

Vessel	Length Over All	Length Between Perpendiculars	Breadth Hull	Breadth Paddle Box	Depth	Loaded Draught	Gross Tonnage	Speed
	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Tons	Knots
Great Eastern	693	686	83	120	58	35	18,915	14
Baltic	725½	709	75	--	49	37¼	24,000	17
Cedric	697½	680	75	---	48½	37	21,000	16½
Oceanic	705	685	68	---	49	30½	17,274	20¾
Kaiser Wilhelm II	706½	683	72	---	52½	29	20,000	23

Although the *Great Eastern* marked an attainment in size which was not surpassed for the ensuing forty years, progress continued to be made in other directions, principally in regard to speed and economical working. The *Royal William* in 1838 took over forty days to make the voyage from Quebec to London. The present record duration of the run from New York to Plymouth or Queenstown is 5 days 7½ hours. About 1850, the standard was 11½ knots per hour; in 1860, 12 to 13 knots; in 1884 the *Umbria* and *Etruria* raised it to 20 knots; in 1893 the *Lucania* and *Campania*, to 22 knots, and in 1901-2, the *Deutschland* and the *Kronprinz Wilhelm* to 23½ knots.

Whilst, however, this record of the progress of steam navigation, marking as it does the energetic pioneering of British shipowners and shipbuilders, is engrossing, it does not completely fulfill the aim and intention of the present article which are to include a review and a comparison of British and foreign oversea trade. Accordingly, we must leave this branch of the subject to deal with the relative development of the mercantile marine throughout the world.

In 1840 we find that the British registered tonnage of steamships was only 95,807 tons. At the same date the United States had a total registered (enrolled and licensed) steam tonnage of 202,340 tons—a figure considerably in excess of the British figure. The steam tonnage of Great Britain, however, rose steadily and rapidly to 1,202,134 tons in 1870, at which date it passed the American contemporary total of 1,075,195 tons, and from that time onwards the lead has not only been maintained, but greatly increased, until in 1903 the totals were 3,029,386 British and 3,408,088 American. The only other competitor of importance is Germany, with a present tonnage of a million and a half, having risen from 82,000 tons in 1870. France and Norway have each just over half a million tons to their credit.

If we treat shipping as a whole, including sailing vessels, we find the British superiority still more strikingly realised. In 1840 the total British tonnage was 3,311,538 as compared with 2,140,625 tons of the United States (and of this only 899,765 tons were registered for foreign trade, the remainder being enrolled and licensed for river, lake and coasting service, and for the cod and mackerel fisheries), 662,500 tons of France, and 276,697 tons of Norway.

According to the latest and recently issued Board of Trade tables, containing returns up to the years 1902–03, the registered tonnage of the principal maritime countries of the world lies between 29 and 30 million tons. Of this the British Empire owns nearly 12 million tons (the United Kingdom alone claiming over 10 million tons) and the nearest competitor is the United States with 6 million tons, of which only 888,776

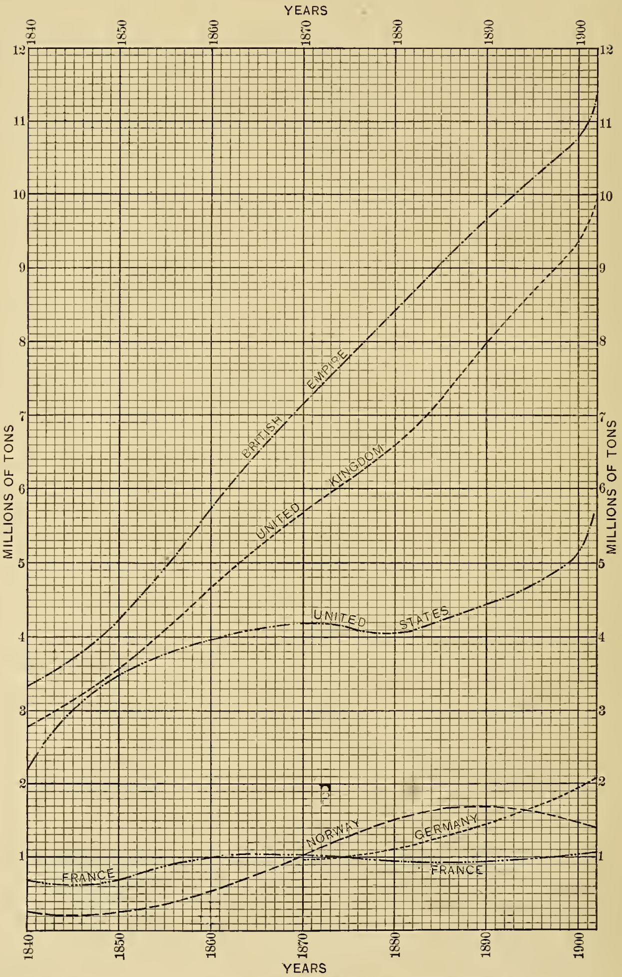


DIAGRAM SHOWING THE TONNAGE OF THE MERCHANT MARINES OF THE PRINCIPAL MARITIME NATIONS FROM 1840 TO 1902 INCLUSIVE tons, or less than in 1840, are registered for foreign trade. Germany with two million tons, Norway with 1½ million tons, and France with 1 million tons are considerably in the rear.

To illustrate the foregoing figures and show the comparative expansion of the various countries, the diagram on page 8 has been prepared. The curves indicate the average rate of progress during the period 1840-1902. The upward tendency of British shipping and latterly also of that of the United States, is very marked. It has, however, been already pointed out that the bulk of the American tonnage is in inland and coastwise navigation.

If we prefer to make our comparison in another form, we may find according to Lloyd's register, that the total number of steam and sailing vessels of 100 tons net and upwards, now in existence, is about 29,300, with a tonnage (net of sailing vessels and gross of steamers) of 34,790,000. Of these the British share is 11,250 vessels, with a tonnage of 16½ millions, or nearly one-half. The United States come next, with 3411 vessels of 3,849,400 tons, followed closely by Germany, with 1935 vessels of 3,369,800 tons. Norway and France are in close sequence, with 2218 vessels of 1,717,654 tons in the former case and 1376 vessels of 1,693,366 tons in the latter. Next come Italy, with 1238 vessels of 1,187,566 tons; Russia, with 1370 vessels of 840,515 tons; Spain, with 579 vessels of 754,855 tons; Sweden, with 1517 vessels of 751,533 tons; and Japan, with 598 vessels of 671,417 tons.

In connection with this enumeration, we may exhibit the following table, showing the distribution of the largest class of vessels among the more important countries:—

LARGEST STEAMSHIPS, 1904

Tonnage	British	German	American	French
Upwards of 10,000 tons	45	25	12	2
7,000 to 10,000	119	23	9	5
5,000 to 7,000	299	92	41	45
Totals	463	140	62	52

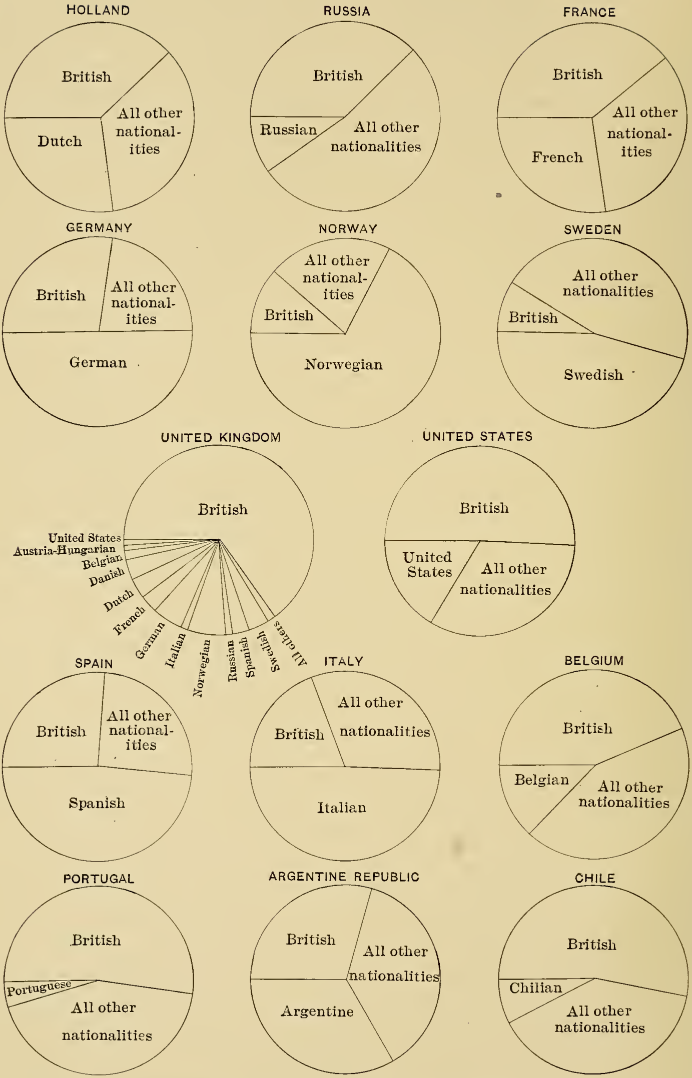
In number, individual size and aggregate tonnage of vessels, British superiority is evidently indisputable; in speed, Germany carries off the palm. There are four German vessels which surpass the fastest British vessels. The four are the *Deutschland*, the *Kronprinz Wilhelm*, the *Kaiser Wilhelm II.*, and the *Kaiser Wilhelm der Grosse*, all of which have speeds varying between 22½ and 23½ knots. It lies apparently with the Cunard Line to wrest the superiority from her foreign rivals with her forthcoming auxiliaries.

So far we have not dealt with the question of trade. Let us now consider the tonnage of shipping actually engaged in the carrying trade of each country. Turning to the Board of Trade returns, we find that of the total tonnage entered and cleared in the foreign trade at ports of the United Kingdom 69 million tons, or 65½ per cent., are British ships. The greatest share of the remainder belongs to Norway, with 6¾ million tons, and after her to Germany, with 6 million tons. Sweden, Denmark and Holland each appropriate about 3½ to 4 million tons.

The foregoing figures deal with vessels in ballast as well as those with cargoes. The result of omitting the former class is not great; it is to increase the British percentage by 2.

One astonishing feature is the comparatively insignificant position occupied by the United States. Her tonnage, occupied in British trade only, amounts to 640,672, or much less than 1 per cent. This disproportion is still more noticeable if we turn to a table showing the tonnage of vessels entered and cleared at ports of the United Kingdom in the trade with the United States. There we find that out of a total of nearly 14 million tons, nearly 13 million tons are British, and only half a million American, and more astonishing still, that the last-named figure is only a fourth of what it was so far back as the year 1856. The fluctuations, indeed, are very remarkable, for in 1892 the tonnage was only 187,190, and in 1898, 302,706, while in 1871 and 1876 it exceeded a million.

Turning now to the foreign trade of other countries, we find in many cases a very large proportion of it in British



GRAPHICAL REPRESENTATION OF THE DISTRIBUTION OF TONNAGE OF VESSELS OF THE PRINCIPAL MARITIME COUNTRIES hands. Thus, using only round figures, the percentage of the tonnage of British ships engaged in the foreign trade of the respective countries is as follows:— In the case of the United States, Portugal and Chili, 50 per cent.; in the case of Russia, Holland, France and Belgium, 40 per cent.; in the case of Germany, 30 per cent.; in the case of the Argentine Republic and Spain, 25 per cent.; Italy, 20 per cent.; and Norway and Sweden, 10 per cent. The foregoing comparison is in reference to the whole tonnage involved, including not only that of each particular country, but of every nationality.

Limiting the comparison to the vessels flying the British and those flying the national flag, the preponderance of the former is greatly increased. Thus, the tonnage of British ships engaged in the foreign trade of the United States is three times that of the country concerned. In the case of Chili it is seven times; in the case of Portugal, 12 times, and so on. The results are best conveyed in diagrammatic form, and the series of circles on page 10 represent graphically the distribution of the total tonnage of vessels engaged in the foreign trade of the principal maritime countries.

Finally, a word regarding the outlook. While it is never safe to prophecy "unless you know," there are certain indications of the general trend of events which afford permissible deductions of an approximate nature. Thus, if we take as an example the diagram of tonnages shown on page 8, we may reasonably continue the curves for the next few years without the probability of any serious deviation from the truth. Where the line of past history is fairly even and regular for some time, it is practically safe to assume that future developments, within a limited period, will not be characterised by any sudden or abrupt changes. Apparently, therefore, the British Empire will continue to maintain a marked upward rate of progress, though possibly not to the degree indicated by the termination of the present curve. Disregarding this, despite its favourable nature, as a slight periodical eccentricity from the general path, we may still reasonably anticipate that the tonnage of the British merchant navy will reach 13 to 13½ million tons in ten years' time, as against 7¼ millions in the case of the United States and 3 millions in the case of Germany.

On the same grounds we may expect the British Empire to increase slightly her present share of the foreign trade, though the general tendency has been to maintain a fairly constant level. Thus, in 1840, her percentage of the tonnage engaged was 68.8,—rather more than at present; and at the end of each succeeding decade the values were 65.1, 56.4, 68.4, 70.4, 72.7, and 6.37, indicating a gradual undulation. The explanation of the apparent lack of progression in this case, and also in that of the share of the trade of other countries, is that whilst British tonnage increases, foreign shipping is likewise growing, sometimes in the aggregate at a greater rate than her own.

In the foreign trade of Germany, for instance, the British tonnage rose from 5 million tons in 1880 to 8 million tons in 1900, but the British percentage fell from 38 to 27. During the same period the British tonnage engaged in the foreign trade of Portugal was more than trebled, but the percentage fell from 63 to 57.

That Great Britain possesses at the present time a prestige so considerable in maritime affairs is mainly due to the energy and enterprise which have characterised her movements in the past. In order to sustain her reputation as the premier sea power, naval and commercial, a continuance of the same qualities is essential under conditions radically different from those which obtained a generation ago and still changing from day to day.

The introduction of the turbine, the differentiation of the cargo and the passenger steamer, the development of speedy mail services, and, above all, the under-cutting of rates and the narrow margin of profit obtainable under the stress of keen competition, are present-day problems necessitating the closest and most careful attention.

BRITISH HYDRAULIC MACHINERY

ITS USE IN THE MANUFACTURE OF MUNITIONS OF WAR

By A. F. Petch

HYDRAULIC machinery is an important factor in the manufacture of munitions of war, as is well illustrated by the field gun and its ammunition. The gun itself is a steel barrel, hydraulically forged, and afterwards wire wound; the carriage is built up of steel plates, flanged and shaped in hydraulic presses; the wheels have their naves composed of hydraulically flanged and corrugated steel discs, and even the tires are forced on cold by hydraulic tire setters, the rams of which are powerful enough to reduce the diameter of the welded tire until the latter tightly nips the wheel.

The shells for the gun are punched and drawn by powerful hydraulic presses, and the copper driving bands are fixed on the projectiles in special hydraulic presses. Quick-firing cartridge cases are cupped, drawn, and headed by an hydraulic press, whose huge mass always impresses the uninitiated as absurdly out of proportion to the small size of a finished case, and finally the cordite firing charge is dependent on hydraulic presses for its density and shape.

As it would be altogether beyond the scope of this article to even mention all the various processes in the manufacture of warlike stores in which hydraulic machinery assists, the writer has contented himself with selecting and describing a few types of the hydraulic machine tools in use. Fig. 2 shows a powerful press, made by the Hydraulic Engineering Company, Ltd., of Chester, for heading and indenting the cartridge cases of quick-firing guns. This is in use in the Royal Laboratory at Woolwich Arsenal, and is capable of exerting a total power of 2500 tons. It is built almost entirely of steel and gun-metal. The entablature carries the main cylinder; the centre crosshead is the die holder; and the base contains a cylinder and ram for ejecting a finished case from the die. The return stroke of the main ram is effected by the two small rams in the centre crosshead. The working pressure during the greater portion of the stroke is 700 pounds per square inch, but the final pressure is taken from the 3 tons per square inch mains. The cylinders are of forged steel, and all the rams are cased in brass liners. The valve arrangement is well thought out; there are only three levers, conveniently placed, to control all motions of the press. As the larger valves are fluid-controlled, the auxiliary valves, being of small bore, are easily manipulated.

A smaller pattern of press, built by Messrs. J. Archdale & Co., Ltd., of Birmingham, for making cartridge cases for 3-inch calibre fixed ammunition, is shown in Fig. 3. This press differs in principle from the foregoing in that the die is not carried by the centre crosshead, but rests on the base, and in that a separate ram is not provided for ejecting finished work, which, as will be seen from the illustration, is carried out by means of a plunger working through the base and connected to the crosshead by the two light tie rods. The side rams are used for returning the main ram as well as for working the ejector. On account of the short stroke of ram, it is necessary to move the top tool in a lateral direction to allow sufficient head room to remove, or place work in the die, this lateral movement being controlled by the small hand wheel to the right of the tool holder. As is usual in this style of press, the earlier part of the

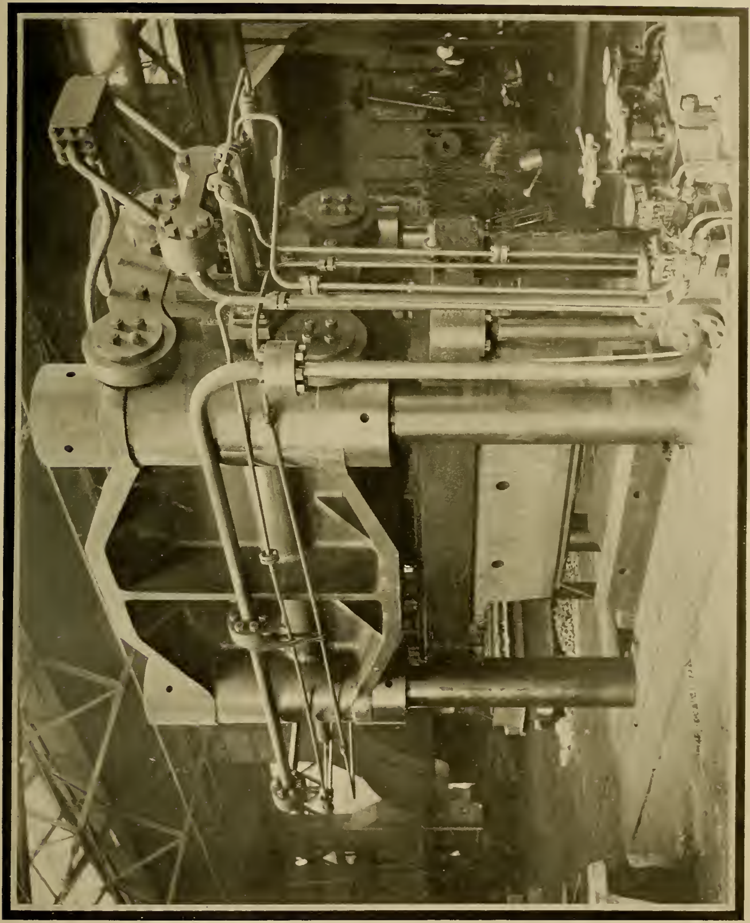


FIG. 1.—A 3000-TON ARMOUR-PLATE BENDING PRESS BUILT BY MESSRS. TANNETT WALKER & CO., LTD., LEEDS.

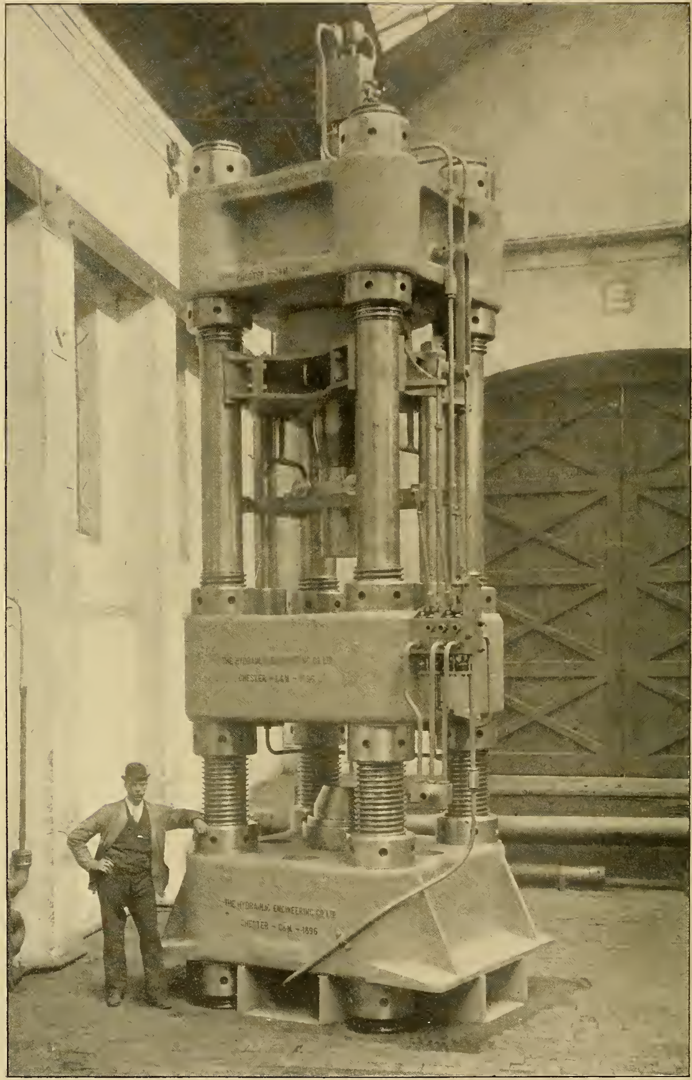


FIG. 2.—HYDRAULIC PRESS, AT WOOLWICH ARSENAL, EMPLOYED IN HEADING AND INDENTING THE CARTRIDGE CASES OF QUICK-FIRING GUNS. MADE BY THE HYDRAULIC ENGINEERING CO., LTD., CHESTER

stroke is performed by water taken from an ordinary hydraulic main; but the final pressure is taken from intensifier mains at about 4500 pounds per square inch.

A steam hydraulic forging press of 700 tons power, which was supplied to Woolwich Arsenal by Messrs. Greenwood & Batley, Ltd., of Leeds, is illustrated by Fig. 4. This form of press is much oftener seen in Germany than in Great Britain, where forging presses on the well-tried Whitworth system still hold their own. This is, perhaps, due to the greater economy in steam consumption of the pumping engine over the direct steam driver, although the latter has certainly the advantage as regards first cost, and as no accumulator is required to operate the return rams, where steam drivers are used, a further reduction in outlay is possible. In Germany these presses are manufactured by Messrs. Breuer, Schumacher & Co., of Kalk, near Cologne, and in Great Britain Messrs. Greenwood & Batley, as above intimated, manufac-

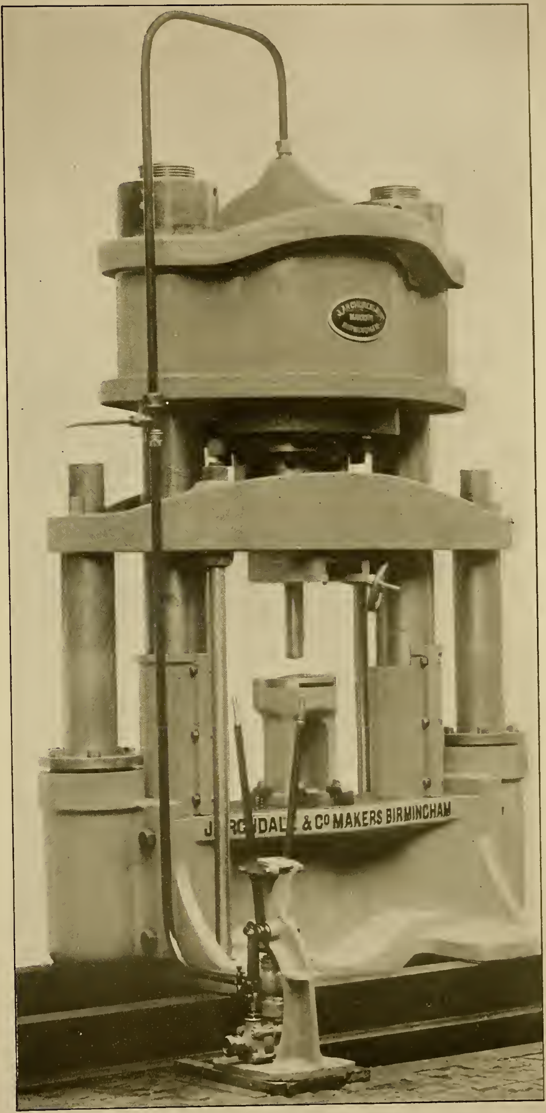


FIG. 3.—HYDRAULIC PRESS FOR MAKING CARTRIDGE CASES FOR 3-INCH CALIBRE FIXED AMMUNITION. BUILT BY MESSRS. J. ARCHDALE & CO., LTD., BIRMINGHAM

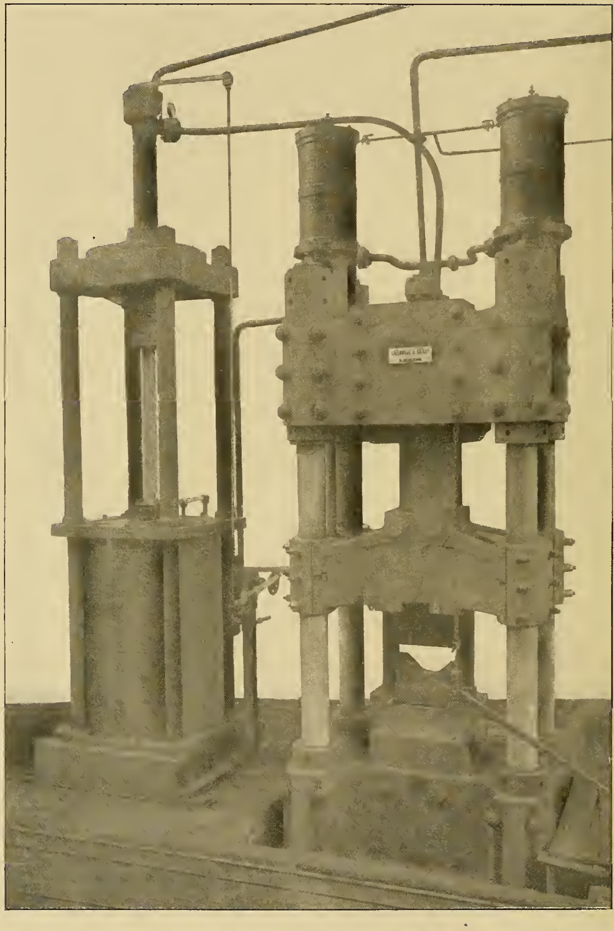


FIG. 4.—A 700-TON, STEAM-HYDRAULIC, FORGING-PRESS IN WOOLWICH ARSENAL. MADE BY MESSRS. GREENWOOD & BATLEY, LTD., LEEDS, AND BY MESSRS. BREUER, SCHUMACHER & CO., KALK, GERMANY

ture from practically the same designs.

The above plant comprises the press, the steam driver, and the distributing valves. The press consists of a steel entablature containing the main cylinder, a base block connected to the entablature by four steel columns upon which slides the ram crosshead. At each end of this part of the ram are fixed the piston rods of the two single-acting steam cylinders for raising the crosshead. The steam driver is of the usual pattern, with a single-acting steam cylinder whose piston rod forms the ram of the pump or intensifier cylinder. The pump cylinder is supported on four columns, and is connected by means of a steel pipe to the press cylinder, there being no valve between the two cylinders.

A valve, however, is placed between the pump cylinder and a small overhead water tank, and as this valve forms an essential feature of Schumacher's patent, under which these presses are made, a sketch (see Fig. 5) is given which will make clear the working of the plant.

Assuming that the work is on the anvil block and the crosshead and ram in their highest positions, the regulating handle on the steam valve is depressed, exhausting the steam from the drawback cylinders of the press and allowing the crosshead to fall until it meets the work. During this time the main hydraulic cylinder has filled with water from the tank, through the valve *A*, the lever *B* of which is coupled to the regulating handle by the rod *C*. A further depression of the steam valve handle raises *C* and allows the spring *D* to close the valve *A*, and at the same time the steam valve has opened the driver cylinder to the boiler pressure. This causes the piston to rise quickly and pump water under a pressure of several tons per square inch into the hydraulic cylinder of the press. Raising the regulating handle opens the steam driver cylinder to exhaust, and as the valve *A* is connected with the regulating handle, this also opens, allowing the hydraulic cylinder to exhaust, and permits the pump cylinder to draw in a charge of water for the next stroke; upon steam entering the drawback cylinders, the crosshead is free to rise. The main steam valve, being of the balanced piston type, may be quickly worked by hand.

An illustration of another tool by the same makers is given in Fig. 6. This is a press for drawing 6 inch shells, and was supplied to the India office of the British War Department for the ordnance factory at Cossipore. The leading dimensions of this press are:—Main ram, 24 inches diameter by 42 inches stroke; side rams, 7 inches diameter by 72 inches stroke; working pressure, 30 cwts. per square inch. The horizontal ram, which is double-acting, is used for moving the die block backwards and forwards.

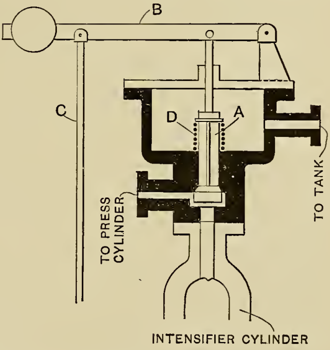


FIG. 5.—SECTION OF VALVE BETWEEN SUPPLY-TANK AND INTENSIFIER-PUMP OF PRESS SHOWN IN FIG. 4

The entablature and base are plain and substantial iron castings, the former being bored to receive the main cylinder, which is of steel and tested to a pressure of 2½ tons per square inch. The columns are of a design commoner in America than in Great Britain, and, being without forged collars, can be passed through the entablature and base, which saves having to lift the entablature over the columns when erecting the press. The weight of the entablature is taken by the split collars, which fit into necks in the columns. Another

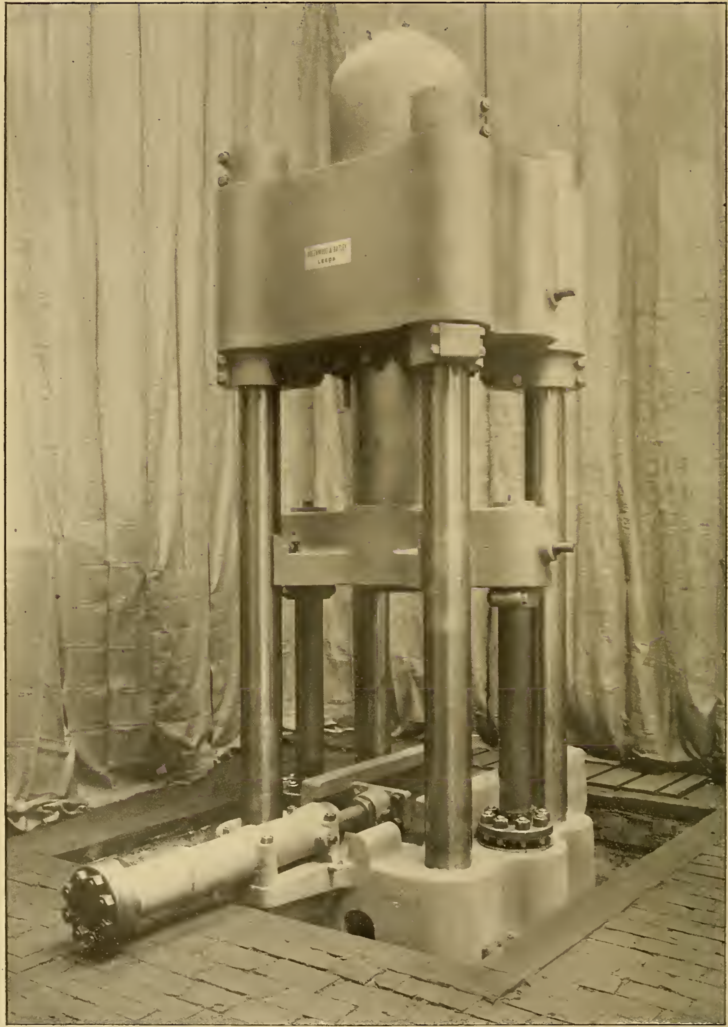


FIG. 6.—PRESS FOR DRAWING 6-INCH SHELLS. BUILT BY MESSRS. GREENWOOD & BATLEY, LTD., LEEDS

convenient feature in the design is the length of stroke of the side rams; this is sufficient to allow the main ram to be removed from the cylinder, or the cylinder from the press head, without dismantling the press.

It will also be seen that the side rams can be taken out by removing the split collars from underneath the crosshead, which leaves the rams free to be drawn through the cored holes in the entablature, after which the side cylinders can be taken away. The crosshead slippers have adjustable wearing surfaces, a very important point in shell drawing presses, where the punch has to travel truly in the axis of the die to ensure the walls of the shell being of equal thickness.

In examining the illustration of this press the side rams may appear unduly powerful, but it must be remembered that the punch may require as much as 100 tons to withdraw it from the work, especially if the metal is allowed to cool.

Four operations are necessary in drawing shrapnel, viz.:—Cupping, punching, first and second drawings. These require powers of 80, 70, 450, and 600 tons, respectively, for a 6-inch shell. The steel from which the shells are made is in the form of round bars of a slightly larger diameter than the required diameter of the shell, cut off into such lengths as to weigh about 2 per cent. more than the finished shell, to allow for scaling.

After the shell has been drawn it is machined and the grooves prepared to take the driving band. These grooves are usually very shallow and left with a number of teeth or undulating vee-shaped ridges, and the sides of the grooves are undercut. When the band is being fixed the copper flows into the grooves and the teeth or ridges are embedded in the copper. When the shell is fired the copper takes the lands of the rifling and imparts to the projectile the high speed of rotation upon which depends its flatness of trajectory. Not only has the band this duty to perform, but it must also act as a check band to prevent any of the high temperature and high pressure gases of the combustion of the firing charge leaking past the shell, which would set up erosion and shorten the life of the gun.

At the present time driving bands are usually made of copper, cut into rings from solid drawn copper tubes; but cupro-nickel bands are superseding them as more powerful explosives come into vogue.

From the foregoing remarks it will be gathered that banding shell is a more important operation than at first appears, and care must be taken to prevent the distortion or upsetting of the shell. Figs. 7 and 8 show two of the presses used at the arsenal at Woolwich for banding shell; Fig. 7 gives a general view of a banding press, and Fig. 8 is a plan view of a slightly different design. This type of press is a radical departure from other forms of hydraulic presses, there being no entablature nor columns, but in their places is a weldless, high-tenacity steel ring, on the inside of which are arranged six bronze cylinders with steel rams. The ends of these rams pass through an inner guide ring, and carry dies ground to the curvature of the band when home. The rams travel in a radial direction to the centre of the press, and as the working stroke is only ½ inch, the return is suitably effected by short, stiff, helical springs.

Pressure is admitted to the cylinders by copper pipes connected up to a circular distributing pipe. The press takes water from the 700 pounds main for the first ⅜ inch of the stroke, and for the last ⅛ inch water pressure at 3 tons per square inch is used. The total pressure on all the rams to band a 6-inch shell is only 600 tons, but for a 12-inch shell no less than 2800 tons is necessary.

These presses are made under West's patents by the West Hydraulic Engineering Company, of London, who are also the manufacturers of the somewhat elaborate presses illustrated in Fig. 9. This shows the front and back of a press, supplied to the Royal Gun Powder Factory, at Waltham Abbey, for making rifle and pistol sizes of cordite.

Cordite is a mixture of gun-cotton, nitroglycerine and vaseline, incorporated in kneading machines, the solvent

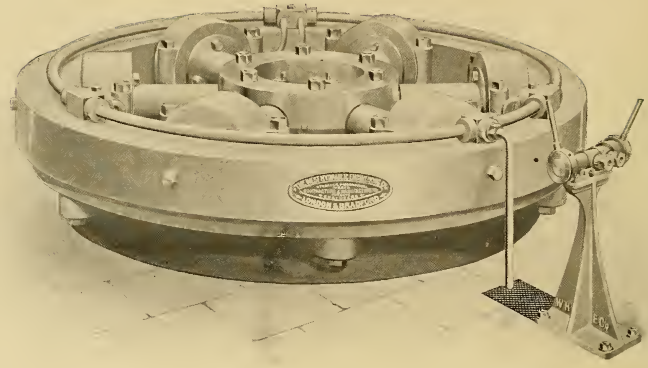


FIG. 7.—SIX-CYLINDER HYDRAULIC PRESS AT WOOLWICH ARSENAL, USED FOR BANDING SHELLS WITH COPPER. MADE BY THE WEST HYDRAULIC ENGINEERING CO., LONDON

employed being acetone, which afterwards evaporates. In manufacturing small arms sizes of cordite a charge of one pound of the incorporated mixture is placed in a steel container, fitted at the bottom with gauze and perforated strainers, and terminating in a nozzle bored with a very fine hole, the size of the thread of cordite. This charged container is placed in a holder on the press and locked in position, and a plunger is caused to descend into the container by means of a screw, driven by a worm and wheel.

As the plunger goes into the container it displaces the incorporated mixture, which issues from the die in the form of a continuous thread which is wound on a special reel by the small machine shown in Fig. 10. This machine is driven from the back shaft of the press and is arranged to wind the cordite as it issues from the machine. It is, of course, of the greatest importance that the reeling apparatus should keep time with the press, for if it were slightly slower the cordite would become tangled, and, if quicker, it would break the thread.

To prevent air bubbles forming in the cordite it is necessary that the plunger exert a constant pressure at constant speed, and so the container and holder rest on a floating hydraulic cylinder and ram, loaded by the small accumulator at the back of the press. This is so arranged that, if the pressure in the container exceeds the limit, the ram is forced downwards in the cylinder, and this causes the accumulator ram to rise. The ratio of the two rams is 50 to 1, so that when the container holder is forced down 0.02 inch the accumulator ram rises 1 inch and reverses the belt drive and stops the press. The presses are so constructed as to reverse automatically when the plunger has made a full stroke, and to stop at the top of the return stroke. This arrangement enables one operator to attend to two machines.

The small press illustrated in Fig. 11 was made by Messrs. Fielding & Platt, Ltd., of Gloucester, England, for use on board H. M. torpedo depot-ship *Hecla*. This ship is in reality a small floating arsenal, and a description of the press is not out of place in this article. This type of hydraulic hammer or press is well suited to shipboard, where the weight of a pumping engine, accumulator, and press would be excessive, and where the vibration of a steam hammer would be equally objectionable.

Small steam hydraulic presses are by no means a new idea, yet as there are several novel features about the "Fielding" press, the writer believes a somewhat detailed description may be of interest. Referring to Fig. 11, the cylinder *A*, sliding in planed guides in the frame and working on the fixed ram *B*, held in place by the crosshead *C* and two tie bolts, is of the usual kind for this type of press. The ram *B* is hollow and forms the pressure inlet to the cylinder. The press has a double-acting steam cylinder *D*, the piston rod of which is connected to the rocking lever *E*, which is also connected to the main hydraulic cylinder *A* at one end, and to the principal steam slide valve at the other. A smaller steam slide valve *G* controls the cylinder *D*, while *H* is a reservoir which holds the water for working the press, and which is under an air pressure of about four atmospheres. A small hand pump is provided for making good any leakage of air or water. Cylinder *K*, of the steam end of the driver, has the usual single-acting piston, whose rod is also the ram of the intensifier cylinder *L*.

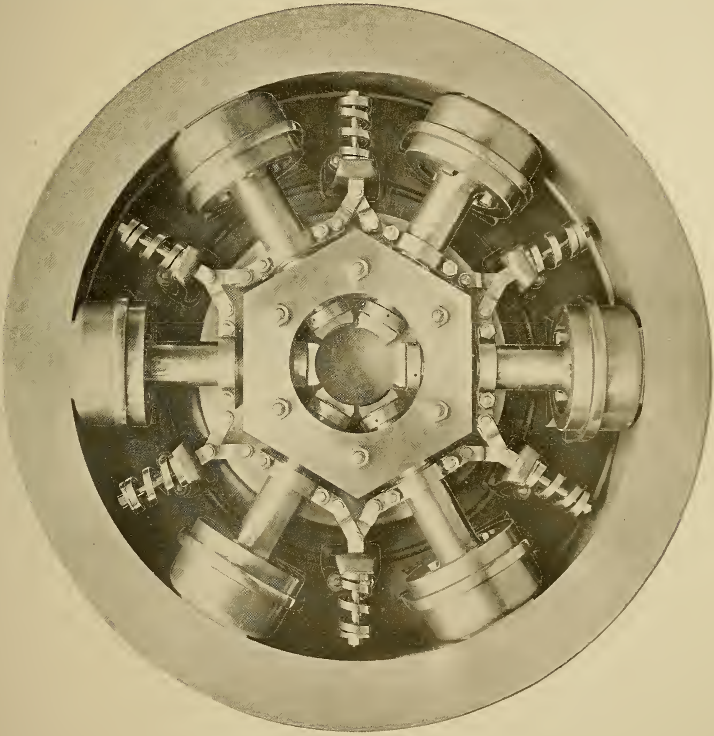


FIG. 8.—PLAN OF PRESS SHOWN IN FIG. 7

The method of working the press is as follows:—To raise the cylinder *A*, the valve *G* is operated by the handle at the side of the frame, so as to admit steam to the under side of the cylinder *D*. This causes the right hand end of the lever *E* to descend and open, through *F*, the cylinder *K* to exhaust; at the same time the left hand end of *E* rises and lifts the cylinder *A*, the water

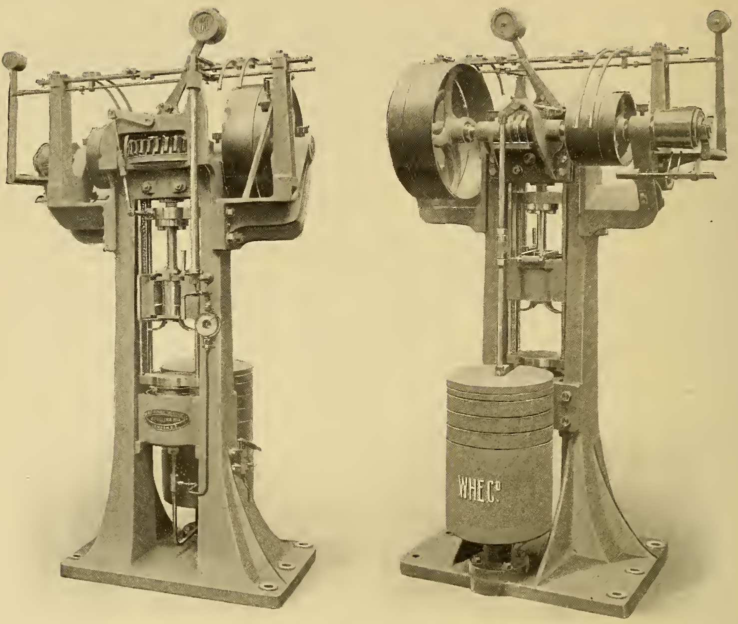


FIG. 9.—FRONT AND BACK VIEWS OF PRESS EMPLOYED BY THE ROYAL GUN POWDER FACTORY, AT WALTHAM ABBEY, FOR MAKING RIFLE AND PISTOL SIZES OF CORDITE. BUILT BY THE WEST HYDRAULIC ENGINEERING CO., LONDON

which the latter displaces being forced into *L* and the surplus into the reservoir *H*.

When the forging is in position on the anvil tool, the valve *G* is operated so as to admit steam into *D* above the piston and open the under side to exhaust. This lowers the left and lifts the right-hand end of the lever *E*, allowing *A* to fall partly by its own weight, also accelerated by the pressure in the tank *H*.

As soon as the top tool touches the forging the rocking lever *E* overruns the cylinder *A* and opens the cylinder *K* to steam, by raising the slide valve *F*. The piston rod of *K* intensifies the pressure in *L* and also *A*. At the same time as the valve *F* is opened a small valve *M* is closed, so that the connection between the cylinders *A* and *L* is shut off from the reservoir *H*.

The speed of working can be altered as desired up to a maximum of about 60 short strokes a minute. The power of the press is 60 tons, and a full stroke of the driver piston causes the hydraulic cylinder to move 4 inches. The whole valve arrangement is very ingenious, but, at the same time, is somewhat complicated, and a reduction in the number of valves would be a move in the right direction.

Fig. 1 shows a 3000-ton hydraulic press in the Royal Carriage Department at Woolwich Arsenal for bending armour plate, gun shields, etc., which was made by Tannett, Walker & Co., Ltd., Leeds. This press is of the ordinary type of bending press, having two main cylinders and rams in the entablature, with the cylinders of the push-back rams in the base, which is below the floor level. The press embodies one novel feature; the main cylinders are not fixed rigidly to the entablature, but are capable of being moved in a lateral direction by the horizontal rams at each end of the entablature. As the cylinders can be moved independently, wide plates of the full capacity of the press can be bent more at one edge than the other without unduly straining the crosshead.

Heavier and more powerful presses than the foregoing are used at the Woolwich Arsenal for forging purposes; but as these and similar presses have been often illustrated in engineering magazines, it has not been considered necessary to describe them here.

Arsenals employ large numbers of all kinds of hydraulic machine tools, similar to those to be met with in general engineering shops, for such operations as riveting, punching, shearing, flanging, pressing, etc., as well as presses for baling clothing, blankets, hay and other stores, not only to economise room on board transports, but also to render them less liable to fire risks. Such hydraulic presses are of the usual types, and are too well known to require special mention.

Of recent years electrically operated machinery has supplanted hydraulic power appliances on account of the convenience with which outlying machines can be supplied with electric current. This is more especially marked in the case of moving machinery, such as travelling cranes, but applies even in less obvious cases, as fixed cranes, punching and shearing machines, bending rolls, etc. For travelling cranes there can be no question that electricity is the most advantageous of all motive powers, and even for fixed cranes, which are constantly at work with loads of greatly varying weights, electricity can show

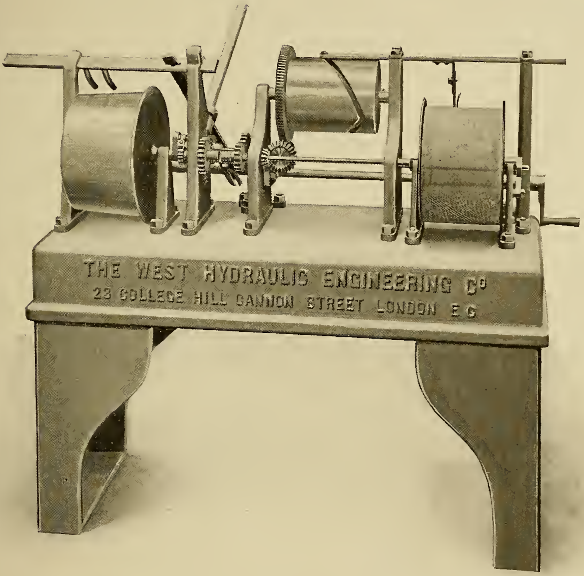


FIG. 10.—WINDING MACHINE FOR REELING CORDITE AS IT COMES FROM THE PRESS SHOWN ON THE OPPOSITE PAGE

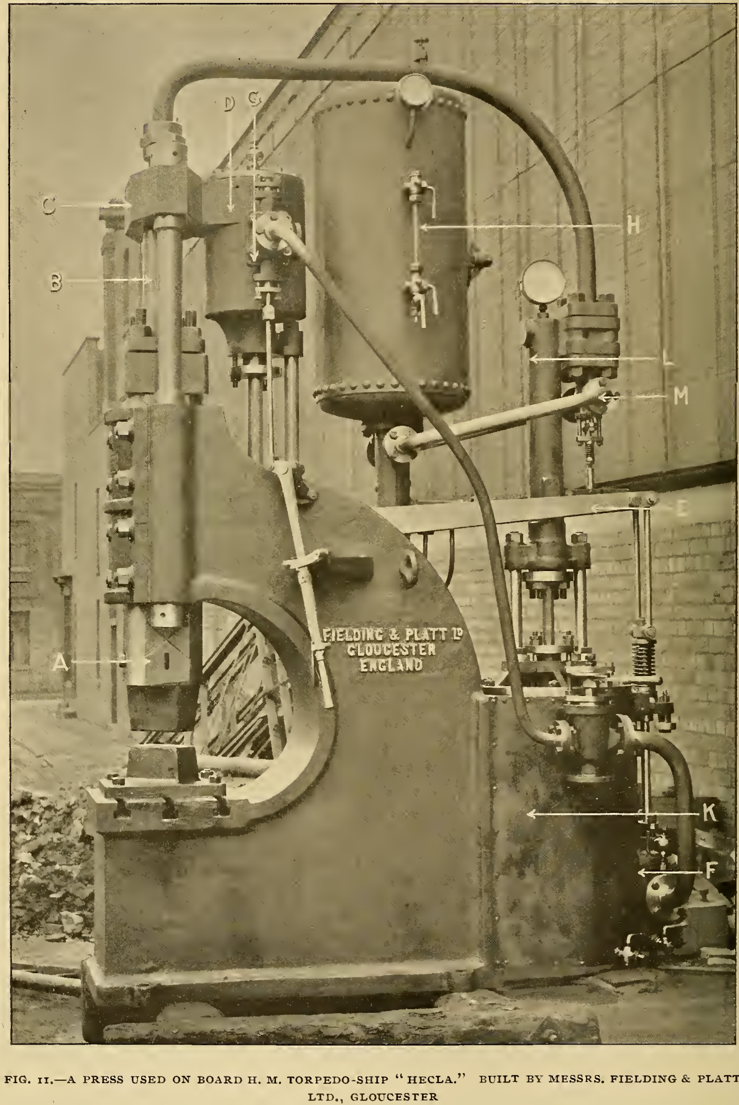


FIG. 11.—A PRESS USED ON BOARD H. M. TORPEDO-SHIP "HECLA." BUILT BY MESSRS. FIELDING & PLATT, LTD., GLOUCESTER

more economical results than hydraulic power, as the consumption of current depends upon the amount of work being performed, while single power hydraulic cranes consume as many cubic inches of fluid whether the load be heavy or light. If, however, the load is always approximately the same, a well-designed hydraulic crane of good construction will have a higher efficiency than an equally good made of electric crane.

For slow-working machine tools, such as manhole punches, where the time is not occupied in the actual operation so much as in getting the material into place, hydraulic machinery is to be preferred, as the speed reduction gear between the motor and the cam shaft are by no means as efficient as the direct-acting hydraulic ram, which has also the advantage of not breaking down if the operator tries to do work beyond its capacity. As all arsenals are now completely equipped with both hydraulic and electric supply mains, the officials are able to decide which motive power to employ, and are consequently free from the worries of the shop superintendent, who would, perhaps, prefer to put down an hydraulic power tool, but who has no hydraulic pressure supply mains, and the installation of a single tool might hardly warrant the erection of a pumping engine and accumulator.

THAWING OUT FROZEN WATER PIPES ELECTRICALLY

By William Maver, Jr.

THERE are a number of claimants for the credit of having first utilised the electric current for thawing out frozen water mains for service pipes. The process appears to have been first applied in the winter of 1898-99, in Chicago and other Western cities, and in Canada. It is said that one of the first users of the process applied for a patent covering this use of electricity, but the patent was refused on the ground that it did not possess any novelty, or that it was too simple.

The principle employed is, of course, quite simple. An electric current is completed through the frozen pipes by attaching one wire of a circuit to a street hydrant, and the other wire of the circuit to the water pipe within a building. Since the iron pipes are much better conductors of electricity than the frozen earth the electric current follows these pipes, heating them to a temperature sufficient to thaw the ice in a comparatively short time.

It can hardly be said, however, that this was a self-evident proposition at the time the patent was applied for, and the fact that the more or less general use of this method followed and did not precede the announcement of the feasibility of the plan, may be assumed to show that it might have required some invention to prove the practicability of the process. Before leaving this part of the subject it may be remarked that there is a tradition, which is probably susceptible of confirmation, that in the early days of the New York electrical cable subways, about 1890 to 1893, it was not uncommon to send a strong current through the lead covering of cables in the ducts to loosen the grip of ice upon them in winter, when it was desired to draw the cables out of the ducts,—a method which might be considered by some an anticipation of the process in question.

It is generally well known that the plumbers' method of thawing out frozen water service pipes is a cumbersome one. In fact, these gentlemen have at least two plans of procedure. One consists in opening the service pipe at a

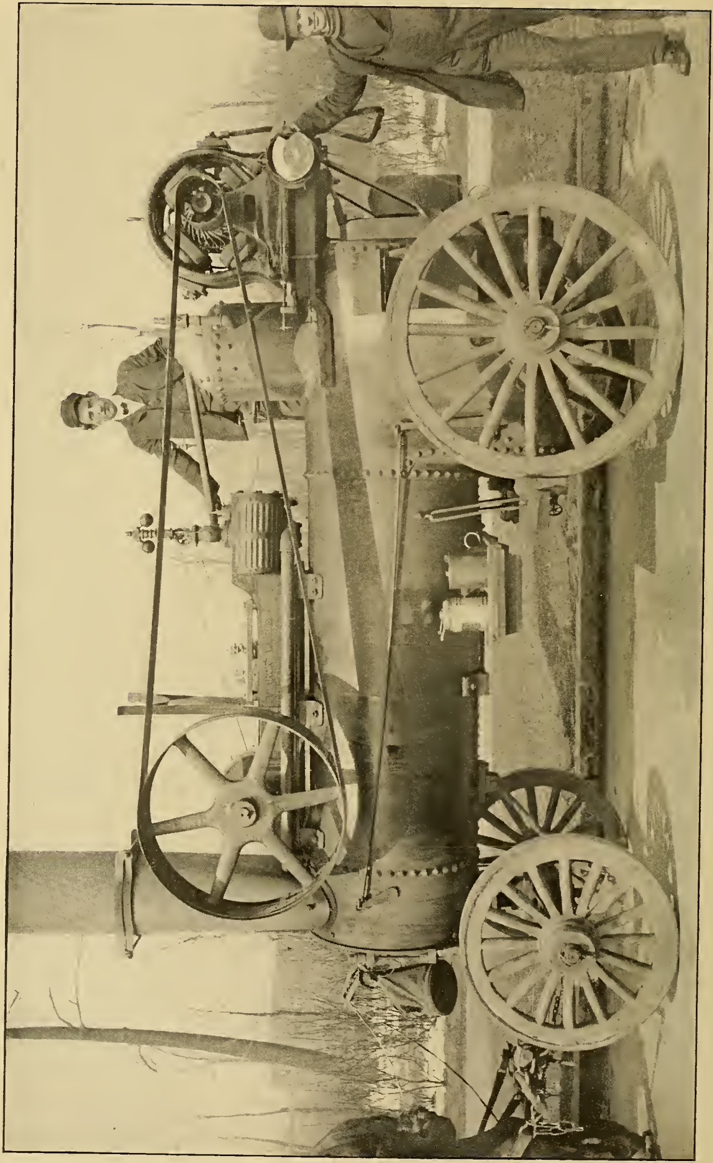


FIG. 1.—A PORTABLE GENERATOR OUTFIT FOR SUPPLYING CURRENT FOR THAWING OUT FROZEN WATER PIPES IS USED IN SOME PLACES WHERE ELECTRIC STREET MAINS ARE NOT AVAILABLE

FIG. 2.—CONNECTING A WATER OUTLET WITH THE ELECTRIC CURRENT SUPPLY

stop-cock within the premises and inserting into the pipe a rubber tube as far as practicable, which if the water pipe is reasonably straight, will be up to the ice. Steam is then injected into the rubber tube and gradually thaws the ice, the rubber tube being pushed further and further in as the ice melts; but there seems to be a well-defined limit in this case beyond which the steam will not carry effectively. The plan is sometimes successful, but has the disadvantage that it is not always possible to readily stop the rush of water at the open end of the pipe when the ice gives way.

Another plan of the plumber, and the one heretofore most generally followed, is to build a fire of wood, coke or coal on the surface of the ground over the water pipes for the purpose of thawing the earth to permit digging down to the pipes, to which heat may be applied externally. This plan is tedious and expensive, and even the plumbers themselves are said to hail with pleasure a method for remedying this trouble which will relieve them of the odium attaching to the profession because of some of the bills to which the digging method has given rise.

The excessive bills referred to are due to the fact that the fire has to be kept going constantly for twenty-four or forty-eight hours, in some cases, and with the double pay for overtime and night work the labour item is large. Bills for $100 for thawing pipes by this process are not uncommon in some cities. There is also the likelihood that, with the earth loosened, the water pipes may freeze again at the same place within a few hours, if cold weather continues.

The plan of thawing out the pipes by heat generated electrically is, on the contrary, clean, expeditious and comparatively inexpensive, and especially in the Eastern States it has been largely resorted to where, owing to the long continued cold weather, the cases of frozen water service pipes in some of the cities have been numbered by the hundreds. In one city alone, of which the writer has knowledge, over 600 frozen water pipes have been thawed out by the electrical process.

There are a number of different methods of bringing the current to the frozen pipes, and almost every ordinary source of electromotive force may be made available for this work by suitable connections and apparatus. There are, of course, some exceptions to this statement, as, for instance, underground electric cables, which cannot readily be tapped. Overhead lighting and power circuits, too, are available only when they are in the vicinity of the frozen pipes; this, however, has proved to be the case in numerous instances.

One method of arranging the connections and apparatus for tapping a 2400-volt, alternating-current overhead circuit is shown in Fig. 3. The temporary connections are made on live wires, and consequently much care on the part of the linemen is necessary. To make the taps, the insulator is scraped off the overhead conductors, and the leads *W W*, which may consist of No. 12 or larger copper line wire, are connected to them by a suitable *T* clamp; or the leads may be simply twisted around the conductors.

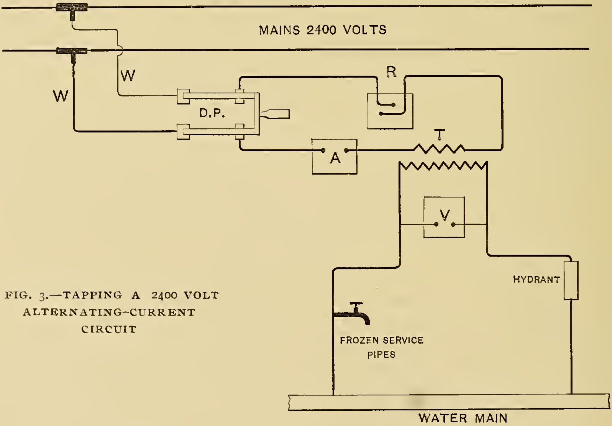


FIG. 3.—TAPPING A 2400 VOLT ALTERNATING-CURRENT CIRCUIT

To facilitate making connections with the overhead circuits and with the city hydrants or faucets within the buildings, at least four sections of well insulated wires, from 100 to 400 feet in length, and of ample capacity to carry the heaviest currents that may be used without undue heating, ought to be carried with the outfit. The terminals to be attached to the line conductors may be provided with close-fitting couplings. In some places sections of No. 000 copper wire have been used for this purpose.

The apparatus indicated in the diagram consists of a double-pole switch *D P*, a water rheostat *R*, an ammeter *A*, an 11-KW transformer *T*, and a voltmeter *V*, all of which are carried to the scene of action on a waggon. The water rheostat is employed to reduce the voltage to a desired amount, say, 20, 50 or more volts in the secondary circuit. In some cases the water is contained in a wooden barrel or in a wooden bucket.

In one arrangement of the water rheostat a coil of bare copper line wire is placed in the bottom of the barrel for one terminal. For the other terminal a number of ordinary arc carbons, tied together by the lead wire, are used; or bare wire alone may be used for such terminals. To increase the conductance of the water, salt may be added, but this is not always considered necessary. When a small vessel is used for this purpose, copper plates are preferable for the terminals. These plates are placed at least 6 inches apart. When

FIG. 4.—IN SOME TOWNS A PORTABLE MOTOR-DRIVEN GENERATOR OUTFIT IS USED IN PLACE OF WATER OR OTHER RHEOSTATS

heavy currents are passing through these rheostats the water may show a tendency to boil, which may be prevented by the addition of ice or cold water.

By means of the ammeter *A* in the primary circuit, the current in the secondary circuit may be calculated, the ratio of transformation being in this case, say, 40 to 1, and the voltage may be read from the voltmeter *V*. When barrel rheostats are used, it is good practice to begin with the terminals about 30 inches apart, gradually shortening the gap. It may be added, however, that after considerable experience in this work with high potentials, some workers have dispensed with the water rheostat altogether, owing to the danger from shock connected with its use. When this is done, reliance is placed entirely upon the transformer to reduce the voltage to a fixed standard for all cases met with in ordinary work of this kind.

Reactance coils are sometimes used in place of the water rheostat, and there are, of course, other well-known means by which the voltage may be controlled without recourse to resistance coils or rheostats; for instance, by winding the transformer so that by a change of the connections any electromotive force in steps of 5 or 10 volts, up to 50 or 100 volts, can be obtained in the secondary circuit.

Another arrangement used on a 2400-volt, alternating-current circuit consists of the usual rheostat or resistance coil, switch and ammeter, together with two 20-KW transformers with the primaries in series and the secondaries in multiple, giving an electromotive force of about 60 volts and 50 to 75 or more amperes in the secondary circuit. With this amount of energy the frozen pipes in numerous instances were thawed out in a few minutes.

Another outfit for this work that has been used successfully in connection with 1000-volt overhead circuits consists of three 6-KW and two 4-KW transformers arranged to be used jointly or separately to give 50 or 100 volts, and 100 or more amperes in the secondary circuit.

While such high potentials as those stated have been used quite extensively for the work in question, with success and without accident, so far as known, it is obvious that there is an element of danger in the handling of the apparatus and in the possibility of grounding the primary circuit through the transformers. There is also a mild objection in some places to the use of the alternating current for this work, namely, that when connected to the water pipes it has been known to set all the telephone bells in the town ringing,—at least all those having ground connections.

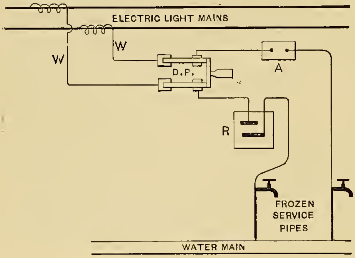


FIG. 5.—CONNECTIONS FROM A DIRECT-CURRENT OVERHEAD LIGHTING SYSTEM

In Fig. 5 are shown the connections from a direct-current, overhead lighting system as utilised to thaw out the frozen pipes in adjoining houses, the connections being made to the water faucets in each building. The pipes in a row of eight houses were speedily thawed in turn by this process. Here the electromotive force on the lighting mains is 220 volts, and in some cases the ammeter indicates over 125 amperes on the water pipes, the current being increased gradually by means of the water rheostat in the manner stated. In other instances the current was increased to 180 amperes before the water flowed. In this use of the direct current, some form of resistance is generally essential to avoid short-circuiting the electric mains and to prevent possible injury to the water pipes from a too prolonged application of the current.

Although the tapping of overhead electric light and power circuits for the purpose of thawing out frozen water pipes has been carried on extensively and successfully for several years past, this procedure obviously possesses certain limitations, as already stated, namely, that the area in which the current can be so used is restricted to the locality of the overhead circuits.

In such cases, however, other ways of obtaining the necessary electric current are available; for example, by means of a portable storage battery or a dynamo driven by a gas engine, both of which sources of electromotive force, mounted on waggons drawn by horses, have been utilised, and will doubtless, when necessary, be much more extensively used in the future for this particular class of work.

The electric light and power companies will probably still retain the bulk of the business by reason of the fact that in ordinary winters the amount of the business of this kind would not warrant the maintenance by private individuals of the requisite independent outfit. To furnish an idea of the revenue derivable from this source in some places, it may be noted that in one city alone an amount approximating $7000 was turned into one lighting company by the water-pipe-thawing department during the past winter.

In a record instance in which the storage battery has been thus employed, the cells were carried on a waggon and were arranged for heavy-current work, the connections being such that the cells could be thrown on in series or in multiple for high voltage and small current, or vice versa, as desired. The heavy current and low voltage were employed for large pipes or mains, and the reverse for small pipes, the voltage used varying from 6 volts and over 800 amperes to 15 volts and 300 amperes. In the first case a small water main about 20 feet long was involved, and water flowed in about three minutes after the application of the current. For a portable gas-engine-driven dynamo outfit, a generator of about 8 or 10 KW, delivering, say, 600 amperes at 12 or 15 volts, will suffice for the work under consideration. The engine ought to be of 12 to 15 H. P. The connections for such an outfit are practically as outlined in Fig. 2, the leads *W W* being, however, connected to the brushes of the dynamo.

Still another portable arrangement that has been used for the thawing out of frozen water service pipes is one in which a 12-H. P. gasoline automobile was drafted into the service, a dynamo of about 7 KW, developing 600 amperes at 12 volts, being mounted on the front part of the vehicle. In this case, the gas engine is employed to propel the vehicle to the desired point, and a belt is carried to the dynamo pulley from the same engine. In one instance in which this outfit was employed the water came in forty-six seconds after the application of the current. This outfit has the advantage that horses are dispensed with, while it retains all the mobility of the horse-drawn vehicle.

Some further data as to the character of the pipes thawed out by the electrical process and the time taken in actual practice for the operation may now be given. In the case of a length of about 45 feet of 1-inch pipe, in which one terminal of the current was connected to the city hydrant and the other to the faucet within the building, with a direct current of 140 amperes, at a pressure of 220 volts, the water flowed in seventeen minutes. In another instance 100 feet of 1-inch pipe were thawed out after an application of a current of 175 amperes for about fifteen minutes.

In one city in which a great many water service pipes have been electrically thawed out during the past winter, the average time of application of alternating current of 100 to 150 amperes at 60 volts was about three minutes. In many cases the water flowed within one minute. When the water did not flow within twenty minutes the attempt to thaw the pipes in this manner was given up, the contracts for the work providing that there would be no charge unless the water was forthcoming.

For this reason, doubtless, the same workers had no success in thawing out frozen fire hydrants; for in another city an application of 90 amperes at 50 volts for fifty minutes produced a flow of water from two adjoining fire hydrants that had been frozen up for some days. It is, in fact, probable that a sufficiently long application of the electric current in sufficient quantity will produce the desired effect in almost every case of frozen water pipe or hydrant, unless perhaps when the frozen pipes are, so to speak, bridged or shunted by much larger mains. Such cases have been met with in practice.

An instance of this condition is illustrated in Fig. 6, in which the service pipes were frozen between the water mains and a gas main, on opposite sides of the street, the mains being cross-connected by a large main at a nearby point. In this case the water pipes within the house were heated to a high degree, but the water did not come, proving that a short circuit of the pipe existed.

In other instances in which the current could not be forced through the service pipes it was assumed that the joints connecting the mains were insulated by means of some non-metallic substance. In still other cases the attempt was unwittingly made to thaw out service pipes which were connected to earthenware mains.

In the case of a water main 4 inches in diameter, about 110 feet of which were frozen, a 10-volt alternating cur-

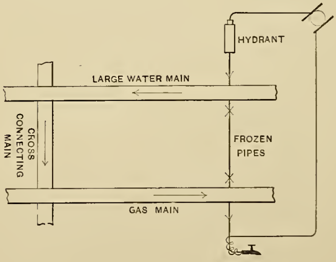


FIG. 6.—A CASE OF CROSS CONNECTION

rent of 150 amperes brought a flow of water after a six-hour application of the current.

In still another instance in which 80 feet of ⅝-inch lead pipe connected to 20 feet of 6-inch iron pipe were involved, an alternating current of 185 amperes at 35 volts brought water in about fifteen minutes.

Frozen gas service pipes have also been successfully treated by the electrical process, but usually the time of application of the current is longer than in the case of water pipes.

In all of the foregoing instances the connections were made at the most accessible points, as at fire hydrants, water faucets, and the like. When the mains are frozen in places at which the pipes do not come to the surface at two nearby points, it is then necessary to dig down to the pipes to make suitable connections with them.

As previously remarked, care must be taken not to apply the current long enough to unduly heat the pipes. So far as the writer is aware, no case of overheating has thus far occurred in practice, the ice and the cold water apparently sufficing to keep down the temperature of the lead or iron pipes. Temperatures of 100 degrees F. have been observed on pipes thus treated, but this is still far below the melting point of lead,—617 degrees F.

While it is a well-known fact that the freezing of exposed service pipes in buildings is almost invariably followed by the bursting of the pipes by the expansive force of the freezing water, it has been observed in connection with the work of thawing out the service pipes that a case of bursting pipes in the earth is very rare,—less than 1 in 600, according to the writer's best information. This is assumed to be due to the fact that the earth first freezes rigidly around the pipes, exerting a counter pressure on the outside of the pipes, thereby preventing them from giving way to the internal pressure.

In thawing out pipes by the electrical process, the ice in the pipe first melts close to the metal, allowing the water to flow through in small quantities at first, but this is soon followed by the full flow of water. In some cities the first flow of water is accompanied quite often by a large amount of muddy water and solid pieces of sediment, as though the freezing had loosened the scale on the pipes. This has led some one to suggest that artificial freezing and thawing of the pipes might afford an economical and efficient method of scouring out service pipes.

THE WATER SUPPLY OF MODERN CITY BUILDINGS

A DISCUSSION OF SPECIFIC SYSTEMS

By Wm. Paul Gerhard, C. E., Mem. Am. Soc. M. E.

N.

CONCLUDED FROM THE OCTOBER NUMBER

THE writer has already pointed out that the pressure with which water in some of the principal cities is delivered to the buildings is insufficient to reach the upper floors of large and particularly of tall buildings. If corporations, building and construction companies, and real estate speculators will persist in erecting so called "skyscrapers," it is unreasonable to require that the municipality should provide a water system adequate for their special and certainly unusual requirements. The correct view, it seems to the writer, is to maintain that owners of such lofty structures must themselves provide the necessary arrangements to supply water at the higher floors for domestic use as well as for fire protection. In other words, each tall building should install its own water supply plant, with ample means for raising and storing a suitable quantity of water sufficient for all needs. In New York, for instance, the water pressure, even in the residential districts, is often insufficient to supply the stories above the second, and the owners of private houses have long ago submitted to the necessity of providing pumps and house tanks. Numerous kinds of pumping apparatus are in use for this purpose, such as hot air and gas pumping engines, and in later years much use has been made of automatic electric pumps wherever electric power is available from the street. For the larger buildings, to which this article chiefly refers, the choice is usually restricted to either steam or electricity as motive power for the water-lifting apparatus.

As long as commercial buildings did not exceed eight or ten stories it was the common practice to locate one or more tanks on the roofs of the buildings (Fig. 1), and to keep these filled by means of steam pumps; the supply was distributed downwards by means of a falling main, with branches for the fixtures on each floor. There are some drawbacks and disadvantages to the roof tank system, such as the liability, and, indeed, the probability, of the

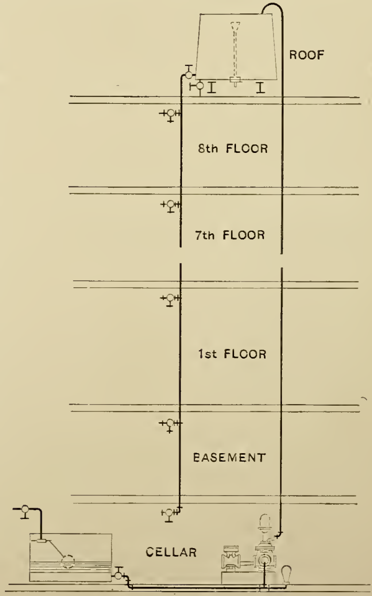


FIG. 1.—THE EARLY PRACTICE OF HAVING SIMPLY ONE OR MORE ROOF TANKS

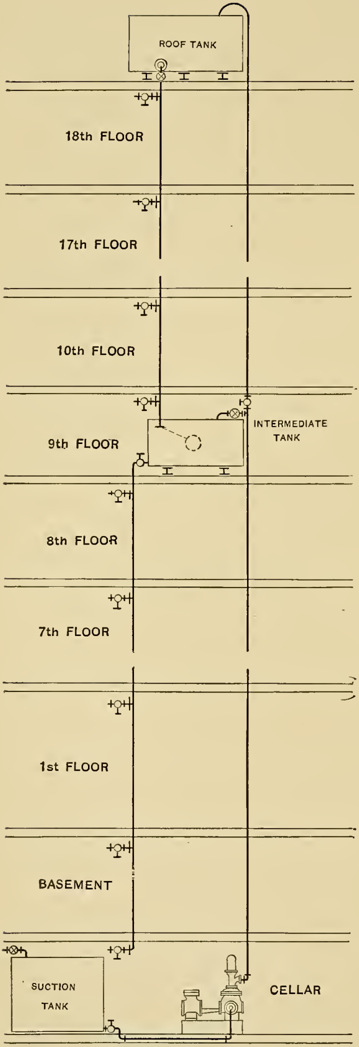


FIG. 2.—USING AN INTERMEDIATE TANK, SUPPLIED BY THE PUMP RISER

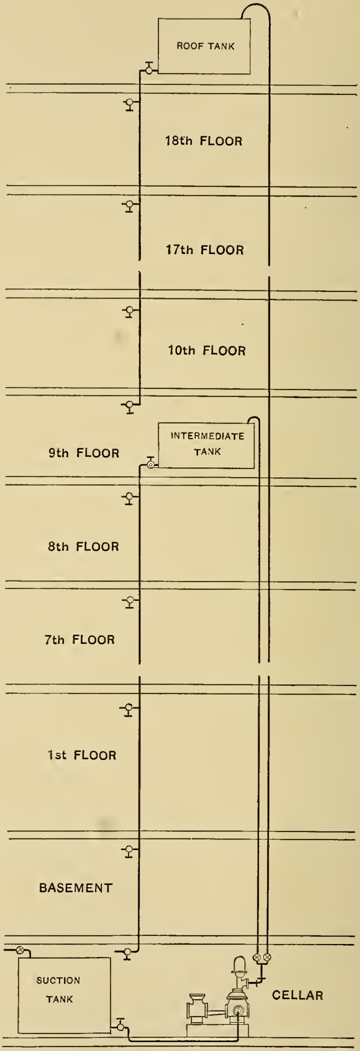


FIG. 3.—SEPARATE PUMP RISER FOR THE INTERMEDIATE TANK

water becoming polluted by exposure to dust, smoke and gases from the soil and vent pipes extending to the roofs of all buildings, and the possibility of tanks and tank pipes freezing in extremely cold weather; furthermore, provision has to be made not only for heavy *I*-beams as tank supports, but the entire iron superstructure has to be calculated of sufficient strength for carrying the weight of the roof tanks and their contents.

With the advent of the skyscrapers it was found that the pressure of water at the fixtures and in the piping of the lower floors became too heavy when the supply was drawn from a roof tank. In the further development of these structures various modifications of supply systems originated, which require brief mention. The first step consisted in providing intermediate tanks. These were supplied either from the roof tanks or by a branch on the pump riser, operated at the tank on the intermediate floor (Fig. 2), or more often by means of separate pump risers controlled by valves in the engine room (Fig. 3).

The latter two methods are preferable, as they do away with the necessity of lifting the entire water required for the building to the height of the roof, involving a considerable unnecessary expenditure in fuel for pumping. In a twenty-story building, for instance, instead of pumping the entire supply for the twenty floors up to the roof, only the supply for the upper ten stories is so pumped, whereas about half the supply is pumped only to half the height into the intermediate tank provided for.

Such intermediate tank, or tanks, however, occupied valuable floor space, particularly in office buildings, where every square foot of space is reckoned as of so much rental value, and this objection led to other methods being tried. A direct pumping system was installed in many instances, consisting in connecting the supply risers directly to the house pumps, which were provided with automatic relief or blow-off valves (Fig. 4). The speed of the pumps was gauged and regulated either by the engineer or automatically, so as to provide for the fluctuations in the consumption of water, and the pumping machinery was installed in duplicate, so that in case of a temporary breakdown of one pump the floors of the building would not be left without water. Such a system, inferior as it is, because it provides no fire protection from Saturday to Monday, when the fires in the steam boilers are banked, might possibly answer for office buildings or lofts, but it would not be suitable for hospitals or hotels, for it provides absolutely no reserve storage of water. Another system tried was the use of roof tanks, the branches to the fixtures being controlled by pressure-regulating valves on the lower floors (Fig. 5) to obviate the defect of a too heavy pressure at the fixtures.

But the modern tendency is toward

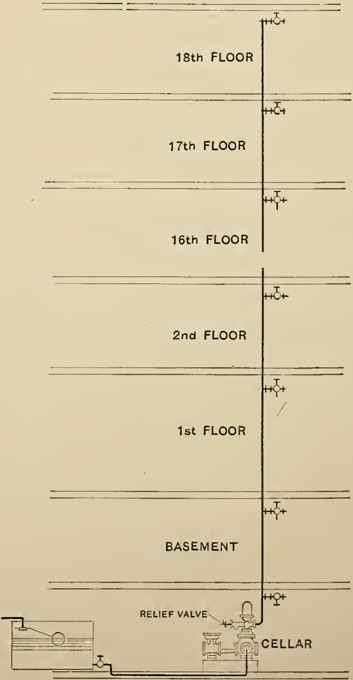


FIG. 4.—A DIRECT PUMPING SYSTEM

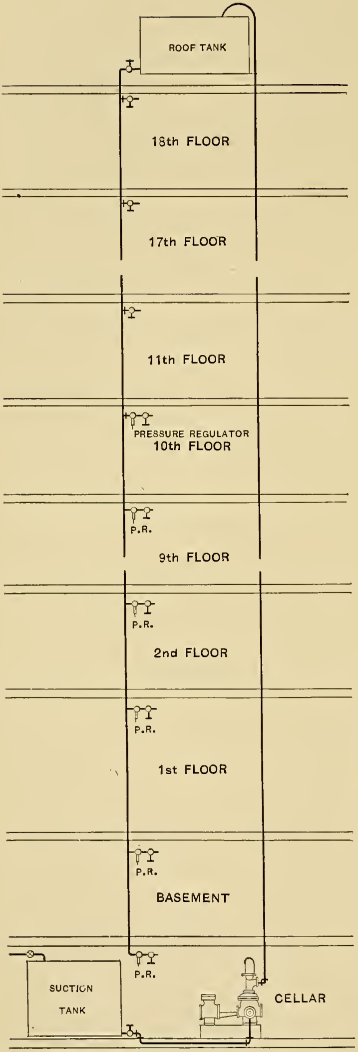


FIG. 5.—ROOF TANK WITH PRESSURE REGULATING VALVES ON THE LOWER FLOORS

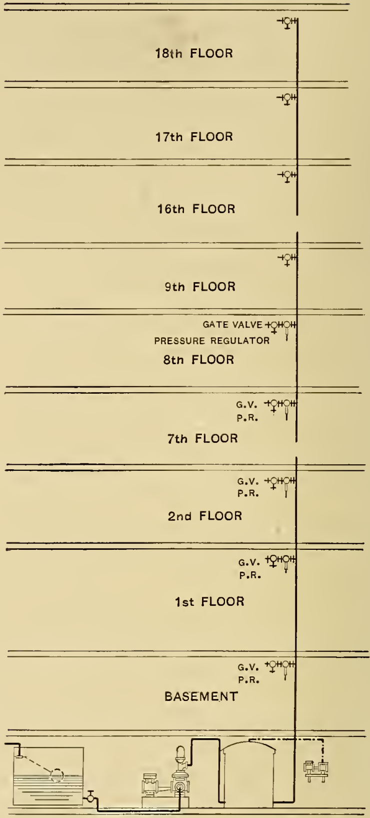


FIG. 6.—PRESSURE TANKS IN THE BASEMENT

the omission of the roof tanks, and the substitution of pressure tanks or drums located in the sub-basement (Fig. 6). These are filled partly with water and their upper parts with air under a pressure sufficient to supply the highest floor. In the better systems of this class the air is compressed by means of special air compressors, and a supply of compressed air is often kept in storage in compressed air drums. The pressure on the lower floors is in such a case again controlled by pressure regulators. A still more complete system provides several distinct pressure zones (Fig. 7), by means of separate pumps and pressure drums for the upper, intermediate and lowest stories; but even in this better system, in which no pressure-regulating valves need be used on branches, the drawback remains that when the pumps stop running very little or no water is available for use. In such systems the mains for the upper lines are distributed in the pent house, while those for the lower ones are run at the cellar ceiling.

Another system, having many sanitary, constructive, and mechanical advantages, provides (Fig. 8) in the sub-basement not only large water storage tanks, but also air tanks, in which air is stored under high pressure, and admitted to the water tanks under a reduced pressure. In this system, which has numerous excellent features, it is possible to obtain water on the higher floors even when the pumps are not running and the fires in the boilers are banked; a special fire pump may be dispensed with, and the only objection is that it requires in the cellar a rather large space for the water and air tanks, which, however, can often be minimized by setting the air and water tanks over one another. Finally, a pressure tank system may be installed in connection with an auxiliary smaller roof tank, which provides some storage of water during a short breakdown of a pump (Fig. 9).

For the water pumping plant of large modern buildings either steam or electricity is used as motive power. Such buildings always require a power plant, and, therefore, steam is available under high pressure. If the building occupies a large area and the power plant is distant from the place where the water pumping plant is located, electric pumps may be chosen, because the electric

FIG. 7.—SEPARATE PUMPS AND PRESSURE TANKS FOR THE UPPER, INTERMEDIATE AND LOWEST FLOORS

transmission of power may prove to be better and cheaper than the running of long steam mains in which condensation necessarily takes place. In that case the pumps for lifting water may be triplex plunger pumps, either direct-connected or driven by means of belting; or the pumps may be rotary screw or worm pumps; or, finally, they may be centrifugal pumps, which quite recently have been much modified and improved so as to be adapted to high lifts.

In the majority of large buildings, however, the pumping machinery is run by steam. Pumping machinery should always be installed in duplicate, to guard against the interruption of the water service by a breakdown, for those who live in cities have become so accustomed to the benefits of a constant water supply that they fail to realise how much depends upon it, and what inconveniences would result from a sudden interruption in the flow. It is not an exaggeration to say that in dwellings, office buildings, factories, and hotels a general upsetting of the activities of life would result were the supply of water to cease for any extended period of time.

The usual practice is to install reciprocating pumps of the direct-acting type. The pumping engines of buildings are usually of the horizontal type, and vertical types are used only where water is pumped from an artesian well, or else where floor space is very restricted.

Until a few years ago the pumps used were either the single or the duplex non-compound, non-condensing kind. Although such pumps have not a high duty, they are installed because of their cheapness, absence of complication, ease in maintenance, and also because they occupy but little space in the engine room. Such pumps are run under a boiler pressure of about 50 pounds. For fire service, the stronger built fire pumps are installed, and in particular the so-called "Underwriter" pattern duplex fire pump, built in accordance with strict and detailed specifications prepared by well-known experts, with a cross connection to the house service pumps so that they may be used alternately for the ordinary water service of the building.

In recent years, owing to the fact that many buildings find it more economical to have their own lighting plant, the steam pressure carried in the boilers has been increased to 90 pounds and even more. Naturally, engineers became anxious to use for the water-pumping plant some apparatus which would give a higher duty or economy in fuel consumption. While it seems

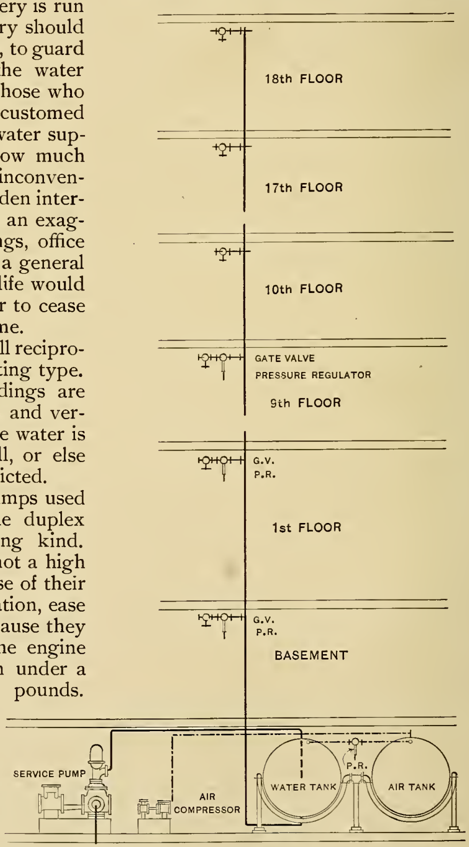


FIG. 8.—WATER STORAGE AND AIR TANKS IN THE CELLAR

impracticable to install the regular high-duty expansion and condensing pumping engines with crank and fly-wheel, such as are used in modern water-works machinery, considerable saving in steam may be effected by using single tandem or duplex compound pumps; even triple-expansion pumps are installed, though mostly in connection with the pumping of water for the hydraulic elevators. The compounding of pumping engines effects a saving of about 30 per cent. in the consumption of fuel, and a further saving of about 20 per cent. can be effected by using condensing engines, with either jet or else surface condensers.

As a rule, however, such improved apparatus is not looked upon favourably by the architects or by the managers of buildings, because its first cost is much greater, and also because the pumping engines are more complicated to run and require a much larger space, which, at least in the cellars of office buildings, is hard to find, the cellar being already crammed full of machinery of all kinds. It is, nevertheless, the duty of the engineer to his client to suggest and recommend, first of all, such apparatus which is economical in running cost, and the future will doubtless see much improvement in this part of the mechanical equipment of buildings.

Wherever possible the pumps should not be located in the boiler room, where they would be constantly exposed to the dust from the coal and the ashes. There should always be a separate pump room, located not too far from the boiler room, in order to get short runs of the steam piping supplying them. The pump foundations should be substantial and rigid and isolated from the foundation walls, to prevent the transmission of vibration. In modern large buildings much more attention is paid than formerly to the proper equipment and finish of the pump rooms, and the mistake, so common formerly, of putting expensive machinery and apparatus in dark and cramped and sometimes damp cellars, is avoided.

The pump room should have abundant light and good ventilation. There should be a generous space all around the pumping machinery, as this tends to facilitate good maintenance and renders all working parts easily accessible. Perfect cleanliness should be maintained in the pump room, and this is more easily accomplished and the room made to look attractive by using for the floors, walls, and ceilings materials which can be easily kept clean, such as vitreous, unglazed tiles for the flooring, and glazed tiles, enameled brick, or marble

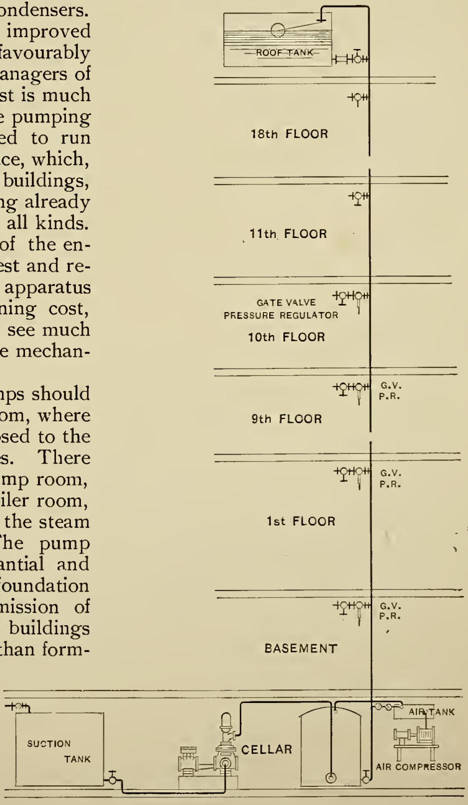


FIG. 9.—A PRESSURE TANK SYSTEM WITH A SMALL AUXILIARY ROOF TANK

wainscot for the walls. There should be provided in each pump room a gauge board with gauges for steam, water, and air pressure; vacuum and altitude gauges; counters registering the number of strokes of the pumps, and an electric clock.

In all large modern buildings provision must be made for a supply of hot water. According to the character of the building, the supply of hot water will be from one-fourth to even one-half of the entire supply; a fair average would be about one-third. The water is nearly always heated in large closed tanks by means of steam coils, and the steam used for the purpose is either high or low-pressure steam, or exhaust steam. The latter is not usually available in winter time, when it is used for heating the building; but in summer time, rather than let the exhaust steam escape into the atmosphere, it is used, sometimes mixed with live steam for heating the water. The temperature of the water is measured either by sight or by recording thermometers and it is, or should be, controlled by means of automatic thermostats, of which there are a number on the market.

In distributing the hot water in the building provision for circulation should be made, so that it will flow hot almost immediately when a faucet is opened, otherwise much useless waste of water will be caused by letting the faucet run until hot water appears. The circulation is accomplished either by providing each hot water riser with a circulating line returning the water into the bottom of the heater, or else, in the case of large buildings with a number of hot water risers, the system is so arranged that one vertical line will be a flow line, whereas the next will be a return line, the two being looped together with necessary check valves so that the flow will occur only in one direction.

Regarding the temperature to which water should be heated, much depends upon the character and object of the building. In bath houses modern practice provides for large volumes of water heated to a temperature not exceeding 140 degrees rather than for a limited quantity of very hot water at from 170 to 180 degrees. In hotels and institutions where there are kitchens, pantries, sculleries and laundries, these require for the dish-washing, and also for the washing of clothes, water heated to at least 180 degrees. For buildings of limited floor area, but of many stories, one or two large hot water heaters placed in a central position relative to the distributing system are considered the best practice; but for buildings occupying a large floor area, or for groups of buildings connected together, it is cheaper and better to decentralise the hot water plant, and to provide several hot water heaters at different points. The steam required for warming the water can be conducted to the tanks more economically than it would be to run an extensive distribution system of hot water pipes at the ceilings of the lowest floors from a central hot water heater to all the distant buildings of a group.

Systems of fire protection for large modern buildings are now in some cities required by law. But whether so called for or not, it is always wise to install an efficient fire-protection apparatus, for even in so-called fireproof buildings there is a large mass of combustible furniture and of inflammable goods, papers and other office materials which may catch fire and endanger the lives of the tenants by flames and by smoke. The fire-extinguishing apparatus put in should be chosen with a view of putting out a fire in its incipiency, and before it can gain any considerable headway. It should consist of fire standpipes, with outlets on every floor, and provided with fire valves, hose and fire nozzles. There should be, in addition, on each floor portable fire extinguishers and some fire pails. The diameter of the standpipe should be increased with the height of the building, and it should never be less than four inches.

For buildings of large floor area several lines of standpipes should be installed. These standpipes are connected with the fire pump in the cellar, and they also have branches with gate and check valves leading to some conspicuous point outside of the building where the so-called Siamese fire department connections are provided, to which the firemen, when summoned to a fire, connect their hose. In many cases the fire standpipe is also connected with the roof or pressure tank system, so that in case the fire pump should cease to operate the available supply of water in the tanks may be utilised to put out a small conflagration.

This article would not be complete without some brief reference to the materials used for the distribution of water. In modern buildings very little lead pipe is used. The piping consists either of galvanised standard wrought iron lines or else of tinned and semi-annealed brass pipe. The latter is the more expensive, but also the more durable, material. For the piping of very high buildings, in which the water pressure in the lower half of the building becomes very heavy, the extra heavy wrought iron pipe is used. In the fittings used for the control of the flow of water a pronounced tendency is noticeable in recent years to use gate valves in place of lever-handle stop cocks or globe valves, this change being the result of recommendations of leading hydraulic engineers who concur in the view that gate valves are preferable because they have a full waterway, and, therefore, give a better flow of water.

In the arrangement of the water supply distribution of modern buildings, considerable improvement is noticeable in the better protection of water supply pipes against freezing. The principal pipe lines are carried more exposed and accessible than formerly; hot water lines are covered with non-conducting covering to prevent loss of heat from radiation, and cold water pipes are similarly covered to prevent sweating or condensation. All fixtures where water is drawn are provided with separate shut-off valves and with air chambers, and where pressure-regulating valves are used, they, too, perform a useful incidental function in acting as cushions and preventing sudden shocks and excessive water hammer, endangering the stability of pipe lines.

Much attention is paid in the running of the supply pipes to prevent the heating up of the cold water from the hot water lines. Faucets, ball cocks and flushing cisterns are made of the best and most durable material, a more extended use is made of polished red metal in place of the perishable nickel-plating, and there is considerable improvement in the numerous other details of the water service. The only point, possibly, in which no progress has been effected is in the noise accompanying the flow of water in pipes, or the flushing of the fixtures. It must be conceded that the solution of this problem in domestic water supply is beset with difficulties.

An extended discussion of plumbing work would be out of place in an article dealing with water supply, and a few points only regarding the fixtures in which the water is utilised will be mentioned. Improvements of lasting quality have been made in the manufacture of both the high-grade enameled ironware and of the solid glazed porcelain ware, for lavatories, bathtubs, and sinks Fixtures of either materials have reached such a high degree of perfection that it is difficult to predict further improvements. Wash basins with plug and lift arrangements are the most sanitary, and among the best recent basin faucets is a self-closing measuring and waste-preventing faucet with convenient push bottom, which seems to be perfectly adapted to the requirements of modern buildings other than residences. In public buildings, hotels, office and commercial buildings and in institutions, special drinking fountains are provided and supplied with artificially cooled water, kept in continuous circulation.

In the water supply to water closets and urinals a tendency has recently sprung up of discarding the reliable overhead flushing tank, and using instead a flushing valve or " flushometer." The results attained in the use of such fittings are, in the writer's judgment, not in accordance with the broad claims made for them, and appear, on the whole, to be of doubtful advantage. Closets with flush valves are not, as the writer finds them in actual practice, always reliable; they are not noiseless, as claimed, except where the flush is unduly cut down; the valves easily get out of order; in a row of many closets no two will be found to work quite alike. If a general roof flushing tank is used to supply the flush valves (as required by some plumbing regulations), the system of flushing becomes excessive in cost. In the opinion of the writer the regular overhead flushing tank should be retained as the standard, which it is not easy to improve upon, and where, in exceptional cases, this cannot be used for lack of proper head room, the low-down tank closets are superior to closets with flushing valves.

A novel feature of water closet bowls deserves special mention, because it forms almost the only improvement brought forward in recent years. This is a bowl so arranged that its rear inside, if bespattered from use, is efficiently flushed after each use, while the front portion is so patterned that no spilling of urine between top of bowl and seat can take place. This removes about the only objectionable feature of the modern open plumbing work of water closets.

The automatic flushing of urinals was exceedingly wasteful of water, but the new chain and pull flush tanks solve this problem, and the general public is gradually getting accustomed to making use of the pull flush. The best urinals for public places are those made in niche form of solid glazed porcelain.

Mention should be made of the increasing tendency to do away with the expensive and useless branch venting of traps, and of the steadily increasing use of good non-siphoning traps for fixtures.

Regarding the general arrangements of toilet rooms in tall, modern office buildings, a vastly better plan is to have a few water closets, urinals and a lavatory on each floor rather than to provide one general large toilet room for the use of the tenants of all floors, for the latter plan, though it seems to be the favourite with architects and real estate men, leads to a great loss and waste of time of office employees, besides tending to crowd unduly the elevator service of the building. Proper attention is given to the ample and efficient toilet room ventilation, and this being accomplished and the fixtures sanitarily arranged, well-flushed and maintained in cleanly condition, there exists no longer any cause for the use of the objectionable disinfecting toilet agencies which are, at best, palliative remedies, not to be compared in efficiency with a good plumbing and water service.

WARSHIPS OF THE GREAT POWERS

A STUDY OF RELATIVE COSTS

By Archibald S. Hurd

NAVAL power of the first class is becoming more and more restricted to those nations which have large financial resources, high technique and well-organised industrial conditions. As men-of-war benefit by scientific research in its bearings upon warfare afloat the outlay on the equipment of warships increases. The modern war vessel is the outcome of a hotly waged contest between the two naval schools of offence and defence. On the one hand there is the gunnery officer, the torpedo officer, and the engineer, each clamouring for consideration of his individual claims when a new ship is being designed.

The engineer urges the importance of speed as a tactical advantage of the highest value in cruisers and of relatively great importance in battleships, since it is the swift ship of whatever class which can fight or run away, and it is the swift vessel which can choose the formation of battle and the range at which it is to be fought. These advantages have been illustrated in the manœuvers of the British and American fleets, and the naval officer of the school of offensive warfare regards the engineer with more favour than was once the case, so long as he does not poach on what is regarded as the minimum equipment of guns and torpedoes. Between these two arms a continual contest is waged, and the result of the Japanese tactics in the opening of the war between Russia and Japan has given to the newer weapon an advantage, which will probably produce some changes in naval design.

On the other hand, there is the defensive school, which urges the importance of heavy armour in order that the stability of the vessel may be preserved under fire. The outcome of this competition between armour, guns, torpedoes and steam is a compromise. As a rule, the gunnery and torpedo officers' claims receive first consideration in a battleship's design after provision has been made for a due measure of protection, and moderate power only is provided for in the engine room.

In cruisers speed comes first. In armoured cruisers of recent date a fairly successful attempt has been made to turn out a battleship with the travelling power of the swiftest cruiser. The success of these vessels has reacted upon battleship design, and consequently the space devoted to propulsion has of late been growing at an astonishing rate. In some of the European navies, constructors are required to obtain a speed of nineteen knots, in battleships, and Col. Cuniberti, the naval constructor of the Italian fleet, has such faith in the tactical advantage of speed in the heavy ships of the fighting line that he is building battleships which are to have a speed of twenty-two knots, a 10-inch belt (4 inches at the ends), carry two 12-inch and twelve 8-inch guns, with 8 and 6-inch armour protection and stowage for 2800 tons of coal,—and all on a displacement of 12,625 tons. No other Power has attempted to imitate this design.

It is recognised that a ship is only a moving gun platform, and to obtain

TABLE I—BATTLESHIPS

Ship	Date of Completion	Displacement	Cost	Weight of Armour (Tons)
Warrior, first ironclad built	1861	9,210	£380,000	980 (iron)
Bellerephon	1865	7,550	356,000	1,100 "
Hercules	1868	8,680	370,000	1,340 "
Devastation	1873	9,330	360,000	2,540 "
Inflexible	1881	11,880	812,000	3,160 "
Anson	1889	10,600	791,000	2,800 (compound)
Resolution	1894	14,000	929,000	4.500 "
Majestic	1897	14,900	983,732	2,880 (Harvey steel)
King Edward VII	about 1905	16,350	1,426,000	-----------
ARMOURED CRUISERS				
Imperiense	1886	8,400	530,000	-----------
Galatea	1889	5,600	291,000	-----------
Bacchante	1902	12,000	787,000	-----------
Good Hope	1902	14,100	1,040,000	-----------
Kent	1903	9,800	735,000	-----------
Black Prince	1906	13,550	1,138,000	-----------
PROTECTED CRUISERS				
Blake	1892	9,000	460,000	-----------
Edgar	1893	7,350	429,083	-----------
Crescent	1894	7,700	411,000	-----------
Powerful	1898	14,200	742,000	-----------
Ariadne	1900	11,000	566,000	-----------

high speed on a relatively small displacement something must be sacrificed or the displacement increased. Consequently in the effort to produce ships combining all the claims of each department and of each school of thought without reducing the strength of the hull or the radius of action, it has been necessary to add to the size. The result has been that in the British, American, Russian and Japanese navies, all of which will soon have afloat ships of over 16,000 tons, the fashion at the moment is in favour of great dimensions, and the moderate dimensions school is in disfavour.

This tendency to increased size and cost can best be illustrated by a few figures drawn from the progress of the British navy, showing not only the increase in displacement, but the growth in the outlay upon ships which has been out of proportion to the augmentation in size, and is due to the introduction of expensive and elaborate scientific equipment and machinery. In Table I. are given the figures as to some typical battleships and cruisers of different dates.

These figures are impressive. They show the immense increase in the cost of modern ships of war, a rise, to take a recent instance, from under a million for the battleship *Majestic* to nearly one and a half millions, the cost of each of the eight vessels of the *King Edward VII.* class now under construction. In the case of cruisers we have an almost corresponding growth, for the armoured cruiser has now displaced the protected ship, and the expenditure runs from three-quarters of a million to over a million sterling.

These figures are sufficiently startling, and reveal the difficulty experienced by a poor country in keeping pace with the programmes of rich neighbours. Italy has failed to maintain her position in comparison with France, and France has signally failed to hold the place she occupied fifteen years ago in contrast with Great Britain, while further west the United States is fast overhauling several European rivals.

But it is not only a matter of money, though with money a very imposing fleet can be bought, as Russia proved when she needed men-of-war in the Far East to support her diplomacy, and as Japan has found, for she also went abroad for all the large ships in her fleet. Japan was wise; she not only acquired the ships, but she trained officers and men on the best system and fitted out adequate bases for the maintenance of a fleet.

Money goes a great way, but unless a nation is prepared to buy everything abroad it needs great mineral resources, especially iron, high technique for the construction of ships, guns and torpedoes and the manufacture of armour, and a smooth-working industrial organisation. Even if she has these advantages her course is not a clear one, for the continual developments in every detail of warlike material is continually causing machinery, representing colossal sums, to become useless. From year to year mechanism representing a huge capital is rendered ineffective, and it has to be put on the scrap heap. All this means the employment of vast sums of money, and not only adds to the cost of the output, but calls for a high courage on the part of those who are willing to realise the instant when it is the truest economy to "scrap" what may quite recently have entailed a large expenditure.

In this respect industrially backward nations are severely handicapped. Consequently naval strength is more and more to the strong—the strong financially, industrially and intellectually, for it is only the quick, "bright" man who can recognise when further additions must be made to the scrap heap. Another important consideration is that with the increase in the size of ships, especially the growth in the length of cruisers,—the *Powerful* and *Good Hope* types are 500 feet long,—new and most costly docks have to be provided wherever these vessels are serving.

It is not without some interest to note how the gross total cost of a modern man-of-war is arrived at, for it is not easy at first sight to see how as much as a million and a half sterling can be put into a single floating gun platform, displacing only 2350 tons more than the new battleships of the *Duncan* type, 19-knot vessels of 14,000 tons, and only 1450 more than those of the *Majestic* class. Admiralty figures are available for one of the eight huge ships of the *King Edward VII.* class. These are the chief items for (a) one of the latest ships of the largest class of 18 knots, (b) a battleship of the *Formidable* type of 15,000 tons and 18 knots, and (c) an older ship of the *Majestic* class of 14,900 tons and 17½ knots:—

	King Edward VII. (16,350 Tons)	Formidable (15,000 Tons)	Cæsar (14.900 tons)
Hull, fittings and equipment	£818,900	713,562	631.324
Propelling and other machinery	217,068	205.319	85.573
Gun mountings and torpedo tubes	215,141	123,022	77,275
Guns	89,070	71,670	64,420
Incidental charges	86,087	82,802	77,154
	1,426,266	1,196,375	935,746

Here is an illustration in some detail of the immense sum which is spent on an armoured man-of-war of the latest type, and further analysis would reveal that a large part of the cost of the hull is represented by the armour, a most serious item, because, owing to the repeated changes in the process of manufacture, the cost per ton is continually increasing. On this aspect of naval expenditure the Admiralty shed no light. Only the officials at Whitehall and the contractors know what is paid for the Krupp steel with which ships are now being provided.

The actual weapons of offence are not expensive in comparison with many other details. The guns of the *King Edward VII.* entail an expenditure of only £89,070; those of the *Formidable* class, £71,670; while the armoured cruiser *Good Hope's* armament cost only £46,040, and that of the cruiser *Kent*, of 9800 tons, only £29,100. It is not the mere guns with which the fighting is done which runs into huge figures, but the type of platform on which these weapons are carried, the character of their mountings, the power of the machinery, the defensive qualities of the armoured belt. Guns are comparatively cheap, but armour is a serious detail which looms large in a ship's estimate. As Mr. Francis Elgar, himself at one time Director of British Dockyards, remarked in a paper read before the Institute of Naval Architects in 1895:—

"Reference is often made to the enormous cost of modern battleships. Each ship of the *Royal Sovereign* and *Magnificent* classes costs, with incidental charges, £850,000 to £900,000, without armament, ammunition, or sea-stores. A little over two-thirds of this amount is expended upon the hull, fittings, and equipment. The most important item of cost is, however, the armour plating; and it is a peculiarity of this item that while the cost of hull, apart from armour, and the cost also of propelling machinery has been greatly reduced during recent years, the cost of armour has been increasing. Modern mechanical improvements, that have so much diminished the cost of production in other departments, have failed to prevent the market price of armour plates from increasing. The armour of the present day is twice as costly as the iron armour of twenty to thirty years ago. The result is that we have reached a point at which the vertical armour upon a ship costs double that of all the other materials of the hull, including the whole of the fittings and equipment, as in the *Royal Sovereign* class; and where it amounts to nearly half the total cost, for materials and labour, of the hull, fittings, and equipment, as in the *Magnificent* class.''

The sums spent upon British ships seem large, and yet the expenditure is less than in any other country, nor are the reasons for this far to seek. It is true that wages in England are higher than on the Continent of Europe; but, on the other hand, they are less than are paid in America. One of the main causes of the differences in the outlay lies in the fact that England has a huge mercantile marine, and still builds an immense tonnage for foreign merchant fleets, apart from the orders she receives from the governments of many states for men-of-war. If works are economically managed, the result of a large output of work, of the ability to keep the machinery and the hands always employed, is a saving in the cost.

For many years past, employment in the British yards has been fairly constant, and another benefit has arisen therefrom. When work is spasmodic, the men who are discharged, it may be well skilled hands, are apt to drift off into other employment; but in England the steadiness of the demand has enabled firms to give high and regular wages to an immense army of skilled workers; in other words, they have been able to keep their staffs together, and as a result the good workmen have had opportunities of becoming more proficient.

Another great factor in favour of British shipbuilding has been the cheapness of money. With consols before the war paying barely three per cent., it was not difficult for the organisers of great industrial works to obtain practically as much money as they desired at a low figure, and this was the period of great development in shipbuilding yards. Ease in the money market led to great extensions and reacted on competition, for many new yards were equipped and there is a larger number of firms now on the Admiralty list of approved contractors than at any previous period in British shipbuilding, all of them firms of good standing, with ample commercial stability and a character to lose if work is badly done.

Without trenching upon heated current politics, it may be added that the system of '' free imports '' of steel and other products from abroad has also had an effect in keeping down prices; but whether this result has been obtained at the expense of other industries is for the politician to say. The bare fact, as stated, cannot be controverted.

The influences which have made for cheapness in the great private yards in the United Kingdom have reacted upon the government establishments in reducing the cost of shipbuilding. The outlay on identical ships built under the government and built by contract are being repeatedly checked, and while the dockyards are more expensive, if allowance is made for the profit represented in the gross sum paid to private firms, the country does not pay more in the one case than in the other on the average. The tendency of late years has been towards employing private firms to an increased extent in shipbuilding, so as to leave the Royal dockyards more free to deal with the repairs of the immensely increased fleet which has been provided as a result of the activity which has marked the period since the Naval

Defence Act of 1889. Though the plant in the government establishments has been much improved of late, it is still far behind what is found in any of the first-class private yards, and this in itself handicaps the official building yards to a serious extent. Every shipbuilder who has visited Portsmouth or Devonport or Chatham dockyards is struck with the antiquated methods still in vogue. It is easy for a First Lord of the Admiralty to obtain money for building fresh men-of-war, because the cry of the nation is continually for "Ships, more ships." But it is difficult, and sometimes impossible, for him to obtain an adequate sum for bringing the equipment of the dockyards up to date.

If there has to be reduction anywhere in the draft estimates at the dictation of the Cabinet, it is the sum which is set aside for improving the government establishments which goes. Why? The question answers itself. The nation wants ships. will have ships; they appeal to the imagination, and when the time comes for a general election, though the navy is far less the battledore and shuttlecock of parties than it was, it stands to reason that the party which has added many men-of-war makes a better impression on the elector than the politicians who explain that while a less sum has been spent on ships, a much needed improvement has been carried out at the dockyard, so as to enable them to deal more effectively not only with the work of repair in peace time, but with the task of dealing with defects made in action and sending injured ships to sea, smartly, to renew the fight, and, it may be, snatch a victory from the foe who is less well prepared at his bases.

It must be added that in recent years considerable progress has been made in the task of better fitting the government yards to do good work cheaply, expeditiously and well; but there is the leeway of years of neglect to be made up, and arrears of a quarter of a century cannot be overtaken in half a dozen years.

This spring, however, the Admiralty recognised that the output of the dockyards was not satisfactory, considering the immense capital invested in building and plant, and it was decided to introduce on March 14 tentatively a "premium" system of payment of labour. It is hoped that the introduction of the premium system will lead to the workmen taking an increased interest in their work, machines, tools, and equipment generally, and to keenness on their part in pointing out to their officers where improvements may be made and time saved, resulting in better methods of work.

Increased energy and industry on the part of the workmen, added to such improvements as may be adopted from their suggestions and resulting in work being done in less time than hitherto, will immediately benefit them by increasing their "premium" earnings.

At first it has been applied to certain classes of machine work, and if satisfactory results are obtained the system may be extended. The system will enable workmen to earn, in addition to their ordinary weekly wages, extra remuneration for doing work in less time than the fixed time allowed for it. The system is thus briefly described in the official Admiralty "notice." When a piece of work is given out, a certain time, based on known times taken for similar work done on ordinary time in the particular shop, will be allowed for it.

This time allowance will include all the necessary time for obtaining tools and materials, preparing the machine, and lifting and setting the work in or on the machine, any removal and resetting, change of tools, and removing work after completion. If the work is satisfactorily completed in less time than the fixed time allowed for it, the workman becomes entitled to a premium, varying in amount with the time saved. If, on the other hand, he takes longer than the time allowed, he will still be paid his ordinary wages.

From this it will be seen that while the workman may increase his wages by his own individual effort, he cannot lose money by the introduction of the system. Premiums will be calculated as follows:—The value of a "premium hour" will be considered to be one-forty-eighth of the workman's weekly wages, and the amount of premium earned on a job will bear approximately the same relation to the ordinary wages due for the time taken to complete it as the time saved bears to the time allowed.

To give an example:—Suppose a man is given forty-eight hours to do a job and does it in thirty-six hours; he saves one-fourth, or 25 per cent., of the time allowed, and accordingly will be credited with 25 per cent. of the time taken to do the job, which is nine premium hours, so that a mechanic in receipt of 36s. per week, and whose "premium hour rate" would, therefore, be 9d., would receive 9 × 9d = 6s. 9d. premium for this job, in addition to his ordinary wages for the period worked. Similarly, a skilled labourer in receipt of 24s. per week, and whose "premium hour rate" would, therefore, be 6d., would, in the example quoted above, receive 9 × 6d = 4s. 6d. premium.

A convenient way for the workman to calculate his premium is to multiply the time taken by the time saved and divide the product by the time allowed, all times being taken in hours. This will give the premium in hours which, multiplied by the "premium hour rate," will give the amount of premium earned. Or it may be stated thus:—

$$\frac{\text{Time taken x time saved}}{\text{Time allowed}} = \text{Premium time.}$$

Taking the case already given:—

$$\frac{36 \text{ x } 12}{48} = 9 \text{ premium hours.}$$

The time taken will be recorded to the nearest quarter of an hour. In calculating the premium the time taken will include all the working hours from the time of commencement of a job up to the time of commencing the next job. Overtime, and night and day shifts, will be paid for at overtime rates, as at present, but will only count as ordinary hours in the calculation of the "premium." Lost time, or absence without leave, will count in the time taken. Absence with leave will not be included in the time taken. It is to be clearly understood that a "premium" is not earned until the finished work has been inspected and passed as satisfactory. Apprentices will not for the present be employed on "premium" work.

What is the cost of shipbuilding in other European countries? It must be admitted that Germany has made immense strides. The progress of the shipbuilding industry in the Empire has been extraordinary. It has grown by leaps, and as the demand has increased so the cost has been decreased, and in some instances work has been done so expeditiously that British records have been lowered. Two of the new battleships of the German fleet were at sea within two years of the laying down of the keel plates. It is several years since as quick construction was achieved in England. In Germany it has been attained by a high standard of industrial organisation, by which every sub-industry has been ready with its contribution before the time it was required, with the result that all stoppages of work have been avoided.

On the general progress of the German shipbuilding industry an excellently compiled and most interesting book, copiously illustrated, has recently been published (Crosby, Lockwood & Son, London). In this volume the compiler and editor, Herr G. Lehmann-Felskowski, thus sums up the position of the industry in Germany:—

"Whilst Germany but three decades ago possessed only a few insignificant shipyards, its shipbuilding being, therefore, quite unimportant, she now participates to a very great and increasing extent in the world's shipbuilding. Germany disposes at the present day of a number of shipbuilding establishments of the very first order.

"Of the 27,000 vessels of more than 100 tons burden existing in 1900 in the chief countries, 1727 had been built in Germany. This is insignificant in comparison with the 13,609 vessels of British origin, representing about one-half of all seagoing vessels existing between the more important nations. Germany has herself drawn upon England for about 30 per cent. of her own merchant fleet. However, within the last decade

Germany's share in the world's shipbuilding has increased to the extent of doubling her output of steamers in the period from 1890 to 1897. For out of every 100 tons of the world's production of steamships Germany has furnished, in 1890, 6.5 tons, and in 1897, 12.8 tons.

"With this increase Germany stands alone, whereas the United States and England have had their respective shares reduced, in the case of England from 81.1 to 75.4 per cent. In the total of all seagoing vessels built in 1898, Germany participated with 8.3 per cent.; in the total of the merchant vessels distributed over the various nations in 1898 to 1899, Germany participated with 8.2 per cent., against 66.1 per cent. for England. This signifies for Germany in 1890 to 1891 an increase of 38.4 per cent., compared with an average increase of the merchant fleets of all nations of only 27.4 per cent.

"As regards the actual output of ships, Germany cannot yet rival England by a long way. England still supplies nine tons to only one ton for Germany (1898), whilst the future competition of the United States still remains an uncertain factor.

"With the increase of German shipbuilding the number of workmen has, of course, multiplied in the same ratio. According to a census of 1895, there existed in Germany 1130 shipbuilding establishments, employing 35,000 hands. Of these, 46 yards with more than 50 workers employed altogether 28,600 hands. In June, 1882, there were more shops, but only 23,000 hands. The number of the latter has since increased by 56.9 per cent., whereas in the shops employing more than 50 hands the number of the employed has risen by 70.7 per cent.

"The total quantity of horse-power in the shipyard engines has increased since 1875 by nearly 800 per cent., viz., from 1121 to 8556. It must be borne in mind that these numbers, owing to the system of compiling the statistics, do not apply to the whole of the large shipbuilding establishments, but only to those departments actually engaged in the building of ships. The increase in horse-power is even much larger, seeing that in the large yards, especially in Stettin, Kiel, Hamburg and on the lower Weser, the electric current generated by German machinery is being used, and this is not included in the above statistics.

"At the end of February, 1898, the eleven more important yards employed 24,220 hands, besides using machinery of 12,494 horse-power. At the end of 1898 twenty-one of the largest German yards employed 30,400 hands. The aggregate horse-power used in these yards was 16,000, and counting the power of one horse as equal to that of 24 men, the force would be equal to 414,400 men all told.

"There were delivered in that year 226 new vessels, of a total tonnage of 120,000, and having a value of 84 million marks. Besides, there remained on the slips 218 vessels, of a total 432,000 register tons and 235 million marks value.

"Nearly all these yards were compelled to extend their works and working plant continuously, thereby increasing their output both in quality and quantity. Amongst these yards there are several which, like the imperial yards at Kiel, lay themselves out for the construction of warships, and have built such vessels both for home and foreign countries. These are:—

FOR THE NORTH SEA DISTRICT

At Hamburg ....Blohm & Voss
At Bremen ......Actien-Gesellschaft "Weser"

FOR THE BALTIC DISTRICT

At Kiel..........Krupps Germania Yard
At Kiel.........Howaldts Works (Howaldtswerke)
At Stettin.......Stettin Vulcan (Stettiner Vulcan)
At Danzig & Elbing—Schichau.

"The three imperial yards employ altogether about 13,000 men, the largest private yards in Stettin, Hamburg and Kiel and Danzig each 4000 to 7000 men. Besides these are the medium sized and small yards at such ports as Flensburg, Bremerhaven, Geestemünde, Tönning, Lübeck, Rostock, Papenburg, Stettin and Danzig. Of the 25 large German yards 12 are in the North Sea district, viz.:—

At Hamburg	3 yards	
On the Lower Weser	5 "	
At Wilhelmshaven	1 "	(imperial)
At Emden	1 "	(in construction)
At Papenburg	1 "	
At Tönning	1 "	

"In the Baltic district there are 13 yards, viz.:—

At Kiel	3 yards (of which 1 imperial)	
At Flensburg	1 "	
At Lübeck	1 "	
At Rostock	1 "	
At Stettin	3 "	
At Danzig	3 "	(of which 1 imperial)
At Elbing	1 "	

"Most of these yards have docking accommodation, either floating or dry docks, the floating docks being mostly in use in the private yards. Hamburg and Stettin have the largest floating docks, with a lifting power of more than 17,000 tons."

In France, in spite of government encouragement, there has been no such development in shipbuilding. Whatever the cause, the French industry has been comparatively stagnant. In the history of the development of shipbuilding French designers and constructors have laid the world under a heavy debt; but, in spite of their initiative, invention, and technical ability, it is other nations which seem principally to have profited by the attention which they have given to the subject. The result is that to-day Germany is building warships not only cheaper, but far quicker than is done in France.

This means that France is paying more for her naval defence than her neighbour. Slow construction is always dear construction, and, moreover, the French have the knowledge that whereas the German ships take the seas representative of the latest devices, the acme of up-to-dateness,—if the phrase may be used,—the French ships, owing to the long period their completion occupies, lose not a little of their efficiency before they take their place in the squadrons. In his report on the French Naval Budget in 1902, M. Lockroy, a former Minister of Marine, wrote:—

"Money is wasted when the construction of new ships of the same type is distributed among several yards. Several sets of plans have to be made, and the cost is proportionally increased. The ships are never quite the same as they ought to be; the price per ton varies in quite scandalous proportions; the loss is great from a fighting point of view,—it is still larger from the economic; and the country's money is being spent without profit. Complaint is being continually made at the cost of new ships, the slowness with which they are built, and the want of homogeneity of our types. But there will be no change while the present régimé continues, which considers it more necessary to satisfy particular interests than to work for the defences of the country.

"It is only by centralising the construction of the same types of ships in the same dockyards,—here small vessels, there large,—that it will be possible to make ships as homogeneous as they ought to be, from the keel to the head; that we shall be able to accelerate the work, and so make sensible economies, and do away with the disquieting and grievous difference of cost for the same work which now exists between the different yards.

"If it has taken nearly six years to construct the *Jeanne d'Arc*,—and we could quote other cases as bad,—it is the fault of neither the constructors nor the workmen; it is the result of old habits, which, formerly inconvenient, are now most hurtful. Formerly if a ship was a long time building the mischief of the delay was not great, but to-day some years in completing a ship means that she is already obsolete by the time she is ready for commissioning. Another cause of delay in completing new ships is to be found in the amount of repairs, which have to be carried out on other ships, to cope with which a large number of men have to be withdrawn from ships building. This is particularly the case at Toulon.

"The proportion of the administrative expenses of the different dockyards, as compared to the actual work carried out on the fleet, is given in the following percentages:—

"Cherbourg, 49.3; Brest, 19.0; Lorient, 29.3; Rochefort, 25.3; Toulon, 41.6.

"The difference between the yards

TABLE II.—RELATIVE COST OF BATTLESHIPS

Nationality	Date of Completion	Ship	Displacement (Tons)	Speed (Knots)	Cost
British	1904	Russell	14,000	19	£1,098,717
"	1902	London	15,000	18	1,114,808
"	1901	Vengeance	12,950	18½	880,872
French (estimate)	1906	Patrie	14,927	18	1,421,708
"	1901	Jena	12,032	18	1,111,340
Germany	1900	Kaiser Wilhelm II.	11,150	18	962,500
"	1902	Wettin	11,800	18	1,071,250
"	1904	Braunschweig	13,200	18	1,157,500
Italy	1905	Vittoria Emanuele III.	12,624	22	1,000,000 (estim'e)
"	1895	Sardegna	13,860	20	1,057,440
Japan	No figures available				
Russia	1898	Poltava	10,960	16	1,093,000
"	1897	Sessoi Valiky	8,880	16	796,333
United States	1901	Alabama	11,565	17	544,539 (*a*)
"	1898	Iowa	11,340	18	618,514 (*a*)
"	1900	Kearsarge	11,540	17	462,345 (*a*)
"	1905	New Jersey	14,948	19	--------

(*a*) Exclusive of armour and armament.

is, therefore, considerable, ranging from 19.0 per cent. at Brest to 49.3 per cent. at Cherbourg."

It has been reported that to some extent economy has since been effected in the administrative expenses in French dock-yards, but there is no evidence to support this view.

It is not easy to arrive at a correct estimate of the cost of American men-of-war, but that it exceeds the outlay in Great Britain there is no doubt. The estimates are prepared exclusive of the outlay on armour and armament, most important items. In various countries the expenditure on armour differs very greatly, as the demand and supply vary.

Details are available which enable a comparison with the relative cost of warship building in various European countries to be presented in a summary form which effectively illustrates the differences which exist. In compiling Table II., battleships of about the same displacement have been chosen, and the results are as shown:—

These figures illustrate that the British people are still able to provide their naval defence comparatively cheaply, but in comparison with their European rivals they have an expensive voluntary service for crews, whereas foreign nations obtain three or four men at the cost of a single British seaman, a fact which helps to equalise the ultimate cost on European squadrons, probably leaving the balance of advantage on the side of the foreigner.

TABLE III.—TONNAGE OF VESSELS BUILT SINCE 1883

	United Kingdom			Germany†	France†	U. S. of America‡			
Years	Sailing	Steam	Total			On the Sea Coast	On the Mississippi River and its Tributaries	On the Great Lakes	Total
	tons	tons	tons	tons	tons	tons	tons	tons	tons
1883	148,090	744,126	892,218	74,469	35,223	210,349	26,443	28,638	265,430
1884	173,179	415,095	588,274	54,727	57,162	178,419	16,664	30,431	225,514
1885	219,094	221,918	441,012	22,241	15,930	121,010	11,221	26,826	159,066
1886	145,248	186,279	331,528	37,741	27,075	64,458	10,595	20 400	95,453
1887	87,127	290,071	377,198	27,170	15 247	83.061	10.901	56,488	150,450
1888	96,393	477,554	573.947	28,281	31,936	105,125	11,859	101,103	218,087
1889	137,147	717,582	854,729	77,706	32,502	111,852	12,202	107,080	231,134
1890	148,692	663,946	812,638	71,895	24.018	169,091	16,506	108,526	294,123
1891	229,610	579,883	809,493	70,547	28,465	237,462	19,984	111,856	369,302
1892	287,072	514,476	801,548	49,307	18,604	138,863	14,800	45,969	199,632
1893	123,874	460,800	584,674	47,685	21,795	102,830	9,538	99,271	211,639
1894	99,628	569,864	669.492	71,960	18,240	80,099	9,111	41,985	131,195
1895	64,717	582,917	647,634	68,330	22,945	67,127	8,122	36,353	111,602
1896	73,291	663,523	736,814	42,179	39,158	102,544	15,771	108,782	227,097
1897	89,700	554,997	644,697	86,619	55,780	103,504	11,792	116,937	232,233
1898	44,890	825,718	870,608	88,608	37.534	112,879	13,495	54,084	180,458
1899	50,483	898,527	949,010	103,311	68,276	196,120	23,552	80,366	300,038
1900	46,122	898,145	944,267	118,828	89,299	249,006	14,173	130,611	393,790
1901	61,663	921,470	983,133	101,886	105,682	291,516	22,888	169,085	483,489
1902	81,064	869,361	950,425	Information not available		290,122	9,836	168,873	468,831

---

† Tonnage built and added to the register. ‡ The figures for the United States are for the years ended June 30th in each case, and represent the tonnage built and added to the register. They include the tonnage of canal boats and barges.

Apart from such considerations, however, the figures as to the first cost of ships are of immense interest. It may be seen from them that Great Britain provides a ship of 14,000 tons at the same outlay approximately as France spends on a vessel of 2000 tons less displacement and with one knot less speed; while the German battleship *Wettin*, of less than 12,000 tons, represents nearly the same outlay as the British *London*, of 15,000 tons displacement. Russia, again, pays more than Germany, and even more than France, if we may judge by the expenditure upon the *Poltava* and her sister ship.

It will also be noticed that Great Britain can afford to build a ship of the class of the *King Edward VII.* at the same cost as the French *Patrie*, of less than 15,000 tons. In effect, for every shilling she lays out in fighting power the British obtain a large percentage more fighting power than any of their rivals. The conditions in the United States are peculiar, because there the outlay on ships is heavy, and they have not the counterbalancing advantage of a conscriptive system to help readjust the balance.

Apart from other influences which are at work in the United States, the high rates of wages paid, which are the highest in any country, have had their effect on the cost of shipbuilding. From a return lately issued by the British Board of Trade, it appears that the wages in certain skilled trades in various countries compare thus:—

Average Wages in Fifteen Skilled Trades for a Typical Standard Year	Great Britain	U. S.	Germany	France
	s.	s. d.	s. d	s. d
In the capital*...	42	75	24	38
All other towns..	36	69.4	22.6	22.10
	Rates of wages expressed in percentages			
In the capital*.....	100	179	57	86
All other towns..	100	193	63	63

* New York is regarded as the capital of the United States.

In spite, however, of any disadvantages under which shipping in the United States may suffer, a remarkable development of shipbuilding has occurred in the past twenty years, and the movement shows no signs of having reached a climax. In Table III., on page 51, is given the tonnage of vessels built in the United Kingdom, Germany, France and the United States since 1883.

From all comparisons the same fact is revealed that while the United Kingdom still builds warships and merchant vessels cheaper than any other country, its pre-eminence is more threatened than ever before.

ELECTRICAL PROGRESS IN CANADA

By George Johnson, Statistician of the Dominion of Canada

THE 24th of May, 1904, was the sixtieth anniversary of the sending of the first Morse message over a telegraph wire. Without entering into the controversy which has sprung up as to the reality of the claims that have been made for other persons, the fact that messages were sent on that date sufficiently differentiates the month of May, 1844, to fit it to become a starting point in an estimate of the development of electricity as a factor in modern civilisation.

There are now throughout the world over one million miles of telegraph line and over four million miles of wire. These represent an outlay of capital equal to 500 million dollars. The outlay for cables will increase the total capital invested to 850 million dollars.

Over head and under seas there is a daily transmission of 1,500,000 telegrams and 36,000 cable messages, the yearly totals being 557,000,000 land messages and 13,100,000 cables in 1903.

This is the minimum, for in South Africa (for instance) there are thousands of miles of line which are in the hands of companies that are not required to make returns. Another fact that has to be taken into consideration is that these figures do not include the telegrams sent by railways in the management of their own business. These number many millions a year. Thus, Russia, in 1902, included the telegrams despatched hither and thither over her 37,000 miles of railway, and the result was a total of 101,639,542 telegrams, whereas in the year before (1901), when railway telegrams were not included, the messages sent numbered only 20,000,000.

A third fact ought to be kept in mind. In many countries, Canada, for instance, the press messages are not included in the number reported. Everyone knows the important part the newspaper telegraph service plays in a country of magnificent distances such as Canada, where for months, during which the Federal Parliament sits, the whole country is absolutely dependent upon the daily telegraphed report for a knowledge of the proceedings. Divided by ten to represent an ordinary message, the millions of words of press "flimsy" would far exceed the other messages sent and delivered in the course of the year, and representing the business, the social and the other activities of the country employing the telegram as a medium of communication.

No estimate can be made of the number of these messages. It is plain, however, that at least 1,500,000 messages pass to and fro every day of the 365 days of the year. All this immense business can be traced to that beginning in May, 1844, when the Morse system turned the plaything of science into an instrument of practical world-wide, every-day use.

The countries which most use the telegraphic mode of communication are the British Empire, the United States of America, Germany, France and Austria-Hungary.

The British Empire has over 218,000 miles of line and nearly 1,000,000 miles of wire, and sends and receives 127,000,000 messages a year.

The United Kingdom despatches and receives about 92,500,000 messages, or 222 per hundred of her population. Her daughters follow her example. Australia goes beyond her, sending 223 per 100 of the population.

New Zealand, the wonderful sister under the Southern Cross, goes far beyond her mother, sisters, cousins, aunts or any other relative or stranger coun-

TABLE I.—TELEGRAPH STATISTICS.

COUNTRIES	Year	Miles of Line	Miles of Wire	No. of Messages	No. of Offices	No. of Messages per Head of Population
Great Britain	1903	49,450	480,400	92,471,000	12,129	2.22
Australia	1902	45,343	121,818	8,431,372	3,102	2.23
New Zealand	1902	7,749	22,672	4,713,351	1,103	6.10
India and other Asian Possessions	1902	57,495	190,887	6,749,372	2,006	.02
African Possessions*	1902	17,885	38,832	7,555,500	......	1.08
Canada	1903	36,780	96,728	5,313,800	3,004	....
Newfoundland and B. W. Indies	1902	3,308	15,187	1,654,000	300	.92
Gibraltar and Malta	1902	67	......	33,500	......	.15
Total British Empire		218,077	966,524	126,921,895	21,644	....
Abyssinia	1902	1,056	3,168	158,400	......	....
Austria-Hungary	1902	39,372	198,303	31,554,715	9,228	.69
Argentina	1902	29,397	58,656	7,000,000	520	1.46
Belgium	1902	4,047	21,874	14,252,100	1,372	2.07
Bolivia	1902	2,465	8,625	1,075,000	68	.47
Bosnia	1902	1,803	4,873	427,452	134	.25
Brazil	1900	14,710	27,720	1,505,042	1,003	.10
Chili	1902	11,060	68,710	4,879,719	608	1.57
China	1902	14,000	49,000	3,430,000	250	.01
Columbia	1898	8,600	25,800	600,000	448	.15
Congo Free State	1902	888	3,108	62,160	40	....
Costa Rica	1902	840	2,940	284,532	68	.92
Cuba	1902	2,300	3,450	430,125	153	.27
Denmark	1902	2,385	8,855	2,409,365	169	.98
Ecuador	1902	1,242	4,347	434,470	60	.31
France	....	90,592	340,180	47,280,070	13,527	1.21
Colonies and Dependencies:						
Algeria	1901	6,520	18,240	2,369,456	539	.50
Tunis	1901	2,420	5,500	978,000	122	.51
Other possessions	....	10,700	32,100	1,605,000	300	.40
Germany	1902	83,526	309,644	45,216,963	25,621	.80
Greece	1901	3,830	5,590	1,205,095	241	.50
Guatamala	1901	3,490	10,470	929,619	157	.59
Honduras	1902	2,825	8,475	618,000	168	1.05
Italy	1901	28,472	107,810	11,682,366	6,078	.36
Japan	1903	†16,128	78,710	18,073,407	2,197	.38
Korea	1902	2,170	6,510	325,500	325	.06
Luxemburg	1902	656	1,390	87,300	196	.37
Mexico	1901	43,675	......	2,665,998	377	.19
Montenegro	1902	343	427	29,590	21	.13
Netherlands	1903	4,010	16,158	5,728,222	761	1.08
Colonies, East Indies	1901	7,518	22,554	729,316	389	.02
Nicaragua	1901	2,440	7,320	140,640	119	.28
Paraguay	1901	500	1,500	97,044	75	.15
Persia	1901	5,480	8,270	16,540	112	.002
Peru	1903	3,220	......	152,808	48	.03
Portugal	1902	5,301	11,688	4,054,230	461	.73
Portugal—Colonies of	1903	2,368	7,104	142,080	80	.01
Roumania	1902	4,350	8,780	2,318,683	1,866	.12
Russia	1902	106,417	325,978	‡101,639,542	......	.15
Salvador	1902	1,920	5,760	715,084	135	.71
Santo Domingo	1902	430	1,290	40,000	65	.07
Servia	1902	2,300	4,925	1,092,527	145	.44
Siam	1902	2,900	7,700	154,000	360	.02
Spain	1901	20,170	47,470	4,627,713	1,534	.25
Sweden	1901	10,077	31,695	2,813,830	2,175	.55
Norway	1902	9,978	53,813	2,278,639	974	1.01
Switzerland	1902	5,556	23,765	3,273,784	2,137	.99
Turkey	1902	25,100	39,800	4,976,070	907	.21
Egypt	1903	2,562	10,868	†1,617,946	544	.16
United States §	1903	196,115	1,029,983	91,391,443	23,567	1.20
Hawaii	1903	250	750	37,500	40	.24
Porto Rico	1903	470	1,410	70,400	70	.07
Philippine Islands	1903	720	2,160	43,200	42	.005
Uruguay	1901	4,604	13,812	397,493	101	.04
Total foreign countries		854,268	3,099,028	430,118,178	100,697	....
Grand total		1,072,345	4,065,552	557,040,073	122,341	

* The statistics for Africa are very incomplete, many thousands of miles of line being in the hands of companies making no returns.

† Not including State telegrams.

‡ Russia including railway telegrams, which numbered 91,639,542.

§ These are statistics of the Western Union Telegraph Company, and include their Canadian ownings. Other minor lines in the United States will bring up the figures to those given above.

try in the world, topping the list with 550 telegrams* per 100 of her population, Maories included.

Canada in 1903 had 36,780 miles of line and 96,728 miles of wire, and her record is 5,313,800 messages, or just about 1 message for every man, woman and child on her broad acreage. In the matter of miles of wire Canada somewhat exceeds the United States, having 18,250 miles per million inhabitants against the United States equipment of about 13,000 miles per million.

The African possessions of the British Empire, notwithstanding that only a comparatively small proportion of the messages sent are included in the available statistics, have a record of 7,555,000 messages, or 108 per each 100 of their population.

Table I. gives as complete a list of countries and telegraphic statistics as the writer has been able to compile.

ELECTRIC PROPULSION

It is about sixteen years since the scientific practicability of propulsion by means of electricity was demonstrated.

In the United States there are about eleven hundred street railway systems. (The United States Census returns give 871 street railways, chiefly electric, for 1900.) There are 25,800 miles of track; the capitalisation is $1,630,000,000 and the funded debt $1,275,000,000, The earnings were over $240,000,000 last year, between $600,000 and $700,000 a day.

The United States have made great progress. They have 322 miles of electric railway to each million of the population of Continental United States. These carried between 5,000,000,000 and 6,000,000,000 persons, or about sixty-five times the population, and about eight times as many as the steam-driven railways carried. Canada's electric railways carried last year 167,704,000 passengers, or about thirty-one times the population of the Dominion.

When it is recalled that the urban population of the United States forms over 37 per cent. of the whole, while Canada's urban population is only 26 per cent., it is evident that the electric railways of the Dominion are doing well and give promise of doing better; as Canada's urban population, following the continent's trend, increases its proportion, Canada's electric railways carried, like those of the United States, about eight times as many passengers as her steam-driven railways.

Ottawa claims to be the first city in Canada to adopt electricity as the motive power of street railways, the Ottawa Electric Railway Company beginning its career in July, 1891. The development in Canada is, therefore, all within twelve years. That of the United States began in 1888, when there were under 100 miles of electric railway in the country.

Table II., on the next page, gives particulars of the Canadian electric railway companies for the years ended December 1, 1901-1903.

The following is the distribution by provinces of the electric railway mileage in 1903:—

	Single Track	Double Track
Ontario	273.14	87.64
Quebec	96.09	82.57
British Columbia	41.75	6.25
New Brunswick	10.06	2.50
Nova Scotia	23.71	1.58
Manitoba	10.00	12.00
Total	454.75	192.54

TELEPHONES

The summer of 1904 was the thirtieth anniversary of the invention of the telephone. In 1874 Mr. Graham Bell, then on a visit to his parents, who lived in Brantford, made some laboratory experiments which proved that speech could be transmitted by wire. Two years later, August, 1876, the first transmission of speech over a telegraph wire took place in Brantford. In 1877 the telephone went into commercial use, the city of Hamilton being the first to establish it.

From that beginning the use of the telephone has been constantly on the increase. The first returns the Statistical Office secured showed that in 1883 Canada's equipment was 44,000 miles of wire; 35,500 instruments, by means

---

* In New Zealand the number of telegrams forwarded in the year ended March 31, 1904, was 4,671,904, an increase of 9.38 per cent over the number for the year 1903.

TABLE II.

	1903.	1902.	1901.	1900.
Total number of railways sending returns.....	46	44	43	35
" miles of track, single........	454.75	421.39	376.35	......
" miles of track, double........	192.54	188.09	179.10	......
" motor cars	2,053	1,895	1,853	1,379
" trailers	298	326	302	......
" snow-sweepers and ploughs..	109	97	85	69
" miles run	39,721,153	36,711,130	34,547,975	28,547,908
" passengers carried	167,703,958	145,609,993	132,885,258	94,616,344
" employees	7,439	5,427	5,443	......
Total amount of capital paid up..............	$29,838,326	$25,961,254	$24,734,040	$18,309,876
" bonded debts	17,013,758	15,794,408	14,166,225	10,454,452
" gross earnings	7,777,324	6,865,907	6,283,666	......
" gross expenses	5,018,779	4,140,490	3,699,283	......

of which 72,500,000 messages were sent in the year. In the ten years since the number of instruments has increased to 81,500 and of messages to 253,970,000, an increase of 144 per cent. in instruments and of 250 per cent. in number of messages.

Taking the population of the last Census, there is in Canada one telephone instrument to every 65 persons.

Provinces	Number Persons to One Telephone
Ontario	57.9
Quebec	63.8
Nova Scotia	99.4
New Brunswick	85.3
P. E. Island	215.0
Manitoba	51.5
N. W. Territories	251.3
British Columbia	33.4

There were on the first day of this year fifty-six companies in Canada, divided by Provinces as follows:—

Twenty in Quebec, eleven in Ontario, seven in New Brunswick, six in Nova Scotia, one in P. E. Island, two in Manitoba, three in the Northwest Territories, one of these being in the Yukon, and six in British Columbia,—the Bell Telephone Company being counted three times, one in Quebec, one in Ontario, and one in Manitoba. Actually there are fifty-three, and we obtained this year returns from all but seven.

Some of them are under the control of the Bell Telephone Company, and their returns are included in that company's returns.

The United States in 1900 showed a per capita of one telephone in forty, while in some places, such as San Francisco, it had reached one in twelve (U. S. Census Bulletin). The latest statistics indicate a per capita of one in thirty-eight. This rate of progress is exceeded by Denmark, in which country the per capita is one in every fourteen. Canada has not used the telephone to the same extent, but we appear to be making great strides forward, and British Columbia has come within measurable distance of the greatest of telephone-using peoples, the people of Stockholm, in which city there is one telephone to every eight persons.

The Dominion began to construct telephone lines, with a commercial end in view, in 1877, as already stated. As far as somewhat incomplete statistics show, fourteen telephone companies now in operation began distributing "hellos" in the decade 1880-1889, fourteen in 1890-1899, and thirteen in the present decade. Of the remainder there is no record. The usefulness of the telephone in business in rural communities is well illustrated by the practice in the great fruit-growing valley of Nova Scotia. The steamer of Halifax is loaded up with all she purposes carrying of other articles. She is to sail on a Saturday afternoon for Liverpool. Her agent telephones to Kentville and Wolfville on Thursday that there is space left for, say, 2000 barrels of apples. Kentville and Wolfville telephone to the sub-agents of the London (Eng.) fruit dealers, "How many barrels can you send to Halifax?" These sub-agents jump into their gigs and in an hour have arranged with the orchardists as to the number of barrels to be delivered on Friday evening at each station along the railway. Then they telephone the result to head stations. Cars are provided in accordance. The fruit is shipped to Halifax Friday night, put on board the steamer the next morning, and off goes the steamer, the fruit having been exposed to high temperature hardly at all, the orchardists having had ample time to get their barrels repacked, the railway full opportunity to supply the necessary cars, and the steamer being able to take on board the freight without exposing it to the influence of adverse conditions of weather on the wharf.

The number of telephone messages per annum for different countries is:—

France	187,002,352
Germany	766,226,337
Great Britain and Ireland	723,246,368
Austria-Hungary	147,543,138
Denmark	59,210,855
Belgium	38,753,367
Switzerland	26,670,381
Netherlands	31,460,979
Norway	1,723,347
United States	3,002,000,000

ELECTRIC LIGHT, HEAT AND POWER COMPANIES IN CANADA

The equipment of electric light, heat and power companies with which Canada has provided herself is of comparatively recent date. No mention is made in the Census of 1881 of the industrial employment of electricity. In the Census of 1891 the following information is given:—

Establishments	80
Employees	763
Capital	$4,113,771
Wages	297,684
Output	1,154,149

The Census of 1901 limited the inquiry as to manufacturing to establishments having five hands and over, smaller industrial establishments being ignored. This limitation renders the Census of 1901 useless either for comparison with the previous census or as a guide to the equipment of the country in respect to any special industry, such as electrical applications. In the preparation of the Statistical Year Book for 1903 an effort was made to procure such data as would give the student a practical and useful idea of the development of the application of electricity to the production of light, heat and power in 1903, with the following results:—

Establishments	316
Employees	1,786
Capital	$20,000,000
Wages	896,215
Output	4,809,227

These figures show a large increase in the twelve years: — Of establishments, 236; of employees, 1023; of capital, $15,886,229; of wages paid, $598,531; and of output, $3,655,078.

The following are the returns of 1891 and 1901 for establishments employing five hands and over:—

ELECTRIC LIGHTS, ETC.

	1891	1901
Establishments	23	58
Employees	630	899
Capital	$3,185,257	$11,891,025
Wages	237,348	451,047
Output	845,134	2,008,017

Expressed in percentages, the increases are:—Establishments, 121 per cent.; employees, 43 per cent.; capital, 273 per cent.; wages, 90 per cent., and output, 137 per cent. In 1891 the yearly wages of the employees averaged $376.75; in 1901, $501. The annual output per employee in 1891 was $1342, and in 1901, $2234.

The percentage of output to capital in 1891 was 26 per cent. and in 1901, 17 per cent. The wages increased 33⅓ per cent., and the efficiency of the workers, judged by output per employee, increased 66 per cent.

The development in the several Provinces, taking the returns of 1891 and of 1903, as seen in the number of establishments of all sizes, is as follows:—

Provinces	1891	1903
British Columbia	2	17
Manitoba	2	7
New Brunswick	7	13
Nova Scotia	7	22
Ontario	48	199
P. E. Island	2	3
Quebec	9	49
Territories	2	6
	80	316

The great Province of Ontario, which in 1891 had 60 per cent. of all these establishments, had 63 per cent. in 1903. The other Provinces have made evident progress. In the Province of Ontario in 1903 about 100 of the plants were found to be using coal or wood, about 60 using water power, and 35 steam and water, the remainder not stating the particulars. In Quebec Province 6 establishments reported using coal or wood, 38 utilised the water power of the Province, and 7 combined water power and steam power. In New Brunswick 11 obtained power from coal or wood and 2 from water. In Nova Scotia 16 used coal and 6 water; in Prince Edward Island, 2 coal and 1 water; in Manitoba, 5 coal and 2 water, with steam as an occasional auxiliary. In the Territories, except in the Province of Quebec, the majority of the plants use coal or wood; sometimes sawdust is utilised. Some of these electric plants have been absorbed by others, so that the 316 plants really represent 324 different places lighted by means of electricity. These in 1903 had 14,780 arc lights and 1,212,861 incandescent lights. Taking the arc as equal to ten incandescent lights, the country had on June 30 last 1,360,661 lights in use. This is an increase of 236,865 lights in twelve months, or over 21 per cent. Where there were five lights in 1902 there were six in 1903. The growth since 1898 has been:—Establishments, 1903, 324, an increase of 65. Arc lights, 14,780; increase, 4391. Incandescents, 1,212,861; an increase of 749,246, showing an increase of 42 per cent. in the number of arc lights and of 161.6 per cent. in the incandescents.

Of the Provinces, Ontario is far away the chief employer of the electric light. This Province had 203 of the 324 plants in use in the Dominion. It has considerably more than one-half the total number of arc lights, and 47 in each 100 of the incandescents. Thirty-four municipalities in the Province supply themselves with electric lighting.

The Province of Quebec has 53 plants, 3,853 arc lights and 409,503 incandescents. It is, therefore, behind Ontario by 4571 arcs and 158,990 incandescents. It has made, however, greater proportionate gain since 1898 than Ontario, the gain in arcs being:—Ontario, 36.2 per cent.; Quebec, 47.6 per cent.; and in incandescents, Ontario, 138.6 per cent., and Quebec, 212.3 per cent. During the period 1898-1903 the number of plants in Quebec increased by 13.

The largest single plant in the Dominion is that of Toronto, with its 170,000 lamps, arcs being taken as each equal to 10 incandescents. The next largest is that of the Lachine Rapids Hydraulic & Land Company, Montreal, 158,503. The third in size is the Ottawa Electric Company, with 111,927 lights.

The other Provinces have made considerable progress. To the west, Manitoba has in 1898-1903 increased its arc lights from 162 to 375 and its incandescents from 13,800 to 31,905.

The Northwest Territories have not increased as rapidly as the other parts of the Dominion, their arcs numbering 29, an increase of 4 in the period named, and their incandescents numbering 6677, an increase of 1997.

British Columbia shows the largest proportionate increase of any of the divisions of Canada, its increase of arcs being 377, or 82 per cent., and of incandescents 74,297, or 257 per cent. In 1898 British Columbia and Nova Scotia had almost the same number, British Columbia having 7 more arcs and 169 more incandescents; yet Nova Scotia has increased the number of its incandescents by 32,140, or 11.16 per cent. The three Maritime Provinces had, in 1898, 951 arc lights and 46,977 incandescents, and in 1903 they had 1267 arcs and 93,120 incandescents, an increase of 33⅓ per cent. for arcs and of over 98 per cent. for incandescents.

In the manufacture of electrical appliances and supplies considerable progress has been made.

Table III. gives particulars of establishments having five hands and over.

TABLE III.—ELECTRICAL APPLIANCES

	1891	1901
Establishments	13	25
Capital	$1,520,000	$5,267,397
Hands	408	1,922
Wages	$158,500	$846,618
Output	801,752	3,032,252

In addition, the census of 1891 gave as follows, for establishments with under five hands:—

Establishments	10
Capital	$43,813
Hands	17
Wages	$14,615
Output	63,100

It will be a safe estimate to give the smaller establishments of 1901 an increase somewhat greater than that of the larger ones, which is about 250 per cent., say, a total output of $3,250,000 for 1901, for both large and small establishments.

In addition, the imports of Canada

have increased very considerably, and attest, like the home manufacturing, the vigorous development of electricity as the harnessed servant of humanity.

Of electric arc lights and carbons and carbon points, Canada imported during the past fourteen years an average of $35,000 worth a year. The imports for 1902 and 1903 averaged $1,090,050 a year, and the imports for the year ended June 30, 1904, were $2,406,912.

In detail the imports of Canada for the last fiscal year were:—Electric light carbons over 6 inches in circumference, $62,794; all other electric light carbons, $25,985; electric motors, generators, dynamos and sockets, $488,944; electrical apparatus, insulators, electric and galvanic batteries, telegraph and telephone instruments, $1,829,189; a total of $2,406,912.

It may also be mentioned incidentally that of this total $2,332,899 were imported from the United States of America.

It appears that the outlook for Canada is one that shows the country going forward by leaps and bounds in its application of electricity. Electricity will drive the carriages on the King's highway as well as those on the iron way. It will do her plowing, sowing and reaping. It will make trolley parks an important part of the national equipment for recreation. If it does not help into this life it will help some one out of it, by order of justice.

It will do the nation's smelting and welding. It will supply from peat bogs fuel for Ontario and Quebec. In the form of the "wireless" it will make travel by sea along her coasts and estuaries as safe as travel about the streets of the towns. It will make hats, cook dinners and warm toes. It will become so tamed to service that it will, with the message, present a photograph of the speaker, and cut out in one town a cheque on a bank written hundreds of miles away, and do it so well that the original will be destroyed and the transmitted cheque remain the only existing original. Already twelve messages have been sent over the one wire. How many more, who can say?

There is in use a telegraph-telephone system by which Canadian railways can employ the same wire for both simultaneously. Her surgeons use it to minister to mind and body diseased. Her warriors use it, in the form of the wireless, to transmit orders from the right to the left of an army in extended order, and thus are able to set thousands moving as one at the same instant over miles of distance.

In fact, the electrical engineer is dealing with a force whose uses have become, and promise to become, even more in the future than in the past, so varied that, more than in any other profession, a man has to be wide awake all the time, or he will be left behind even while he is positive he is well to the front.

The up-to-date man of to-day is rearguard to-morrow if he is not always on the alert, so rapid are the movements, so numerous the applications of the electrical forces.

CONDENSING PLANT

TYPES OF BRITISH CONDENSERS AND ACCESSORIES

By W. H. Booth

Concluded from the October Number

THE condenser of the Wheeler Company is known as the Admiralty type, with rectangular shell, ribbed against collapsing pressure, and with a large dome at the top for storage capacity. At each end is a brass tube plate, and the cooling surface consists of seamless drawn brass tubes, usually ¾ inch external diameter, and of No. 18 wire gauge, held in the plates by screwed ferrules and cotton packing, lips being provided on the ferrules to prevent the tubes from creeping. The water ends are of cast iron, in the form of a curved bonnet at one end and a deep water box at the other. This water box is provided with a horizontal baffle plate, and the water makes two passages through the tubes.

In another type of condenser, useful where the circulating water is of good quality, the tubes are arranged on the Field system, in which the circulating water enters and passes down an inner small tube and returns through the annular space between the tubes, thus exposing a thin layer of water to the steam and insuring a high efficiency in cooling effect.

The Wheeler Company make the American type of air and circulating pumps of the horizontal, direct-acting kind, consisting of one steam cylinder which works the air and circulating pumps, placed on either side of it, by means of one piston rod. The arrangement shown in Fig. 15 with the condenser mounted over the pumps is very economical in space, and, owing to the perfect drainage afforded to the condensed steam by the air pump, a high vacuum can be held. In places where independent or vertical pumps are preferred, or for steam turbine equipments where a guaranteed vacuum within 2 inches of the barometer has to be maintained, the Wheeler Company, like many others, supply air pumps built under license from the Edwards Air Pump Syndicate, as described above.

For circulating purposes the centrifugal pump is then used, direct-coupled to an engine or an electric motor, and for outfits of moderate size an arrangement of triplex Edwards air pump and centrifugal circulating pump is used, driven by one motor placed between the pumps, with the pinion for the air pump connected to one end of the spindle, the other end of which is direct coupled to the circulating pump.

For jet condensers, this company's "standard type" consists of a cylindrical cast iron shell, fitted with a copper spray tube, to deliver the injection water in a fine spray into the condenser. On the side of the condenser is a vacuum-breaking device, which consists of a float so arranged that should the pump stop for any reason and allow the injection water to rise in the condenser, the float opens a valve to the atmosphere and breaks the vacuum, so preventing the water from being drawn up the exhaust pipe to the engine.

It is often essential to make arrangements for removing oil from the condensed steam. In some systems this oil is filtered from the water after leaving the air pump or on its way to the boiler. Although this may remove the oil in suspension, it does not get rid of

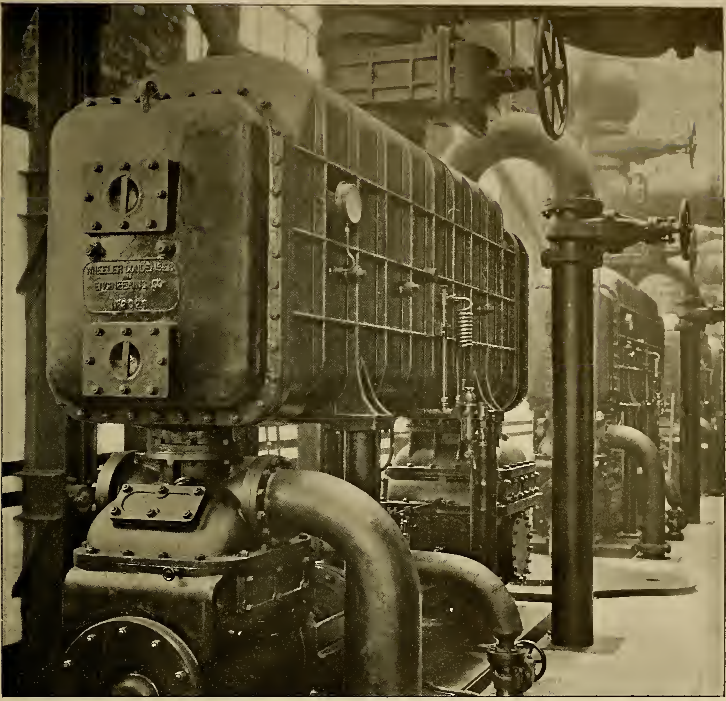


FIG. 15—CONDENSING SETS MADE BY THE WHEELER CONDENSER & ENGINEERING CO., NEW YORK AND LONDON

a certain amount of emulsified oil which passes through the filtering medum. In other systems the oil is coagulated or precipitated by chemical means; this, however, entails considerable attention and expense for the necessary reagents. Other methods treat the oil by electricity and filtration, all of which means expense and trouble.

The Wheeler Company provide a separator which removes the oil from the exhaust steam. This consists of a vacuum-tight vessel, fitted with a series of baffles upon which the exhaust steam impinges, and the oil particles in suspension collect on this surface and run down to the bottom of the separator, where the oil and a certain amount of water which collect are removed by a small vacuum pump. By this means, it is claimed, practically all the oil is removed, leaving only one part of oil in 150,000 parts of water,—an amount small enough to be negligible.

Generally speaking, with surface condensing and taking the initial temperature of the circulating water at 70° F., usual practice allows about 30 pounds of circulating water for every pound of steam to be condensed. Where the water is higher in temperature than this, a larger amount of water has to be allowed for, this depending entirely upon the existing conditions in each case. The above allowance is for 25 to 26 inches of vacuum, this being what is usually required for ordinary reciprocating engines. Where steam turbines

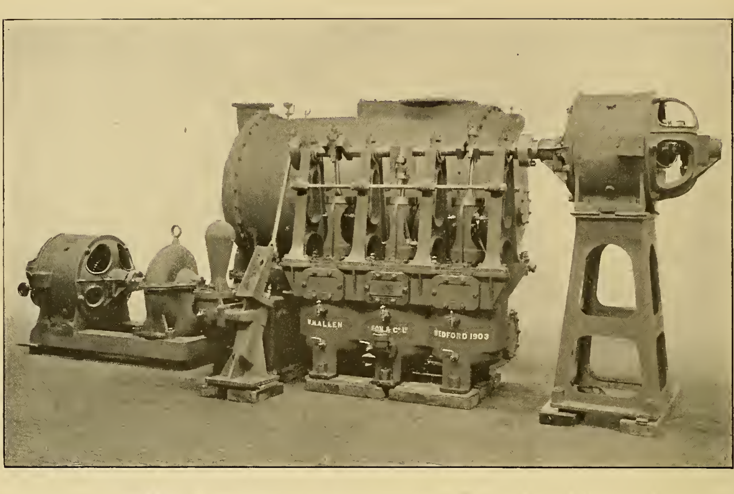


FIG. 18.—CONDENSER WITH ELECTRICALLY DRIVEN AIR AND CIRCULATING PUMPS, BUILT BY W. H. ALLEN, SON & CO., LTD., BEDFORD

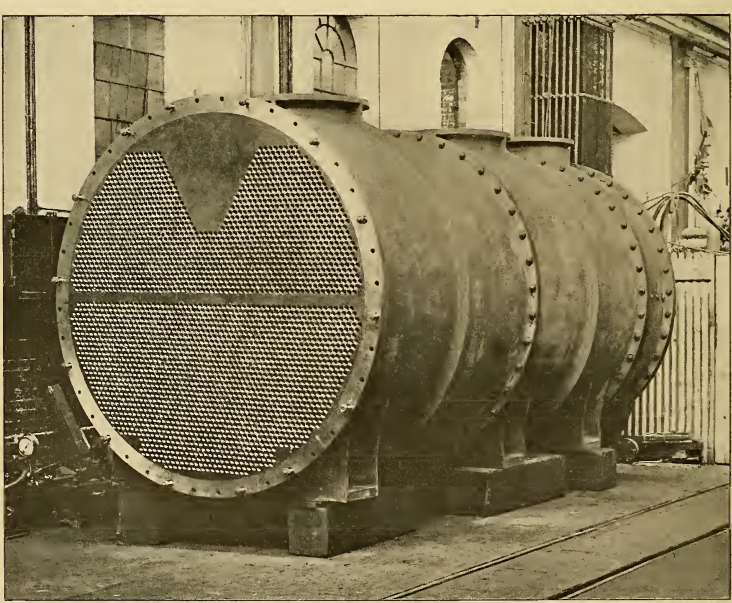


FIG. 19.—END VIEW OF SURFACE CONDENSER MADE BY W. H. ALLEN, SON & CO., LTD.

are used, it is usual to guarantee a vacuum within 2 inches of the barometer, say, 28 inches vacuum with a 30-inch barometer, and under these conditions 60, 70, or even 80 to 1 have to be circulated, depending upon the initial temperature of the water available. In jet condensing the amount of water required is somewhat reduced, the usual allowance being about 24 to 1 with cold water for ordinary vacua.

The capacity of an air pump depends entirely upon the conditions, and varies with the different temperatures of the circulating water available, length of exhaust line and liability to air leaks, and it is difficult to give any fixed rule for determining it. The average allowance is, however, that the air pumps should displace twenty-four times the volume of the water it discharges.

With steam turbines the temperature must be so low and the volume of air in the condenser is so many times that at normal or atmospheric pressure that an ordinary air pump cannot deal with it. The Parsons Turbine Company have, therefore, employed a supplementary air pump in the shape of a steam jet which gathers the extremely rarefied air from the condenser and delivers it to the air pump through a small supplementary condenser. The condenser is placed on a slope and the water leaves it by the lowest end, and a trap is thus made which shuts off the water outlet from the air outlet. If the steam jet will push up the air pressure by an amount equal to 2 inches, then the high vacuum of 28 inches will be dealt with by an air pump otherwise fitted only for a 26-inch vacuum.

The steam auxiliary is simply another way of compounding an air pump. If not employed, the turbine would require air pumps about six times the ordinary capacity. Given, however, a sufficiently low temperature of the water, so that the pressure of vapour is low, a condition secured only with ample and cold water, a

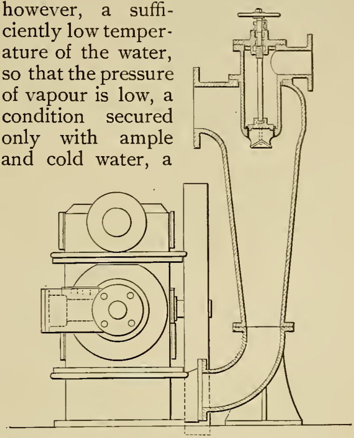


FIG 16.—END ELEVATION AND SECTION OF CONDENSER SHOWN IN FIG. 17

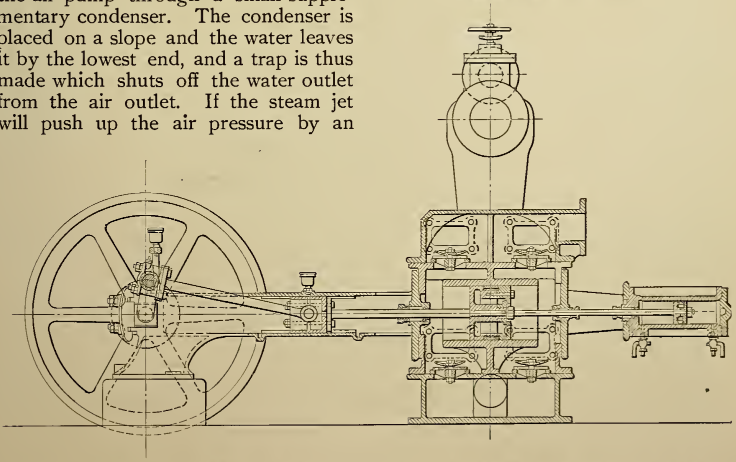


FIG. 17.—LONGITUDINAL SECTION OF HORIZONTAL JET CONDENSER MADE BY THE PULSOMETER ENGINEERING CO., LTD., READING

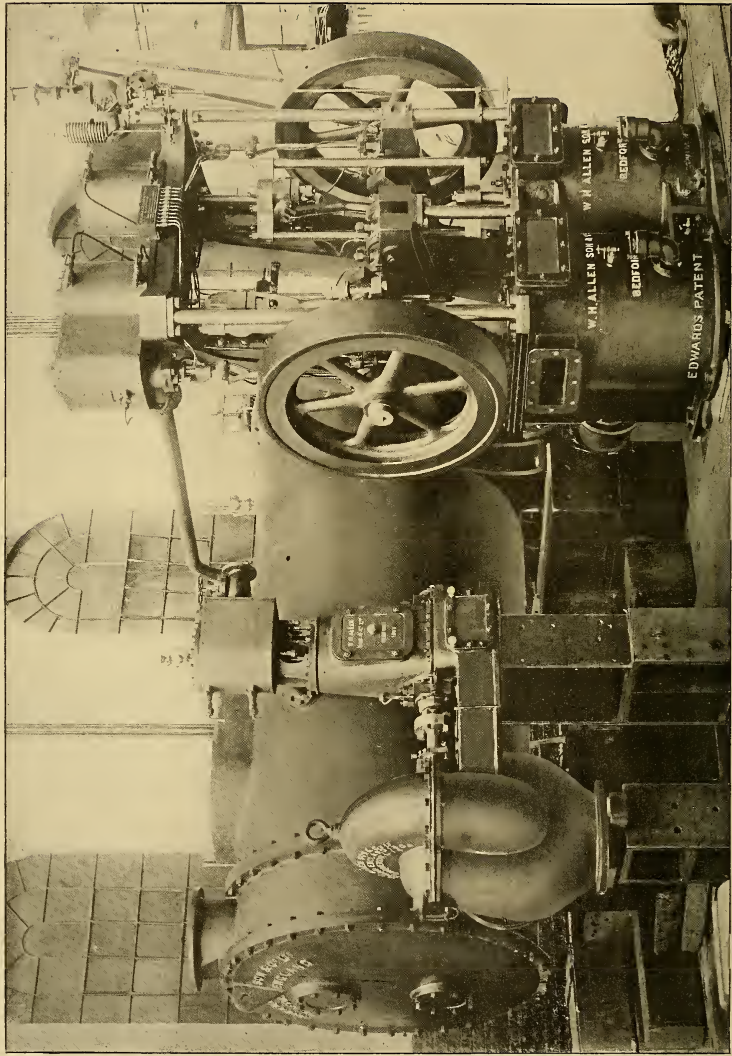


FIG. 21.—INDEPENDENT CONDENSER WITH TWIN AIR PUMP AND CIRCULATING PUMP. BUILT FOR JAPANESE SERVICE BY MESSRS. W. H. ALLEN, SON & CO., LTD., BEDFORD, AND THE EDWARDS AIR PUMP SYNDICATE, LTD., LONDON

careful attention to air leakage will do much to make an ordinary air pump satisfactory. Most of the bad vacua are due to carelessness on this point, and it is common to see air pumps over-driven with the object of getting over the faults due to air leakage that ought to be checked by good joints, painted pipes, and proper attention to packing of glands.

In jet condensers a very convenient arrangement is that of Figs. 16 and 17, as supplied by the Pulsometer Company, of Reading, with horizontal steam-driven pump, their vertical type being that of Fig. 20. The horizontal is the type generally used for jet condensing; in the vertical type the air pump is of the ordinary Edwards type, but the circulating pump is of special construction. The ordinary circulating pump is not suitable for working on cooling towers, except when running very slowly. With the design shown in Fig. 20 the pump can run comfortably at 150 feet per minute on a cooling tower 40 feet high, or, under ordinary conditions of condensing, at 180 feet per minute. The water has a clear run through, and the direction of the water is continuously one way.

In the horizontal pump the steam cylinder is coupled on at the end, and, as there is a fly-wheel, the steam can be worked expansively, which is more economical than direct-acting without flywheel. In the jet condenser the steam enters near the top at one side, and is met by a shower of water spread from a mushroom valve with a sprayer guard beneath. The water falls down the converging vessel, carrying with it the air to the pump, the form of which is clearly shown in the sectional view. The arrangement is such that the air can rise directly upwards to the delivery valves and will be promptly discharged.

In the vertical pump, Fig. 20, the circulating water is drawn in by both ends of the bucket and delivered through valves placed opposite the inlet valves, all parts being sloped where necessary to prevent the formation of air traps, and the top valve coming flush up to the top of the discharge chamber, so that the air will be fully discharged without formation of pockets, which destroy the efficiency of a pump and should be carefully guarded against.

The usual form of surface condenser shown in Fig. 19, as made by Messrs. W. H. Allen, Son & Co., of Bedford, makes clear the arrangement of the numerous brass tubes and the central diaphragm which divides the tubes into two sets so that the water shall make a double pass through the tubes. The extension of entrance surface is made clear by the *V*-gap in the bundle of tubes.

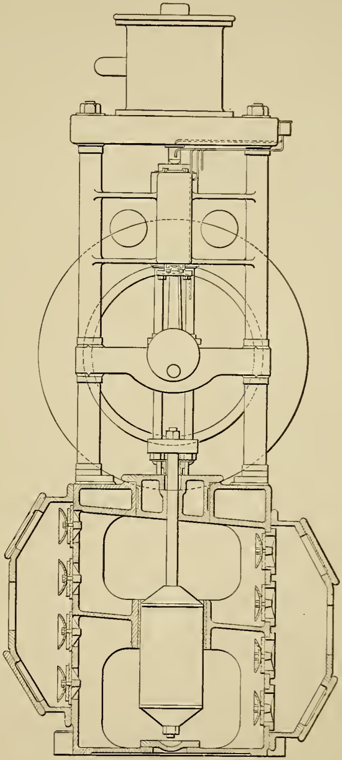
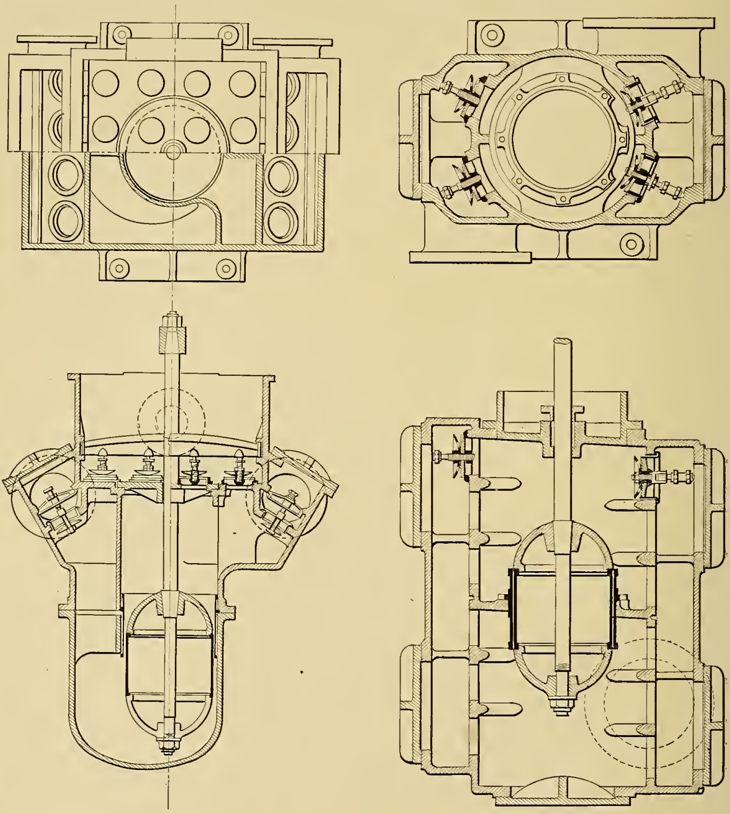


FIG. 20.—VERTICAL CIRCULATING PUMP

The same firm also supplied the condensing plant shown in Fig. 21, and made up of a condenser of 4000 square feet of tube area, a twin 20″× 11″ air pump driven by a compound engine 9″ and 15″× 11″, with a 14-inch circulating centrifugal driven by a 9″× 6″ enclosed engine. The air pumps are of the Edwards type, and the whole forms a good arrangement of a combined condensing plant. A similar combination, electrically driven, is shown in Fig. 18, the surface of the tubes in this case being 2500 square feet, with three-throw air pumps 12″× 10″, a 4″× 8′ water pump, and a 12-inch centrifugal. The water pump takes away the condensed steam, leaving only the air to be dealt with by the air pump. With circulating water at 80° F., Messrs. Allen provide 11,000 square feet of surface to deal with an hourly steam supply of 90,000 pounds, or a little over 8 pounds of steam per square foot per hour. With colder water more duty per square foot may be expected.


Air Pump

Circulating Pump

FIGS. 22 AND 23.—PLANS AND SECTIONS OF AIR AND CIRCULATING PUMPS MADE BY MESSRS. HICK, HARGREAVES & CO., LTD., BOLTON

The vertical displacement air pumps

of Messrs. Hick, Hargreaves & Co. is shown in Fig. 22. Though double-acting, there is no place in which air can lodge. Entrance to the pump body is through the inclined valves on either side of the sectional view, and escape is through the numerous valves in the cover. By the peculiar arrangement of the casting the two ends of the pump and the inlet and outlet valves are divided into separate chambers.

In Fig. 23 the same design of plunger is shown applied to a circulating pump. There are two rows of six valves on each side for inlet and outlet, respectively. The sloping roof of each chamber prevents lodgment of air which escapes readily through the uppermost of the outlet valves, which, it will be observed, are at the extreme top of the left side or outlet chambers flush with the roof of the cover.

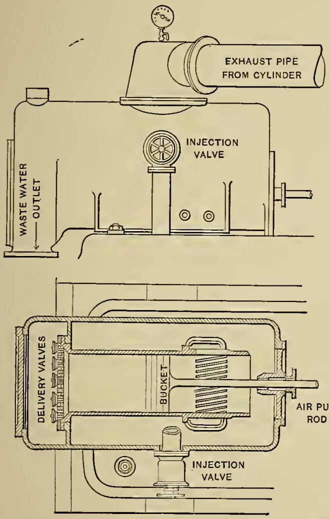


FIG. 24.—ELEVATION AND PLAN OF LONG-STROKE AIR PUMP MADE BY MESSRS. POLLIT & WIGZELL, LTD., SOWERBY BRIDGE

Messrs. Pollit & Wigzell, Ltd., of Sowerby Bridge, have long been noted for the quiet running of their long-stroke air pumps, one of which is shown in Fig. 24. The air pump is carried in the middle of the condenser, and its front end is open to the condenser, while its back end is occupied by the discharge valves. The bucket is simply a plain, ring-packed piston, attached to the tail end of the low-pressure piston. Steam is condensed by the jet, and falls to the bottom of the condenser. The bucket creates a very thorough vacuum on its out-stroke between the delivery valves and the diagonal inlet slot, through which, when uncovered by the bucket, the air and water rush into the barrel and are ejected through the delivery valves. These air pumps are running at 150 revolutions per minute at a speed of bucket travel of nearly 900 feet per minute.

A combined air and circulating pump and surface condenser of the same firm is shown in Fig. 25, in which will be noted the peculiar entrance of the exhaust steam to the condenser by way of a sloped passage which distributes the steam over the whole length of the tubes and minimises the risk of short circuits, which end is secured also by the great length of the outlet to the air-pump chamber.

The fact that steam, even at very low pressures, will flow at a high velocity into a still lower pressure, is made use of in the ejector condenser. One of these condensers, as made by Messrs. Ledward & Co., of London, is shown in Fig. 28. Water enters preferably under a head of several feet,—the greater the head, the better the result. Steam enters by the petticoat pipe, and is entangled with the water, and, a vacuum once formed, the steam flows with a high velocity and adds velocity to the flowing water, the combined streams flowing off together. Condensers of this type will give a vacuum of 26 inches under ordinary circumstances. Where a head of water is not available, the supply is furnished by a pump.

The ejector condenser is simply a particular case of the exhaust steam injector, which, however, it antedated many years. A simple calculation will show the manner of working. The velocity of steam being, let it be assumed, 800

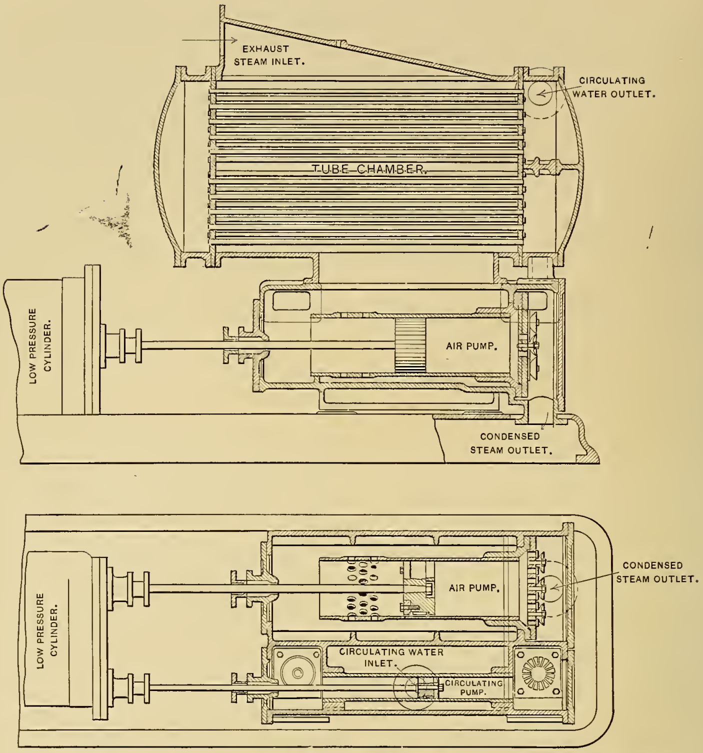


FIG. 25.—SECTION AND PLAN OF SURFACE CONDENSER WITH CIRCULATING AND AIR PUMPS AS INSTALLED BY MESSRS. POLLIT & WIGZELL, LTD., SOWERBY BRIDGE

feet per second, and the ratio of steam to water being 1.20, the combined velocity of steam and water will be about 40 feet per second, or one-twentieth of 800. Then by the law of falling bodies we have $V=8\sqrt{H}$; but $V=40$, when H must be 25 feet, and a head of 25 feet represents 10 pounds.

If, however, the velocity of approach of the water be already that due to a head of 9 feet, or 24 feet per second, then the total velocity will be 40 + 24, or 64 feet per second, which corresponds with $H=64$ feet, or a vacuum of about 27 pounds, which is more than possible, and simply tells us that, with an initial head of 9 feet, a good vacuum is possible with a velocity of steam less than 800 feet per second, or with a higher ratio of water than 20, and generally that the ejector condenser is a perfectly feasible and non-mysterious appliance.

Fig. 26 shows an electrically driven set of air and circulating pumps by Messrs. Cole, Marchant & Morley, of Bradford. In their practice this firm have developed three principal systems for driving the pumps required in connection with independent jet and surface condensing plants, viz., steam; rope or belt drive from the main engines; and electric motor drive.

The last of these three, from many points of view, is most convenient in

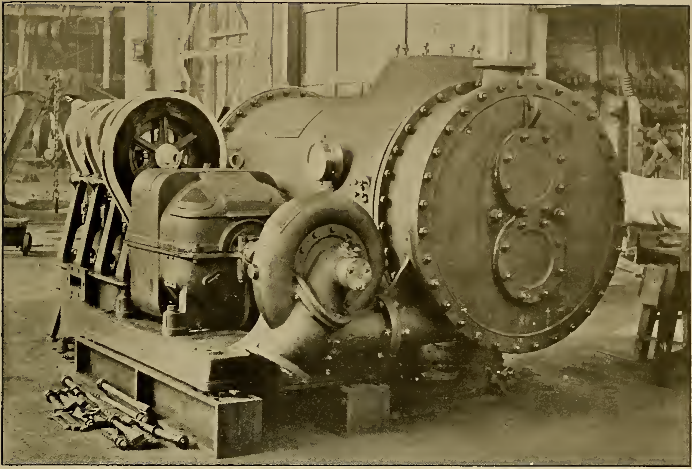


FIG. 26.—ELECTRICALLY DRIVEN AIR AND CIRCULATING PUMPS MADE BY MESSRS. COLE, MARCHANT & MORLEY, LTD., BRADFORD

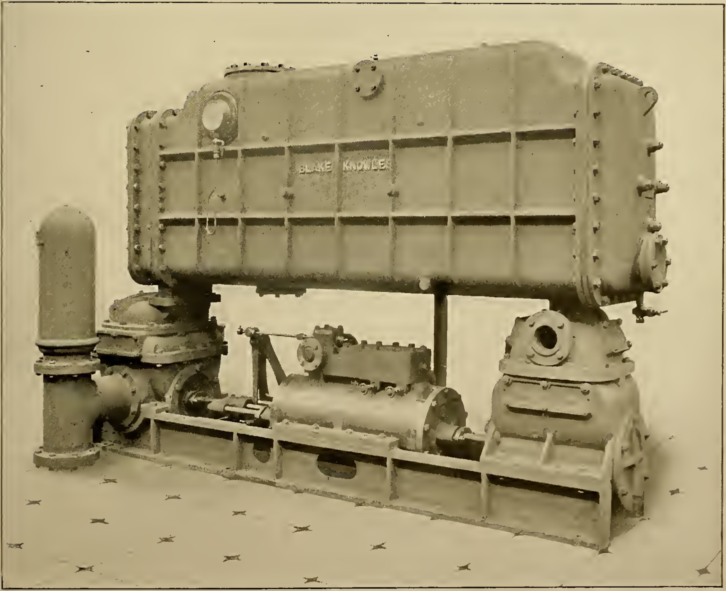


FIG. 27.—ADMIRALTY TYPE RECTANGULAR CONDENSER MADE BY THE BLAKE & KNOWLES STEAM PUMP WORKS, LONDON

electric generating stations. With surface condensing plant for driving by motor no system works more smoothly than the three-throw air pump with the centrifugal circulating pump. Frequently each pump is driven by its own motor, but the cost of a slow-speed motor for driving the air pump direct is often prohibitive; therefore, a high-speed motor is used with single reduction, machine-cut spur gearing to drive the air pump.

Instead of two high-speed motors, especially in the case of smaller units, it has been found of great advantage to have one motor coupled direct to the centrifugal pump and carrying on the opposite end of the spindle the pinion driving the spur wheel on the three-throw air pump shaft. The pinion may be of rawhide, and the pumps are so balanced as to avoid excessive noise, the whole plant being efficient, compact and easily maintained. The arrangement shown in Fig. 26 is made in a series of sizes suitable for condensing from 3000 pounds of steam per hour upwards, though in very large units it is generally found convenient to drive the pumps by separate motors.

The writer would point out, finally, that the independent condensing plant has no constitutional disabilities. It has the defects of its qualities. Its very convenience of arrangement which enables it to be set to work to pump up a vacuum before the main engine is started is a temptation to the ignorant or careless man, who, too idle to maintain air-tight connections, uses his air pump to cover up avoidable defects and wastes more steam than the condenser saves. But this is no fault of the system. The fault is with the engineer who misuses the plant.

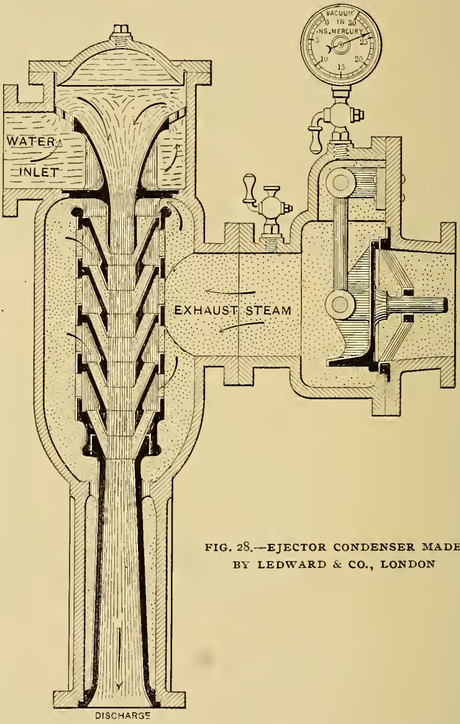


FIG. 28.—EJECTOR CONDENSER MADE BY LEDWARD & CO., LONDON

There is a good deal of misapprehension generally regarding the economy of condensation. As it means an addition of 12 or 13 pounds of mean pressure on the piston, it is clear that condensing is very important in small traction stations where the load factor is poor and the mean pressure on the pistons of the engines is low, for the equivalent of the vacuum forms a larger ratio of the total pressure. The benefit expected from condensation must always be considered from such standpoints, so that the true commercial economy may be accurately estimated.

The Blake & Knowles Admiralty type condenser is rectangular in cross-section, the shell being of cast iron, with a dome which allows room for the expansion of the steam on entering the condenser. Under the opening is a perforated baffle plate, to distribute the steam over the cooling surface. The tubes are of seamless drawn brass of ¾ inch external diameter, and of not less than No. 18 B. W. G., and it is their standard practice never to put in tubes of less than ¾ inch.

The circulating water preferably enters the lower part of the condenser, passes through the lower bank of tubes, and returns through the upper bank. The circulating water thus enters and leaves the same end of condenser.

The condenser is usually mounted above the combined air and circulating pumps. This enables all piping between the condenser and pumps to be dispensed with. The circulating pump delivers directly into the water box and the air pump draws from the condenser body direct into the air-pump cylinder. Both pumps are driven through one continuous piston rod from the steam cylinders located midway between the pumps. The design of the steam cylinder can be varied, and in Fig. 27 is shown a set arranged with ordinary single steam cylinder. These sets are built with from 50 to 60 square feet of surface, to sets as large as may be reasonably desired, having practically no limit in as far as the size is concerned. These outfits are also very largely used in connection with cooling tower work, and sizes can be properly proportioned for this.

In connection with turbine plants, where very high vacua have to be maintained, it was found practically impossible under ordinary conditions to guarantee the vacuum necessary, so that a special plant had to be designed for the conditions.

This plant consists of a condenser of the above type, but arranged, on the circulating suction side, with a vapour cooler, in direct connection with the air pump, and also hot-well on the lower part of condenser. In connection with the above a special form of dry vacuum pump is used, arranged exclusively to pump the air, while the ordinary centrifugal, or wet vacuum, pump deals with the condensed water. With this arrangement it has been possible to get a vacuum close to the possible maximum, and a vacuum of 28 inches is guaranteed.

THE PROPOSED 20,000-TON AMERICAN BATTLESHIPS

By a Late Chief Engineer of the United States Navy

FROM current reports, it appears that plans are in course of preparation in the United States Navy Department for new battleships which shall surpass, in some respects, any fighting machine now building or afloat. The ships proposed are of 18,000 to 20,000 tons displacement, with an armament consisting of guns of but two calibres,—ten 12-inch placed in turrets and in broadside, and, as a secondary battery, at least twenty of the new 3-inch, quick-firing type. It is claimed that such a battery of heavy guns would constitute the most formidable armament for long-range fighting that is practicable under present conditions, while the flood of fire from so many, and, in this respect, such effective guns as the 3-inch now is, would give the best possible defence against attack by torpedo-boats or destroyers, since this gun can now be fired as rapidly as those of less calibre, and is, of course, of greater range and destructive power.

The advantage of restricting the armament to guns of but two calibres needs no supporting argument, in so far as simplicity of hull-design and facility of operation are concerned, and the calibres proposed seem those which the highest expert opinion favors at this time. The main objection to the design is, as reported, that in order to construct a ship of sufficient size to carry so large a weight of armour, armament, and ammunition, sacrifices must be made in other directions, notably so in engine power and speed. The latter, it is stated, may be limited to 16 knots, the argument advanced being that such a ship is built "to fight, and not run away." The time-worn answer to this is that she must first catch her enemy before it will be possible for her to fight. The fortress at Port Arthur is also built "to fight and not run away," but Admiral Togo's fleet seem to have no difficulty in escaping its fire.

The proposed design is not a new project with the officials of the United States Navy Department. It is, in effect, a growth of years. The fact that ships of this large tonnage are not already afloat in the United States fleet is due less to expert objection than to the difficulty of securing Congressional consent and the necessary appropriations. It took years to force American battleship displacement from 10,000 to 16,500 tons, and the proposed increase will probably meet the same opposition.

There is no doubt that, with proper design, more fight can be gotten out of 20,000 tons than from 16,500, although, both in America and in Great Britain, a not inconsiderable weight of opinion favours two 10,000-ton ships in place of one of the total tonnage. All sorts of arguments of the "too many eggs in one basket" type, the division and greater mobility of gun power, and others, are advanced as to this; but when naval designers have faced the problem in practice, they have found that, to fill all requirements as to armour, armament, speed, coal endurance, ammunition, stores, and room to billet her crew, the larger the ship, the more readily the best features of an ideal design could be embodied. In the attempt to keep tonnage down, first the engine power and next the coal endurance have suffered, with the result that some battleships strike an undesirable mean, being able neither to fight nor "run away" effectively. If, for example, the battleships of the Port Arthur fleet had possessed both high speed and strong offensive power, they might, long since, if well handled, have either escaped to Vladivostok or have made a worthy effort to wrest the command of the sea from Japan.

In view of the fact that Great Britain is already designing 18,000-ton battleships, the size of the proposed vessels, —20,000 tons,—is not revolutionary. The tendency of the modern design to avoid sacrifice in qualities of vital importance leads inevitably to the largest practicable displacement in the battleship, which must not only have the maximum power of offence, but be capable of high speed in the chase and of long passages to distant seas. Especially is the latter true of the naval forces of the United States, since the changes wrought by the acquisition of Hawaii and the Philippines and the development of Alaska have given her a future, measureless in its possibilities, on the Pacific and in regions near the Asian littoral.

Some expert opinion favours, for the proposed main battery, twelve 10-inch instead of ten 12-inch guns, the reasons advanced being that a 10-inch shell will batter in anything but the turrets of any ship afloat, and as a greater number of rounds of 10-inch than of 12 can be carried, the advantage, in action, might rest with the ship thus armed. As to the secondary battery, below 5-inch, the calibre is not of cardinal importance in close fighting. The main object in this is to pour a smothering flood of shell on the enemy, driving his gun-crews from their stations. The great weakness of the small calibre for general purposes is its short range. It is good for close work only, while with good marksmanship, as the Japanese have so notably shown, the naval battle of our time may be fought and won at 6000 or 7000 yards, with heavy guns.

As far as torpedo attack is concerned, any shot down to that of a shoulder-rifle will disable any torpedo craft, since the latter have hull plates but one-tenth to one-eighth of an inch thick, and three-fourths of the whole length of these frail vessels is filled with mechanism, engines and boilers vital to their offensive power and mobility. A well-aimed one-pounder shot or shell will cripple the most powerful torpedo-boat if it finds its mark in either boiler or engine. With regard to the submarine, the tragic fate of a British vessel of this type shows at least one effective way of meeting its attack, namely, that of running it down. A swift fleet of deep-draught vessels under way in the daylight has, with vigilance, but little to fear from under-water foes. The proposed 20,000-ton battleships promise, as a whole, a distinct advance in offensive power. As to their speed, it would be a military folly to construct any battleship, at this time, with any such speed, or lack of it, as that of 16-knots gives. One of the principal lessons of the war in the Far East is that speed is a vital essential. The strength of a battery is no better than weakness if, at will, it cannot be brought within range of the enemy.

Current Topics

If there is any real good to be accomplished by automobile races of the kind exemplified by the recent contest held in the United States under the auspices of the Automobile Club of America, it remains yet to be demonstrated. The only things that such races seem to have proven are that freak machines, unfit for commercial service, can be run on ordinary roads at speeds which good sense ought to discourage, and that there are some foolhardy persons willing to operate them at the risk of their own as well as other people's lives. Of course, we are told that automobile racing affords the right kind of stimulus to good automobile building, that it shows what the weak points are in the machines which break down, and that from such breakdowns good lessons are to be learned; but when it is borne in mind that in a race like this latest one there was not a single machine of commercial type, it would seem a waste of time to speculate as to the value of the results. A freak racing automobile affords very little basis for profitable study. It matters little, except in the interests of sport alone, that such a machine can be run at 70 or 80 miles an hour; indeed, there is nothing very remarkable about it. It means an over-powered machine, a fairly good road, and a madcap driver, and in some cases a serious accident before the run is ended. Ordinary automobiles in regu-

LAUNCHING THE BATTLESHIP "NEBRASKA," OF THE UNITED STATES NAVY, AT THE YARD OF MORAN BROTHERS, AT SEATTLE, WASHINGTON lar service,—business or pleasure service,—do more to develop good automobile engineering experience than any number of such wild races. Last month's contest is said to have shown that the really weak points in all the machines in the race were the tires; but as nails and broken bottles were also said to have been plentifully scattered over the road at some places by ill-disposed persons, thus creating abnormal conditions, the tires clearly would seem not to have had a fair chance.

———

WARSHIP launching has been a conspicuous feature of American happenings during the past few weeks, three battleships and one gunboat having gone into the water in as many different yards. The battleships are the *Connecticut*, of 16,000 tons displacement, built at the New York, or, as it is familiarly known, the Brooklyn Navy Yard, and launched on September 29; the *Nebraska*, of 15,000 tons, launched on October 7 at Moran Brothers' shipyards at Seattle, Washington; and the *Georgia*, also of 15,000 tons, launched on October 11 at the yard of the Bath Iron Works, at Bath, Maine. The gunboat in question is the *Paducah*, launched on October 13 at the yards of Messrs. Charles L. Seabury & Co., Morris Heights, New York. The *Connecticut* is a sister ship of the *Louisiana*, being built by the Newport News Shipbuilding and Dry Dock Company, both vessels having a load water-line length of 450 feet, an extreme breadth of 76 feet 10 inches, and a draught at full load of 26¾ feet. Twin screws and triple-expansion engines of 16,500 I. H. P. will drive the ships 18 knots an hour, and Babcock & Wilcox water-tube boilers will supply the steam. Each vessel will have a complete water-line armour belt 11 inches thick for about 200 feet amidships. Forward and aft of this the maximum thickness is 9 inches within the limits of magazines, from which points the thickness is gradually decreased to 4 inches at the stem and stern. In armament both ships will be more powerful than any other American battleship now afloat. There will be four 12-inch guns in fore and aft turrets, and eight 8-inch guns in turrets at each corner of the superstructure. There will also be twelve 7-inch broadside guns, while the secondary battery will be composed of twenty 3-inch rapid-fire guns, twelve 3-pounder, semi-automatic rifles, eight 1-pounder automatic rifles, two 3-inch field guns, and eight machine guns. Four submerged torpedo tubes will complete the offensive equipment. There will be a crew of 780 men and 42 officers. The limit of cost of each vessel, exclusive of armour, was $4,212,000. Both vessels, according to a recent tabular comparison, are superior to any vessel of any other navy either afloat or under construction.

———

THE *Nebraska* is the first battleship built on the Pacific coast of America north of San Francisco. She is a sister ship of the *Georgia*, the largest vessel ever built in the State of Maine, and also of the ships *Virginia*, *Rhode Island* and *New Jersey*. Her cost was $3,733,600. An interesting feature of her launching was the presentation of a check for $100,000 to Moran Brothers by the citizens of Seattle by way of bonus and as a mark of appreciation of their enterprise in establishing works in that city capable of turning out battleships. Eighteen years ago these brothers opened a little machine shop, 10 × 15 feet, on the water front, for the purpose of repairing the machinery of small craft. To-day their plant covers five acres. The *Georgia*, as already noted, is a 15,000-ton ship, and is 441 feet long, of 76 feet beam, with a draught of 24 feet. She will have a speed of 19 knots and 19,000 I. H. P. Water-tube boilers here, too, will supply the steam to twin-screw, triple-expansion engines. Four 12-inch guns, eight 8-inch and twelve 6-inch guns will make up the main battery, while the secondary battery will comprise fourteen 3-inch guns, twelve 3-pounders, sixteen smaller guns and four torpedo tubes.

A NEW kind of labour union foolishness has just come to light in the city of New York. It is illustrated in a recent daily newspaper account, according to which one of the contractors engaged in erecting ironwork on the stations of the new Subway was taking on new men and needed both finishers and helpers. The Housesmiths' and Bridgemen's Union has two classes of members,—finishers and helpers. They are two distinct trades, but are governed by one set of officers. A helper, after serving an apprenticeship, can become a finisher, but each class must stick to its own kind of work. A finisher gets $4.50 a day, a helper, $3. The contractor had no difficulty in obtaining all the finishers he needed, but there was a lack of helpers. He was looking after his work at one of the stations when a man applied for a job as a finisher. He had no helper and said he could not find one. It was necessary that a finisher and a helper should work together on this particular job. Just then another workman came along and asked that he be put to work. He was a finisher, but when the contractor said he needed a helper, the man said he would go to work for the smaller pay, as any work was welcome. The two men were started putting up the iron grille around one of the stairways. The contractor moved on up the Subway to see how the work at the other stations was progressing. The next morning his foreman reported that neither of the two new men had turned up. Then the man who had been employed as a finisher came to the contractor's office with the explanation. He and his mate had been at work for about an hour, he said, when an eagle-eyed agent of the union came along. He asked for the men's cards. Each produced a finisher's card. The finisher who was working as a helper was told to quit, as he had no right to work in the grade below, even though he was willing to accept less pay. The fact that no helpers were to be had made no difference. He obeyed the order to quit, and the other man had to quit, too, as it was impossible for him to work alone. The man who wanted to work as a helper could continue to do so, the agent told him, if he would take out a helper's card. If he did so, however, he would have to work his way back into the finishers' class, and that might take several years. No one would have suffered by the finisher's working as a helper; but, according to union dictation, he had to remain idle, and his companion as well, though work was in sight and both were willing to do it.

TELEGRAPHING overland for a distance of 300 miles by wireless means is one of the noteworthy engineering achievements of the past month. It was accomplished with the De Forest system between St. Louis and Chicago, and while the country between these two cities is practically level, and, therefore, well suited to wireless transmission, it is to be noted the cities themselves intervened between the two transmitting stations, affording obstacles to successful wireless work which earlier experiments had shown to be formidable ones. Wireless signaling overland is, of course, not altogether a novelty. It is, for instance, well known that Fessenden has had in experimental operation a circuit between Jersey City and Philadelphia, a distance of about 100 miles, for more than a year. In the experiments also that Marconi carried on between the Mediterranean and Poldhu, in England, in 1902, it may be remembered that signals were reported to have been received from Gibraltar, and beyond,—a distance of 750 miles, several hundred miles of which were overland. These last mentioned signals were, however, sent in one direction only, namely, from Poldhu to the Italian cruiser *Carlo Alberto*, the transmitting apparatus at Poldhu being very powerful. In the De Forest experiments between St. Louis and Chicago the masts were 200 feet high and twenty vertical wires were employed. It is now stated that attempts will shortly be made to open up communication by wireless telegraphy to New York from St. Louis,—a distance of 1200 miles. Contemporaneously with the announcement that Dr. De Forest had succeeded in sending messages by his wireless system from St. Louis to Chicago came the prediction by the promoters of the enterprise that in the course of a few months messages would be sent direct from Seattle, in the State of Washington, to the Philippine Islands. Predictions of transoceanic wireless communications, however, have not been wanting during the past few years, so that actual proof of such transmissions in a regular commercial way would be infinitely more interesting and important.

Apropos of President Roosevelt's now much-quoted remark relative to carrying the "big stick," it is interesting to note that the car conductors on a certain portion of the electric railway in Montreal are required to carry a stick for a very useful purpose. Where the line passes over the Lachine Canal and several parallel forebays for water power at St. Gabriel locks, the road is single track, owing to the limitations of the bridges. Because of several turns in the road there it is impossible to see from one terminal of the single track to the other. To avoid the inconvenience that would ensue from the meeting of two cars on the single track, not to mention the possibility of serious accidents, the company has provided a painted stick about 1 foot in length which is handed to the conductor about to cross the bridge, the possession of which stick entitles the conductor to the right of way. When this car reaches the other side of the bridge the conductor passes the stick to the conductor of the car there waiting to cross in the opposite direction, and the latter is now habilitated with the right of way. He, in turn, when he reaches the other end of the single track, hands the stick or baton to the conductor of the first car he meets coming in the opposite direction. It is an imperative rule of the company that no car shall start over this restricted portion of the road unless the stick is in that car, and this ensures that but one car at a time can be on the restricted portion of track. In case of a blockage at points remote from the bridge this system is, of course, at a disadvantage; but it appears to suffice for the end in view. This use of the stick, as the insignia of right of way on railroads, is, however, not altogether peculiar to the city of Montreal, inasmuch as it was in vogue years ago in a number of instances in Great Britain, and possibly other places on single-track railroads.

ALBERT WILLIAM SMITH

Director of Sibley College, Cornell University

A BIOGRAPHICAL SKETCH

By Walter C. Kerr

JUDGED by all of the standards that go to make a man and an engineer, Albert W. Smith represents the best type that Cornell University has graduated. He is personally well known to a large circle of Cornell alumni, and to others by reputation, for his advanced views respecting modern engineering methods with their relation to educational processes, and for his power of conservative and diplomatic administration. That he should have been called to succeed the honoured Dr. Thurston as director of Sibley College, at Cornell University, is, therefore, more the result of common assent than special selection.

The academic generations in the important departments of universities may be considered as marked by the changes of administration which follow from the election of new heads. This follows from the fact that the men who fill such positions usually live and serve their natural term and are succeeded only at long intervals by others. A professor filling such a chair, therefore, has opportunity to develop his main ambitions, during which time changed conditions in the world bring about such new phases of demand as to leave ample room for his successor to start a new train of effort. The competency with which the higher positions in engineering institutions have been filled has given broader and better foundation for the work of each succeeding administrator, and thus, in the main, engineering education has prospered through the few academic generations of its existence.

Early growth is the fastest and most conspicuous, while the later development has opportunity, under favourable conditions, to be the more sturdy. At Cornell University the first generation of the College of Mechanic Arts prospered under the leadership of Professor John L. Morris, with Professor John E. Sweet at the head of the shops which formed a peculiarly characteristic feature of the early development. This was from the early seventies until about 1885, when there followed the greater development of the College of Mechanical Engineering under the guidance of Director Robert H. Thurston. Eighteen years later, in the fall of 1903, the death of Dr. Thurston suddenly left this department, aggregating nearly one-third of a university of 3000 students, without a head.

During the following winter Professor Albert William Smith, the head of the Department of Mechanical Engineering of Leland Stanford Junior University, was called to the director's chair. His acceptance marks the beginning of another generation, with whatever it may contain of advancement. Dr. Thurston's work was, in many respects, finished. He had largely accomplished that for which he had gone to Cornell, namely, the building up of a department of mechanical engineering which in size and quality should meet the existing needs. In size it almost outran itself, and it has been difficult for the University to provide sufficient instruction and accommodation for the students who have pressed to enter. Here it should be remembered that though an engineering student pays only $125 tuition, it costs the University over $300 per annum to educate him. In quality it quickly took first rank, and always stood for progress.

Professor Smith, in accepting the responsibilities of shaping the lives of one thousand young men, undertakes the administration of a department of developed size and quality, aided by the general courses of a large university in which the engineering students receive about one-half of their instruction. To continue the excellence imparted by Dr. Thurston is not a sufficient motive for the succeeding generation. Those best posted know that the task of advancing the quality of engineering education is one requiring great foresight, a willingness to introduce and rationalise new methods, and perception of the ever-changing relationships to other forms of education. It was only after many conferences with the University authorities and some of the older alumni that Professor Smith felt willing to undertake an extension of educational effort from the point at which Dr. Thurston left it.

Professor Smith is temperamentally well qualified to direct the educational work of a large engineering department. He has a generous fund of human sympathy, the capacity for interesting students, and a personal dignity and character of the undefinable type which makes him beloved of all who come in contact with his personality. To those who do not know him, a glance at his portrait in this issue will be sufficient.

The motive of the new director and the interest voiced by some of the most experienced alumni are parallel, and Professor Smith, therefore, takes up the administration of this important department with motives and methods promising to lead to a betterment of engineering education which, it is believed, will compare favourably with its development during any previous academic generation.

The selection is not the result of seeking the man whose name would bring additional publicity to the work. The opportunity is internal, and, therefore, requires specific talent of like kind with the results to be performed. Professor Smith's own career contains the elements of the mission he has accepted. Born on August 30, 1856, he lived in Westmoreland, Oneida County, New York, until he entered Cornell University with the class of '78. His first position after graduation was with the Brown & Sharpe Manufacturing Company, at Providence, R. I. Next he was associated with Professor John E. Sweet at the Straight Line Engine Works, at Syracuse, where he became foreman of the shops, and later he was mechanical engineer of the Kingford Foundry & Machine Works, at Oswego.

After about seven years thus spent in practical work, he returned to Cornell University as a graduate student, receiving the degree of M. M. E. with the class of '86. He next had charge of the mechanical laboratory of Sibley College; was then for four years assistant professor of mechanical engineering, and later laid the foundations of the present department of machine design.

Leaving Cornell, he was, for one year, professor of machine design at the University of Wisconsin, and in 1892 became professor of mechanical engineering at Leland Stanford Junior University, which latter position he has now relinquished to again become associated with Cornell University.

During this period he employed his vacations, or sabbatical years, in active engineering work. He spent one year with the Dickson Manufacturing Company, at Scranton, Pa., principally designing large steam engines; two years with Westinghouse, Church, Kerr & Co. in engineering work and investigations, and a summer vacation with the Solvay Process Co., of Syracuse, N. Y. It will be seen that his experience alternated between educational and industrial occupation, and, therefore, to an unusual degree combines the knowledge and opportunities of the university and the world.

Professor Smith is thus not the typical professor whose life has been lived in college halls, nor yet is he the practicing engineer whose life has been lived in the whirl of commerce and construction; but by taste and experience he is a well balanced product of the university hall and the field, competent to judge each in the light of the limitations of the other and to carry from one into the other that almost indefinable touch which inspires within the university the spirit of the outside world in which the students must perform.

The tendencies in engineering education have diverged from the purpose for which it exists,—not so far as to injure the character of such education, but rather reducing the rate of growth of its efficiency. To prepare young men for a given world the preparer must understand that world and be of it. He must understand the world of to-day and not of yesterday. Thus engineering schools require close contact with, and the inspiration of, the engineering world. This can be aided in many ways, but nothing is so effective as to have the professor impart knowledge, stimulate ambitions, direct methods, and in many ways lead young men toward their goal by his own self-knowledge of the world for which he is training them. In the mission of enhancing the efficiency of engineering education at Cornell University. Director Smith has the sympathy, backing, and co-operation of the board of trustees, faculty, and graduates, many of whom are large employers of young men from such institutions, and who have practical knowledge of what is needed.

It is not within the scope of this sketch to outline the ways and means by which betterment of the educational conditions at Cornell will be brought about; but they lean toward greater practicability, effectiveness, and that high form of intellectual training which follows from achieving knowledge for use. Perhaps the most specific and immediate feature is the method already approved by the board of trustees and referred to the President and to Director Smith for administration, namely, the providing of opportunity for the professors to alternate periodically between the university and practical engineering, thus bringing instruction into close touch with actual engineering work. This should in time tend to create a new type of professor, a man of much broader experience, better fitted in every way for the instruction of youth. Those who conduct the plan will be left entirely free to carry it out through whatever ways and means may be found most practicable.

Nothing revolutionary is contemplated at Cornell. The Department of Mechanical Engineering is, and has been for years, of the highest order. It has to an unusual degree represented a well-filled mission, conducted on a well-rounded plan, and it is the intention of its managers and friends to further enhance its value, chiefly by internal development, in such a way that it will prepare young men, even better than heretofore, for their engineering missions.

This demands additions to the financial resources of the University. All engineering education is ultra expensive, and if the available income for this work could be doubled or quadrupled, results would be obtained in a few years which otherwise would require a generation. Large additional expense is required to do justice to all of the young men who are now ready and competent to take up engineering studies. With less financial opportunity, less will be done, and the eventual development will be delayed; but nevertheless this department, under the administration of Director Smith, will continually draw closer to the spirit of the engineering world than has been common in technical institutions. The motive will be strong to develop standards of competency which recognise that success depends less upon the amount of knowledge acquired than upon ability to use it.

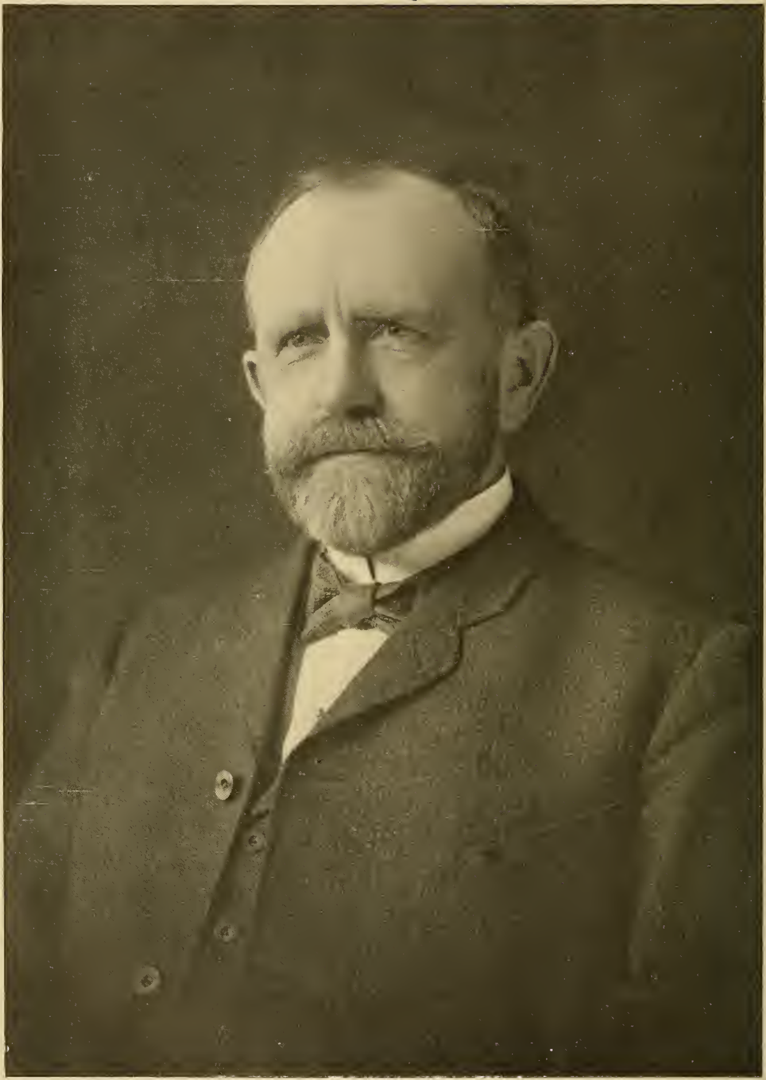


PHOTO BY SABINE STUDIO, PROVIDENCE

JOHN R. FREEMAN

THE NEXT PRESIDENT OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

SEE PAGE 167

CASSIER'S MAGAZINE

VOL. XXVII DECEMBER, 1904 No. 2

THE RAILWAYS OF NATAL

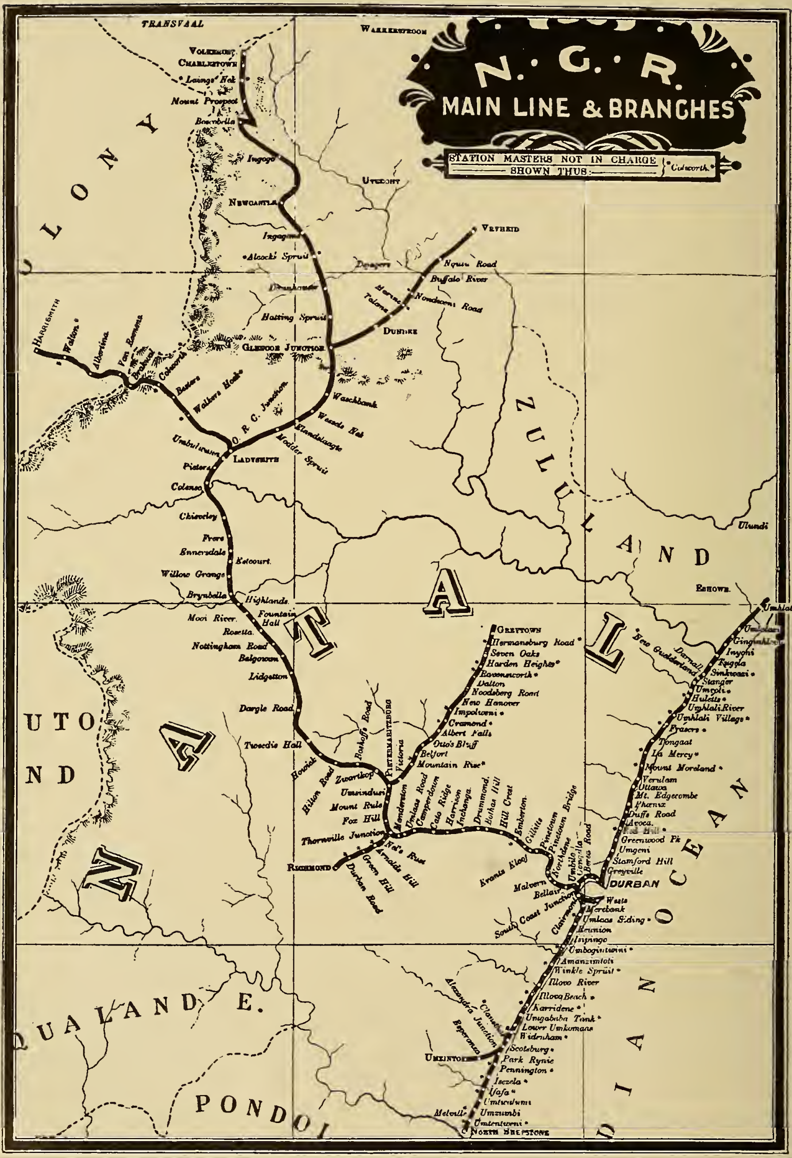
THEIR CHARACTERISTICS, TRAINS AND TRAIN SERVICE

By J. F. Gairns

THE DINING CAR EXPRESS, 5000 FEET ABOVE SEA LEVEL. THE "TRAIN DE LUXE"

THE Colony of Natal, unlike most of the other South African colonies, does not depend to any considerable extent upon gold and diamond mining, the only benefits it receives from these sources being due to the carriage of men and minerals between the mining centres of neighbouring colonies and the port of Durban. Instead, it owes its importance to the development of agriculture, and, in a lesser degree, to manufacturing industries and coal mining.

The latter, though it may be somewhat of a revelation to many readers, is of considerable importance, as evidenced



MAP SHOWING THE MAIN LINE AND BRANCHES OF THE NATAL COLONY RAILWAYS, 768 MILES OF WHICH ARE OPEN TO TRAFFIC. THE MAIN LINE CONNECTS DURBAN, ON THE COAST, WITH CHARLESTOWN, ON THE TRANSVAAL BORDER, A DISTANCE OF 306 MILES by the annual report of the General Manager of Railways for 1903, which states that during that year 22,247 tons were supplied to Cape Colony, 7551 tons to the Transvaal, and 3378 tons to the Orange River Colony, while the consumption of coal for railway and harbour purposes amounted to no less than 206,327 tons, and other amounts consumed in the colony bring the total up to somewhere about 360,000 tons, of which at least 200,000 tons are provided by the mines in the Dundee district. Including all qualities, the total yearly output of the mines is about 600,000 tons.

There is a very large area under cultivation, and a still larger proportion of the total area is devoted to cattle grazing. The agricultural industries are concerned with the following products, among others:—Mealies and Kaffir corn, sugar-cane, tea, bark, vegetables, wool, cattle, dairy produce, hides and skins, bananas and sub-tropical fruits, etc. There are also many manufactories and works devoted to woodworking, wagon-making, bricks and tiles, tanning, confectionery and preserve manufacture, ice making, stone cutting, ship and boat building, printing and bookbinding, saddlery and harness making, etc., besides which there are a number of iron-works, engineering establishments, electric light stations, numerous coal mines, railway workshops, and the extensive fishing industries of Durban and other places on the coast.

It will thus be seen that Natal has considerable importance from an industrial point of view. Although its state of development must already be reckoned as high-class, what has been done can be considered only as indicative of far greater possibilities in the future.

The railway system,—it may be stated as an axiom that the development of a country is directly dependent upon the extent, sufficiency and management of its railways,—is already extensive, and at the present time there is a total of 762 miles in operation; but it is still possible to travel in many directions in a straight line for more than 100 miles from a station without encountering another railway track.

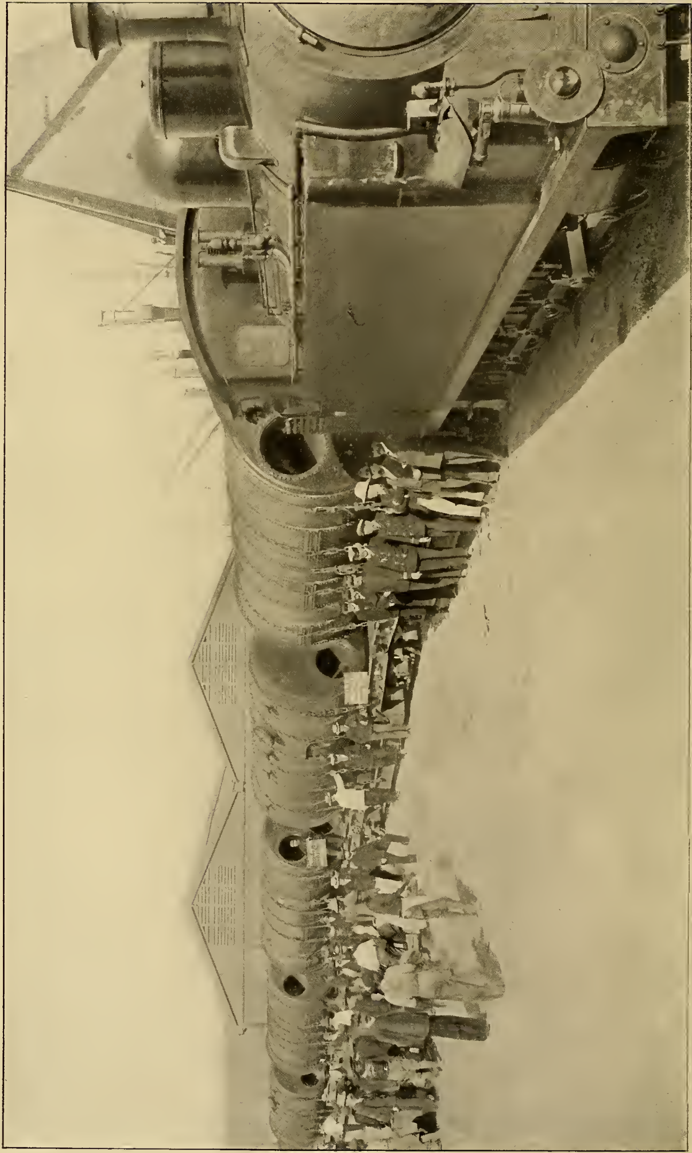
Numerous surveys for new lines have been made, and many of these projected extensions will become actualities before many years have passed; but while the government is trying to adequately serve the whole of the country by their railway system, the natural difficulties to be overcome are so severe in parts that the expense of many of the new lines must be almost prohibitive, owing to the fact that civilised population (away from the railways) is scattered, and many unremunerative years must pass before the influx of workers to, and the development of industries in, the new districts can result in sufficient traffic to cause adequate return and profit.

At the present time the railway system of Natal already connects all places of importance in the colony. It also provides the best means of reaching the principal towns of the Transvaal, and supplies the only connection with Harrismith, in the Orange River Colony.

Having thus briefly dealt with the Colony of Natal and the general aspects of its railway system, it will be well to more particularly consider the real subject of this article, the railways of Natal, their characteristics, extent, traffic, trains and train services, and other matters of interest.

The principal characteristics of Natal railways are undoubtedly gradients and curves. There are very few miles of really level line, and most of these are on branches where loads are light and gradients are not of so much consequence; the major portion of the main lines, and also many of the branch lines, have heavy grades, and as these are often combined with sharp and numerous curves, as the railway winds around and amongst the hills and mountains, it is not astonishing that speeds are low (or would be so considered in this country), locomotives powerful, loads very light in proportion to the engine power, and difficulties of traffic working extreme. As an instance of the climbing which has to be done, the following may be interesting:—

The ruling gradient of the main line



A DOCK SCENE AT DURBAN HARBOUR. A TRAINLOAD OF BOILERS

THE KITCHEN ON THE RESTAURANT-CAR OF THE CORRIDOR DINING EXPRESS

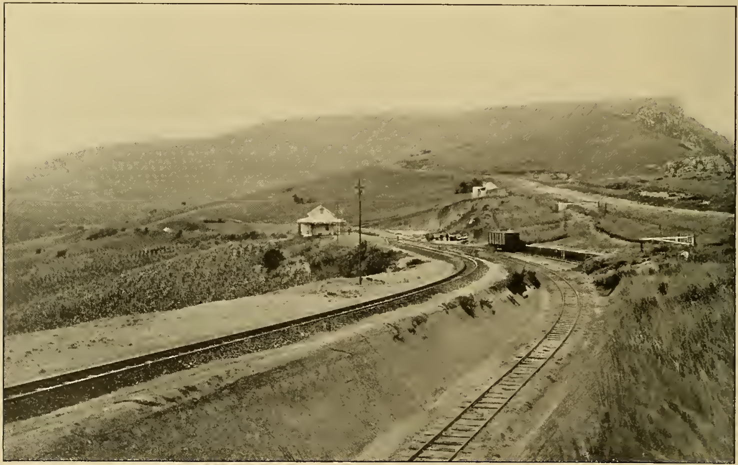
between Durban and Ladysmith (190 miles) is 1 in 30, the line continually rising or falling. A train running from Durban to Charlestown, on the Transvaal border, has to ascend in the aggregate the equivalent of nearly 2½ miles of vertical elevation, crossing altitudes of 2000, 3000, 4000 and 5000 feet above sea-level, which, when reached, are often lost again and have to be recovered.

For example, at Thornville Junction (59 miles from Durban) the train is 3054 feet above the sea; 13 miles farther on (Maritzburg) it has descended 800 feet; in the next 12 miles the loss is more than regained, and at Hilton Road 3700 feet are attained; 50 miles farther on, at a station most appropriately named "Highlands," a height of 5000 feet is reached, only to be reduced to 3284 feet at Ladysmith. Proceeding, the summit of the Biggarsburg chain is crossed at Glencoe at a height of 4400 feet, and when the border is reached the train will have climbed to 5400 feet. The Harrismith branch line rises continuously in Natal territory and crosses the Drakensburg Mountains at a height of 5520 feet above the sea.

Owing to these gradients, many of which are at 1 in 50, 1 in 40, and in places 1 in 30, the engine loads have at intervals to be reduced and readjusted, all of which operations add to the difficulties of conducting traffic, involving shunting, breaking-up and remaking of trains, and consequent loss of time, when even the most powerful locomotives have to be restricted to goods train weights of 200 tons or even less, at slow speed, whereas the same engines, if working under British conditions, for example, would be able to deal with 800-ton trains at fair speeds. It will be understood that, in many cases, it is only by the best of management that the trains can be made to pay at all. These local restrictions also add to the difficulties of traffic working, owing to the fact that four or five trains have to be run where, were the line reasonably level, one would suffice; and thus the line, all of which is single, except for six miles near Durban, is probably one of the busiest single-track lines in the world.

With so large a traffic the " crossing " stations, where trains of opposite direction can pass one another and faster trains can pass and overtake a slower train in the same direction, have to be numerous, and it is nothing unusual to find "crossing" operations taking place at almost every station.

All the " crossings " are arranged for in the " working time tables "; but if trains are running late or out of order, which with traffic of this kind must inevitably occur several times a day, or special or duplicate trains are being run, the " crossings " have to be rearranged by telegraph by the station masters concerned in such way as will best expedite matters and prevent undue delay on account of trains being kept waiting. As a consequence of these conditions of traffic working, although there are several trains which are called " expresses " (and are so in the sense that they are not cumbered with a lot of intermediate station-to-station traffic, and they are somewhat faster than the slow trains), the fast trains have many other stops besides those which appear in the public time tables. When these facts are borne in mind, such time allowances as 229 minutes for 70¾ miles, which is the booking of the " weekly corridor dining express " (to be described later) between Durban and Pietermaritzburg, without any intermediate publicly booked stops, appear quite presentable.



DRUMMOND STATION, SHOWING TYPICAL ARRANGEMENT OF SIDINGS TO ALLOW TRAINS TO PASS ONE ANOTHER

There are numerous other stations at which, if specials are running or trains are running late, other trains may have to be passed or crossed either instead of, or in addition to, those mentioned.

The above represents only the first stage of the journey, but similar arrangements obtain over the whole of the main line, and considering only booked trains in the 306 miles from Durban to

FAMILY COMPARTMENT ON THE CORRIDOR EXPRESS. THE BERTHS ARE MADE UP READY FOR OCCUPANCY

Charlestown, no less than seventy-three other trains have to be "crossed" or overtaken and passed, while in practice there may be also several other trains in addition.

The arrangement employed at the crossing stations is worthy of notice before leaving this subject. A typical crossing station of an up-to-date type is shown on page 88, the particular example being Drummond station, 36 miles from Durban. This station is situated on a 1 in 40 grade, but level at the centre of the station, where a scissors crossing is located, providing direct access from the "through" line to sidings extending both ways for trains travelling in either direction, or the trains can "back," as may be most convenient. The sidings are "dead-end," and are "banked up" or "in cutting" when necessary to obtain a level track. In the illustration the severely curved and slightly rising track to the left is the main line, while the siding at the further end of the station can be seen on the embankment; that at the near end is correspondingly depressed.

At Cedara station, where a train proceeding towards Ladysmith is on a heavy falling grade, one of the sidings is built up to 35 feet above the main line. Another station, Alverstone, is situated at the summit of grades of 1 in 30 and 1 in 35, so that both sidings have to be built up to a considerable height.

At several places, too, what are known as "reversing" stations are employed to minimise the track gradients in mounting severe slopes. The line is carried in a suitable direction (it may be quite opposite to the direction required) on a gradient as steep as can be allowed and is necessary, to a dead end. The engine then runs round its train and proceeds back on to another line, which rises still further, so that the necessary height, which would be prohibitive if made in one stage, is attained in two stages. Such methods are employed in the mountain districts of India, but otherwise the Natal railways are almost unique in this respect.

In some instances double "reversing" stations are used, so that the climb is effected in three stages, but at the expense of engine shunting and loss of time. In Natal several of the reversing stations are situated on the main line as well as on important branches. On the Harrismith line there is a series of no less than three reversing stations separated by about half a mile each, so that trains are booked, when climbing, to occupy from 42 to 55 minutes between Brakwal and Van Reenan stations (8 miles), and when running down are allowed from 25 to 30 minutes.

From the foregoing probably as correct an impression will be gained as it is possible to obtain without personal knowledge of the characteristics and difficulties of traffic working on the Natal railways.

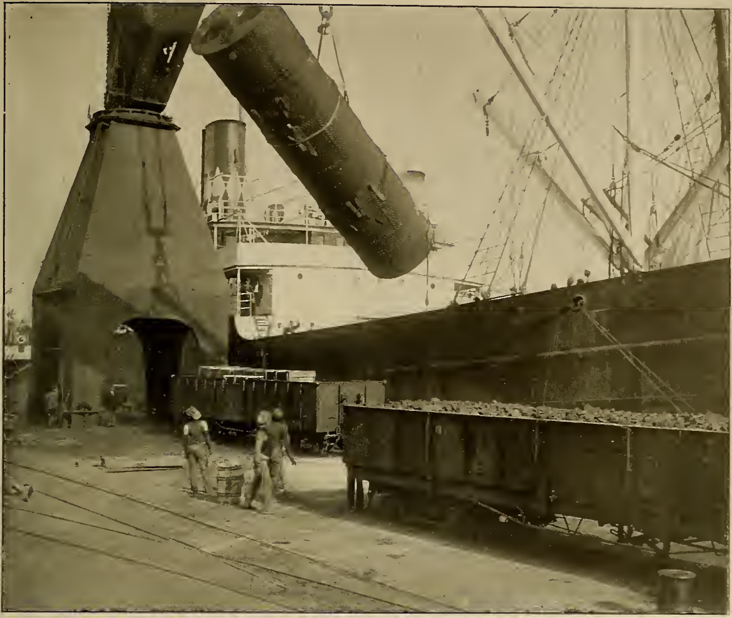
The several lines, which are worked as a government department, are of 3 feet 6 inches gauge (the standard for South Africa), and 768 miles are now open for traffic. All of this is single track, except for 6 miles in the neighbourhood of Durban, with crossing places to enable trains to pass one another at most of the stations and at some intermediate places.

The main line of the Natal railways extends from the port of Natal (Durban) to Pietermaritzburg (the capital of the colony 70¾ miles inland), and thence to Charlestown (306 miles from Durban), on the borders of the Transvaal, where it connects with the Central South African railways. The mail and corridor trains from Durban proceed through to Johannesburg, with connections for Pretoria, and with Transvaal trains to various parts of South Africa.

From Ladysmith there is an important branch line (59¼ miles) to Harrismith, Orange River Colony, and the other up-country branches are,—Pietermaritzburg to Greytown (64¾ miles); Glencoe Junction to Dundee and Vryheid, in Zululand (59¼ miles); and the Richmond branch (17 miles).

From Durban there are three branches, all of importance and two of considerable length. Northwards, there is the North Coast line, which extends for 169¼ miles to Somkele (Zululand), following the coast, for the most part, but generally a few miles inland. Southwards, the South Coast line branches from the main line a few stations out from Durban and proceeds to North Shepstone (72⅜ miles), with a short branch from Alexandra Junction to Umzinto; while the "Bluff" line branches from the South Coast line at Clairmont and completes a circuit of the Bay of Natal, its terminus, "West's," being right opposite to, and within a short distance of, the Point, as the dock district of Durban is termed.

There is also a line, two miles in length, connecting the town of Durban with the docks at the Point. This line, it may be mentioned, was the first railway to be built in the whole of the African Continent (in 1860), and it is



A 50-TON CRANE AT THE DURBAN HARBOUR DOCKS

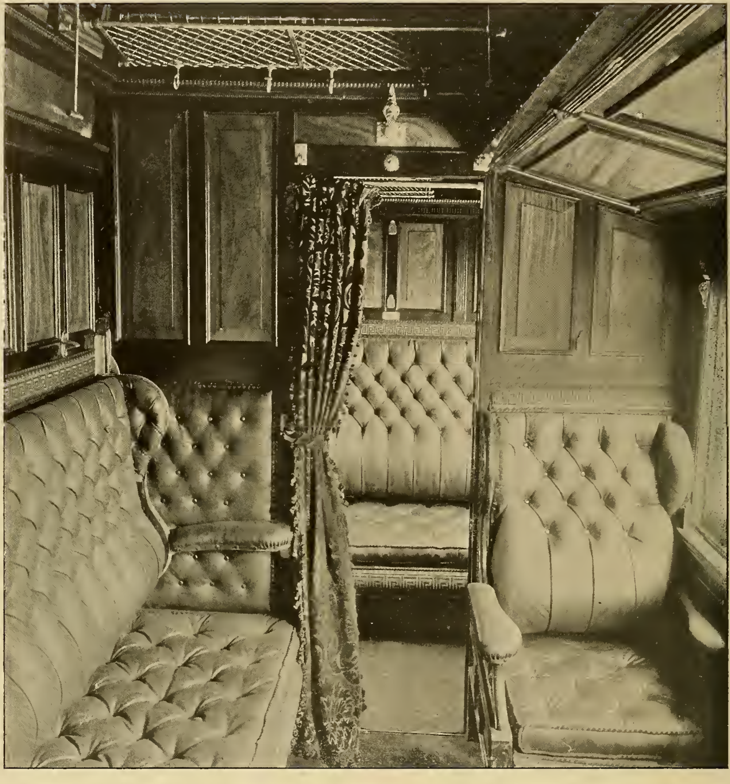
on record that when, as frequently happened, both of the two small locomotives which constituted the total locomotive stock were " in hospital " at the same time, the trains had to be pushed along by natives; and that the financial state of affairs was so unpromising that it was not unusual for the wages of the staff to be paid wholly, or in part, by means of orders for groceries, etc., on indebted tradesmen, or else the employees had to await the return of the manager from a debt-collecting expedition.

At Durban, or rather at the Point, are situated very complete and extensive docks fitted with up-to-date appliances, and it is here that practically all connection with other parts of the world is effected. A few notes concerning the Point and its work will fittingly precede more detailed notes concerning the various lines of the Natal railways.

The harbour at Natal provides 2856 lineal feet of quay accommodation, with a water depth of 23 feet alongside at low water, and a further 1000 feet is now under construction. There are also 2300 feet of timber wharfage (14 to 20 feet at low water), while on the opposite (" Bluff ") side there are 1050 feet, with a low water depth of 25 feet.

There are extensive railway sidings in all directions, and for loading and unloading purposes the following hydraulic cranes are provided:—1 fifty-ton fixed crane; 1 thirty-cwt. fixed crane; 15 thirty-cwt. shed cranes; 4 thirty-cwt. travelling cranes; 16 three-ton travelling cranes; and 1 ten-ton travelling crane. There are also steam shears of 20 tons capacity.

The area of the wharf sheds is about 24,000 square yards, and this is being added to. The docks are well equipped in other respects, with which we cannot



FAMILY COMPARTMENT ON THE CORRIDOR EXPRESS. ON PAGE 89 THIS IS SHOWN WITH SLEEPING BERTHS MADE UP READY FOR USE

now deal. Several interesting photographs of dock scenes are reproduced in illustrations accompanying this article.

In the town of Durban all local transport requirements are well provided for by electric tramcars, though extensive use is made, especially by visitors, of the jinricksha, so that the railway is of no importance for purely urban traffic, though there are several stations within the residential limits.

The central station, which, unlike many other central stations, is very correctly described, is conveniently situated just off West Street, the principal business thoroughfare of Durban. It has two double-sided platforms, each 350 feet in length and 25 feet in width, with a central carriage road, and is provided with an arched roof having a clear span of 105 feet, 210 feet in length, and with a centre height of 56 feet. The station fittings are very complete. The railway offices are arranged in the station buildings, and help to form a very imposing edifice as viewed from the street.

The railway works are situated opposite the goods depot, a short distance from the passenger station, and are concerned not only with locomotives and rolling stock, but also with the up-keep of electrical apparatus, electric light and power being very extensively employed all over the railway, nearly all the principal yards, stations, offices, shops, and trains being electrically lighted, while electric cranes are fitted in the works, and electric motor-driven machines are also being installed.

The works maintain the largest number of skilled employees in Natal. They are sufficiently equipped and extensive to be able to deal with the repair and rebuilding of all locomotives and rolling stock, besides constructing a considerable proportion of new engines and vehicles. The works staff comprises about 1800 Europeans, and about 1300 Indians and Kaffirs. About 700 Europeans are employed in running the locomotives. The total engineering and maintenance staff numbers about 500 Europeans and 2000 natives. The engineering department has its headquarters at Pietermaritzburg.

A short distance from the central station the North Coast line branches off; but all other trains use the main line past the three stations, Berea, Congella and Umbilo, for 4½ miles to South Coast Junction, where the South Coast and Bluff trains diverge. The outer suburban districts of Durban may be said to terminate there. The train service is not excessive, as we should consider it, there being only about a dozen trains a day which serve these suburban stations, and some of these are "mixed" trains, or goods trains, by which passengers are allowed to travel; but, as has already been stated, the electric trams serve for practically all "about town" traffic, and the town stations are principally stopped at, to pick up for or set down from, the country stations, and many of the trains do not serve these local stations at all, but run fast to beyond South Coast Junction or stop there to transfer junction passengers.

The extreme limit for only one train, to which short-distance main line trains proceed, is Botha's Hill (31¾ miles), but several terminate at Pinetown, the total train service for stations between South Coast Junction and Pinetown comprising eight trains daily, and three on Saturdays only to Bellair (7¼ miles).

For beyond Pinetown, with the exception of the train which terminates at Botha's Hill, the trains are as follows:—

2.10 A. M.—Mixed train to Ladysmith.

9.10 A. M.—Morning mail corridor train to Pretoria (semi-fast).

12.25 P. M.—Mixed train to Pietermaritzburg.

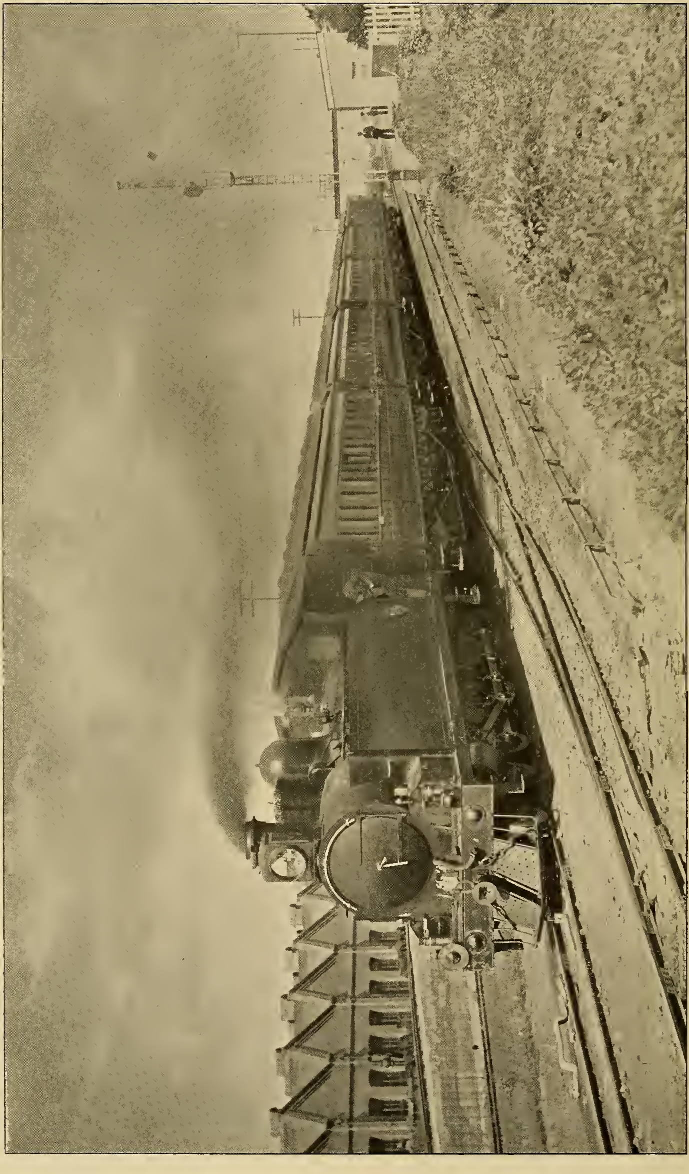
4 P. M.—Fast corridor train to Pretoria, with connections to Cape Town, etc.

6 P. M.—Corridor train to Pretoria and Johannesburg.

There is also the weekly corridor dining car express (the "train de luxe" of the railway, of which more anon) which leaves Durban on Wednesdays at 8.05 P. M. In the reverse direction the trains, of course, correspond.

The 70¾ miles from Durban to Pietermaritzburg present many features of natural and engineering interest which cannot be passed over without brief mention. Immediately after passing South Coast Junction, which place marks the termination of the double-track section of the railway, the line enters on a stretch with a ruling gradient of 1 in 30 for trains from Durban; this is known as "Jacob's Ladder." The views obtained from the train at this place are very fine, including, as they do, bush and fruit-clad hills, the Bay of Durban, and the "Bluff"; but the line winds about in an extraordinary fashion, and the curves, combined with the gradients, make the task of an engine driver with a heavy train anything but an easy one.

The rise extends almost continuously as far as Botha's Hill (31¾ miles), past Pinetown, where the waterworks for Durban's water supply are situated, part of the climb being negotiated amidst the wildest of mountain scenery. In the neighbourhood of Botha's Hill the line is situated in several places on platforms cut from the hillside and winding in all directions to minimise the severity of the ascent. After a short descent



VIEW OF CORRIDOR EXPRESS TAKEN NEAR DURBAN. THE TRAIN, WHICH IS DRAWN BY A TEN-COUPLED TANK-ENGINE, CONSISTS OF THREE DINING AND SLEEPING, ONE RESTAURANT AND ONE LUGGAGE CAR and a tunnel 180 feet long, which presented considerable engineering difficulties in its construction, the rocky country is left behind for the time and pasturage is entered upon.

At Cato Ridge (44¾ miles) extensive storage sidings are provided, extending rather curiously, though no doubt conveniently, in all directions. At Thornville Junction (59¾ miles) the Richmond branch makes connection with the main line. A few miles on a falling gradient, and Pietermaritzburg, the capital, is reached, the station at this place being the second largest in the colony. The Richmond branch trains, two "mixed" daily in each direction, proceed through to Pietermaritzburg, and use a long bay at that station. At Pietermaritzburg the Greytown branch leaves the main line.

Continuing, immediately the capital is left, climbing on severe grades recommences for main line trains, 1 in 30 being again the ruling gradient, the line winding through cutting after cutting amid beautiful scenery. At Hilton road the line eases somewhat, though 1 in 30 grades are still met with, until at Highlands (5000 feet above sea-level,—130 miles) a summit is reached which marks the end of the continuous climbing for many miles for trains from Durban, the hard work being transferred to trains proceeding in the opposite direction. The district following is that associated with the late war, and there are many matters of general interest which cannot be dealt with here.

At Estcourt is a fine five-span bridge over the river, which, together with the bridge over the Klip River at Ladysmith, were the only structures of consequence within 158 miles of the border which escaped demolition by the Boers. Frere, Chieveley and Colenso are included in the succeeding stations. Beyond Colenso is the splendid new girder bridge over the Tugela River, which replaced the bridge whose destruction formed such an important event of the late Boer War.

The task of erecting a temporary trestle bridge at this point was a difficult one, owing to the great swiftness of the current and the unevenness of the river bed. The present bridge is a fine structure of five spans supported on four massive piers.

A few miles further on Ladysmith is reached, 190 miles from Durban. From here extends the branch over the border of the Orange River Colony to Harrismith. At Ladysmith the station premises, sidings, etc., are very extensive. From Ladysmith the greater portion of the remaining length of main line is on easier grades than have been previously experienced, 1 in 50 being about the maximum.

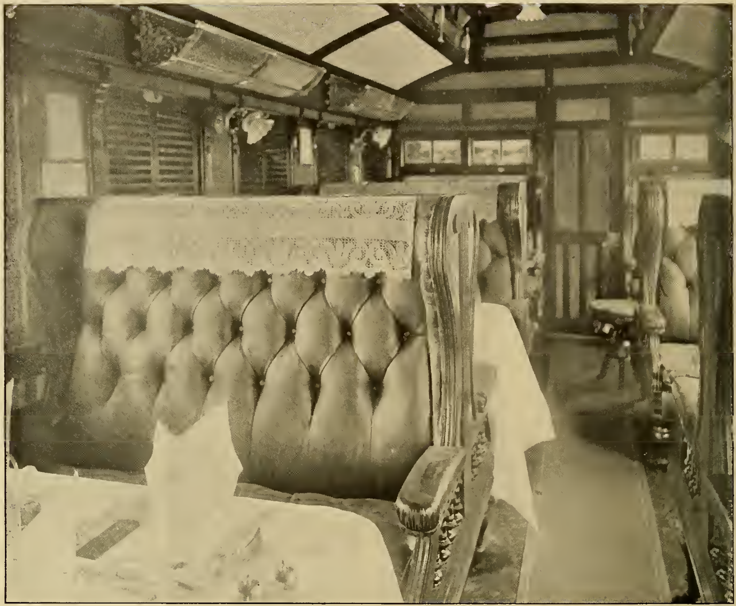
At Elandslaagte the coal country commences, and scenes such as we are familiar with, comprising the headgear of a mine, are presented at intervals, while coal trains are common, and here and there occur sidings connecting the various collieries with the railway.

The Dundee branch, which is also important for coal traffic, leaves the main line at Glencoe Junction, which station is one of the busiest traffic points in the system, as the bulk of the colony's export and private consumption coal,—some 360,000 tons and 240,000 tons, respectively,—passes through it.

At Ingogo, a few miles past Newcastle, a long upward grade, extending the rest of the way to Charlestown, on the Transvaal border, commences. In one place there is a double set of reversing stations, by which the line zigzags over the Ingogo Heights. These are followed by a magnificent horse-shoe curve, including three important bridges.

Until 1895 Charlestown (306¼ miles from Durban) was the terminus of the railway, but it is now connected with Johannesburg and Pretoria and with the rest of the Central South African system, and through connections are possible with the Cape Colony lines.

The Dundee-Vryheid branch (59¼ miles) was completed into Zululand in 1903, and while the first portion is important for coal traffic, the extension now affords access to a gold mining district. The Harrismith branch for Ladysmith,—the Orange River Colony line,—has a very limited train service, one



A COMBINATION DINING AND SLEEPING CAR

passenger "mixed" train daily each way, and a few goods trains; but it is already an important line, and will be more so, providing, as it does, the only railway connection at present with Harrismith. The line is a very severe one, and includes the triple reversing stations referred to earlier in this article. The Richmond and Greytown branches, though the traffic is comparatively small, are important feeders to the main line, and open up extensive tracts of the colony previously unprovided with railway facilities.

The North Coast line now extends from Durban to Somkele (Zululand) for 169¼ miles. Only one train daily (mixed) proceeds right through; but as far as Verulam (19¼ miles), the train service is good, and a few trains proceed still further.

The South Coast line runs from South Coast Junction to North Shepstone (72½ miles) with a branch line to Umzinto from Alexandra Junction. Only one train daily proceeds through to North Shepstone, but three which convey passengers go to Umzinto. It is interesting to note, too, that it is the Durban and Umzinto engines which deal with the trains to and from Durban, while branch engines convey the through trains between Alexandra Junction and North Shepstone.

The Bluff line extends round the bay, leaving the South Coast line at Clairmont. The train service is limited, though there are a number of goods trains, as the shortest way from Durban to the favourite resort on the Bluff, known as West's, is by boat across the bay.

The rolling stock employed on the Natal railways is exceptionally good, and notwithstanding that the gauge is less than the British standard, the carrying capacity, both for passengers and goods, is little less than would be the case were the wider gauge in use. With few exceptions, and those mostly old vehicles used on branch lines, rolling stock of all kinds is mounted on four-wheeled bogies. The first and second-class carriages are as good as any in Great Britain, but the third class is used only by coloured people. The vacuum brake is universally employed for all stock, and central buffers are fitted. Most passenger coaches have clerestory roofs, and the windows are made to open, as well as the door windows, a boon for the traveller during the hot summer.

The ordinary bogie passenger vehicles are very similar in style to those used in Great Britain. The six-wheeled vehicles are of older design. Many of the cattle waggons are adapted so that they can be easily converted for use as third-class carriages for native travel.

For goods traffic most vehicles are mounted on two four-wheeled bogies, and the principal types in use are:—

1.—Open mineral and goods waggons.

2.—Flat trucks, some having the centre part depressed, and known as "well" waggons.

3.—Box and closed waggons.

4.—Cattle waggons.

5.—Combined goods and cattle waggons.

For the principal through trains between Durban and Johannesburg "corridor" trains have been recently introduced, and these trains must be reckoned as among the finest and best equipped in the world. On page 94 is shown one of the corridor expresses near Durban. More especially is this correct of the special weekly express which leaves Durban on Wednesdays at 8.05 P. M. and arrives at Johannesburg at 8.22 P. M. the next day, and the corresponding and slightly faster train from Johannesburg at 6.50 P. M. on Fridays.

At many of the more important stations modern refreshment rooms are

THE DINING SALOON ON THE RESTAURANT CAR OF THE CORRIDOR EXPRESS provided, and the mail trains are timed so that passengers can make use of them. The weekly corridor express, however, is provided with dining and sleeping car accommodations, and as this train is the " train de luxe " of the colony, further description with reference to the photographs reproduced in these pages will be of interest.

In the equipment of the corridor trains will be observed the close attention given to detail and the luxurious accommodation provided for the traveller. Owing to the nature of the road which has to be traversed between Durban and Johannesburg, the train is limited to five coaches,—three dining and sleeping, one restaurant, and one luggage car. The dining and sleeping cars are 60 feet 6 inches long and 8 feet 9 inches wide; the body of the coaches is constructed throughout of teak, the panelling being of steel. There is a platform at each end, shaded by the roof and also by a spring canopy arranged in such a way as to form a continual shelter, no matter on what degree of curve the coaches may stand.

The interior of the dining and sleeping cars is finished in walnut and satinwood panels, all mouldings and rail facings being curved. The metal fittings throughout are silver-plated and of the highest possible finish. The back cushions in the compartments form the upper berths for sleeping purposes. The clerestory roof is supplied with ornamental deck lights worked by silver-plated handles, and a silver-plated rack for light articles is fixed above each seat; hooks and trays are also provided. Electric bells are fitted through the entire train. The seats throughout are upholstered in green buffalo hide and lace and trimmings to match.

The restaurant car is of the same dimensions as the dining and sleeping cars, and contains a dining saloon to seat eighteen passengers, kitchen, buffet, attendant's office, lavatory, and bathroom. The dining saloon is fitted in every way to match the other cars, in walnut and satinwood, the upholstery being in green buffalo hide, and photographs of Natal scenery are fixed above the end seats against the partitions. The kitchen car is a commodious compartment, and is provided with a large kitchen range, sink, coal bin, plate racks, water connections, etc. The buffet is situated next to the kitchen, and is arranged with locker-couch. serving table, safe, writing accommodation, wine cupboards, glass racks, etc. The bathroom is arranged at one end of the coach, and is furnished with a shower bath.

The luggage car is of the same outside dimensions as the coaches, half being set aside for luggage space and accommodation for the conductors, including a lavatory. The remaining portion of the car contains accommodation for the train attendants and waiters, and is fitted with fixed bunks.

The entire train is lighted on Stone's " double battery " system, current being supplied also for electric fans and bells in all compartments. The electric fittings are silver-plated throughout as regards electroliers, switches, etc. The under frames are of steel. The wheels are 3 feet 3 inches in diameter, the journals being 10 inches by 5 inches in diameter. The gross tare of the corridor train is 186 tons.

No. 1 corridor train was constructed by Messrs. Cravens, Ltd., Sheffield, and No. 2 by Messrs. Marshall & Co., Birmingham, sent out to Natal in parts, and fitted up in the locomotive workshops of the department at Durban.

The catering on the dining cars on these trains is conducted in the best style, while the charges are moderate. Light refreshments are also provided, and families travelling with children may, if they prefer, dine in their own compartments, each compartment being supplied with a portable table. A library, consisting of over 100 volumes, which are frequently renewed or replaced, is also provided.

The standard locomotives at present are heavy, ten-coupled, tank engines designed by Mr. C. W. Reid, the late locomotive superintendent, and which are usually referred to as the " Reid " engines. A " Reid " engine is shown at the head of a train on page 94.

The first and fifth pairs of coupled wheels are not provided with flanges, and the engines are consequently well adapted for rounding the sharp and frequent curves. About 100 of these engines are now in use in Natal, and the bulk of the traffic is worked by them.

The principal older engines are known as "Dübs" engines (after the builders), and have eight wheels coupled. Besides these there are a few old, six-coupled, tank engines, which are used on the lighter branches.

Some new engines, with tenders, which have been designed by the present locomotive superintendent, Mr. G. A. Hendric, will shortly be delivered, fifty being on order at the North British Locomotive Company's works. These will, to some extent, supersede the Reid engines, as the ten-coupled engines are somewhat deficient in speed capabilities, and, being tank engines, the necessity for taking water occurs more frequently than is conducive to express work. For use on the Durban-Ladysmith section the new engines will have eight-coupled wheels, while on the easier sections beyond six-coupled engines will be employed. In both cases the engines are of massive and powerful designs and weigh more than 100 tons (with tender) in working order.

The more important stations are well-built and conveniently equipped structures; but the roadside stations, many of them little more than stopping places, often consist of a banked-up platform and a galvanised iron shelter.

According to the general manager's annual report for 1903, the record for punctual working of the mail, passenger and mixed trains on the Natal railways is, considering the difficulties of traffic working, a good one, for out of a total of 26,918 trains, 23,457 (87.14 per cent.) of them kept right time or within five minutes, while only 999 (3.71 per cent.) were more than twenty minutes late.

There are many other aspects of the railways of Natal which could be considered here, but space will not permit.

The writer is indebted to Sir David Hunter, the general manager of railways in Natal, for the supply of the very complete and exhaustive information which has formed the basis of this article, though not a tithe has been used, and for the photographs with which the article has been illustrated.

THE PRINCIPLES OF EXCHANGE TELEPHONY

By Herbert Laws Webb

TELEPHONE service is a very general term. A study of the details which go to make up what is generally known as telephone service is seldom pursued by those who look at the subject merely from a general point of view. Much confusion has been created in the consideration of telephony by the early adoption of a wrong unit. The telephone subscriber, or the telephone instrument, has generally been considered to be the unit of the telephone business, and this fallacy not only exists in the mind of the man in the street, but unfortunately it has also often been adopted by those who construct and manage telephone systems. The object of a telephone system is to make telephone connections, and the telephone connection, or message, is the real unit of the business, not the telephone subscriber.

Let us consider first the effect of the fallacious unit on the science of telephony. The adoption of the telephone subscriber as the unit, leads to the desire for an expert telephone subscriber at every telephone instrument, and, since the wish is the father to the thought, many telephone systems are planned as if an expert subscriber could be counted upon to be always present at every telephone instrument. This leads to a reliance upon the subscriber to perform a certain series of actions every time he uses the telephone, in order that the plant may be properly worked. This reliance is not justified by the practical conditions of the telephone service, for the reason that an expert user is by no means present at every telephone every time it is used.

There are many reasons which make such an ideal impossible in actual practice. The telephone population of any city is constantly changing. Old subscribers are constantly giving up the service for one reason or another and new subscribers are constantly coming on. In very many cases, probably in the majority of cases, any given telephone is available to a number of different people, and is used daily by a number of different people. Under these conditions, which are most obviously true, it is quite unpractical to count for the correct working of a telephone system upon the presence of two expert users,—for two users are concerned in a telephone connection,—for every telephone message.

The proper unit of the local telephone service is the message, and if the operation of a telephone system is studied with the object of determining the best means of handling the message, or individual telephone connection, a very different point of view is obtained from which to study both the general working of the service and the engineering design of the system.

A popular description of a telephone exchange system would be that it is a plant for the manufacture of telephone connections, and clearly the aim must be to manufacture accurate, complete and perfect telephone connections as rapidly and as economically as possible.

Every manufacturer bends his efforts towards organising skilled labour and acquiring the labour-saving machinery best adapted to his purposes. He does not make the mistake of relying upon a general mass of unskilled and unorganised labour for important steps in the completion of his product. The telephone system which relies upon the subscriber or user to perform important steps in the operation of the plant makes just the mistake which no intelligent manufacturer would dream of making.

In order to study the operation of a

telephone system from the correct point of view, regarding the message as the unit of the work, we must consider the work which a telephone plant is called upon to do and the manner in which it does that work. The work primarily is the making and unmaking of temporary connections between numerous individual lines. The operations attendant on the making and unmaking of these connections involve other important points.

Each line must possess a means of signalling the exchange at the beginning and at the end of each connection, and the exchange must possess means for signalling the stations at the ends of the lines. It is important that the signals be easily, rapidly and accurately operated. It is on the machinery for working these signals, for rendering them accurate and automatic, and for giving them a distinct and unmistakable meaning that inventive effort in telephone engineering has chiefly been exercised.

One most important point about a telephone connection is that it must be unmade as rapidly as possible after the conversation is ended. When two telephone lines are connected together each of them is "engaged" (in America, "busy") to all other calls which may be made for those two particular lines. Not only does this "engaged" condition apply to the two individual subscribers' lines, but it also applies, in a large proportion of connections in a city telephone system, to a junction line (in America, a local trunk) between two exchanges, as in city telephone systems the large majority of calls pass through two exchanges and require the use of a junction line.

Therefore, it is clear that both for the interests of the users of the service and for the economy of use of the plant, every connection should be unmade immediately after the conversation is ended and the useful purpose of the connection has been served. To effect this prompt disconnection after the end of the conversation, it is essential that both instruments concerned in the connection shall give at the exchange an unmistakable signal that conversation has been concluded.

In the early days of telephone exchange working, the signals used at the exchange were electro-magnetic annunciators, in which the passage of a current caused the signal to be displayed by the dropping of a shutter. These signals required to be replaced by hand by the operators every time they were used. A separate signal from that which served to notify an original call was used to notify the desire of the telephone user for disconnection.

This disconnection signal, commonly called the "ring-off" indicator, only came into the circut when two lines were temporarily connected at the exchange. It had to be operated by the subscriber pressing the button on his instrument or turning the crank of the hand generator. The operation of the disconnection signal, therefore, required that the subscriber should remember to press the button or to turn the handle.

This method of operating the disconnection signal, which is one of the most important signals in telephone exchange working, is an effective illustration of the reliance upon an expert user for every connection. Unless the user remembered to press the button or turn the handle, the disconnection signal would not be given and the exchange operator would be left in doubt as to whether the connection was still usefully employed or not. Time and testing would eventually inform the operator of the true state of affairs, but meanwhile many connections would be maintained uselessly for longer or shorter periods, owing to the failure of the telephone user to operate the disconnection signal.

To realise the disadvantage of relying upon the user invariably to give a signal, of the greatest importance in the working of a telephone system, one must consider the number of daily operations and the possible frequency of the failure to give the signal, together with the effects of such a failure. To take an example, we will consider a system of 10,000 telephones, with a daily traffic of 100,000 calls.

If 25 per cent. of the daily users omit to give the disconnection signal, there will be 25,000 connections daily which will be maintained for a longer period than they should be maintained. The period will vary from a few seconds to many minutes, according to the volume of traffic and according to the zeal and expertness of the operators and of the supervision; but whether the period be long or short the principle remains the same.

Twenty-five thousand times a day two individual lines, and in many cases also a junction line, will be occupied for a certain period when they should not be occupied. This results in many calls being blocked by an unnecessary "engaged" report, and in wasteful use of the junction lines and of the plant generally. The aggregate loss of time and wasteful use of plant in a year's working would be very great.

It is quite clear, from this simple example, that when we come to study the telephone service by the working of the individual connection, we are impelled, both for the sake of the efficiency of the service and for the sake of the economical use of the plant, to reduce the time occupied by each individual connection to its lowest possible limit.

There is a certain portion of the time occupied by each connection over which we have some control and a certain portion over which we have none. The portion over which we have no control is that occupied by the conversation. That the users of the service determine for themselves. It varies in different places, in accordance with the characteristics of the place and of the people, and it varies to a certain extent with the general development of the service and with its efficiency.

If the service is widely developed and highly efficient, so that the inhabitants tend to use the telephone much and often, the time occupied by the average conversation tends to increase somewhat, as people employ the telephone for a greater range of uses. Beyond this the time of conversation is a point over which telephone engineers and managers have no control.

Over the time spent in operating the connection, however, the telephone engineer has very large control, and for all reasons he must bend his efforts to make this time as small a proportion as possible of the total time occupied by the connection. The connection must be established as quickly as possible, and, when done with by the users of the lines, must be disestablished instantaneously. This involves relying upon expert labour and automatic apparatus for the operation of the connection.

If the fallacy of regarding the subscriber as the unit of the telephone business is indulged in and reliance is placed upon the user to operate the system, measures are adopted which are a direct contravention of the principle just laid down. For example, it has already been shown that in the earlier methods of operating the telephone service the subscriber worked the signals by pressing buttons or turning handles.

In some cases advantage has been taken of the fact that the subscriber has a handle to turn, to make him turn it not only to call the exchange, but also to call his correspondent when the exchange has connected him. This manœuvere clearly involves a waste of time on every connection so handled.

The operator at the exchange is provided with appliances which enable her to ring the called subscriber by merely pressing a button, and she does this in the train of operations involved in completing a connection without the loss of a second. If the operator has to inform the calling subscriber that he is connected and then the calling subscriber has to replace his telephone on the hook and ring his correspondent, there must clearly be a waste of several seconds, as compared with the time occupied by the operator in pressing the ringing-key immediately after she has inserted the connecting plug. This waste of time applies not only to the telephone user concerned, but also to the telephone plant.

In a city telephone system, as has already been mentioned, a junction line is concerned in the majority of connections besides the two individual lines. A waste of time of several seconds on each individual call gives an aggregate waste of time every day, with a traffic of, say, 100,000 daily calls, of considerable importance. The money value of such a waste of time on a year's working would be no negligible figure. To put the waste of time arising from this method of working the telephone service (which, although it has its advocates, is not very generally employed nowadays) at only a few seconds is really a conservative estimate.

As a matter of fact, telephone users who are obliged by the method of working to ring each other up, get so much into the habit of ringing that many of them answer a ring by a ring. This evil example spreads, because any telephone user would rather receive a ring on the bell than in the receiver at his ear. Consequently when a subscriber has correspondents who habitually ring back in answer to his ring, he gets in the habit of leaving the telephone on the hook until he gets the answering ring.

This forces those who have not already acquired the habit of ringing back to acquire it, because, if they get no answer when they lift the telephone, they naturally ring to get attention from someone. In this way there results a general ringing to and fro before the caller and the called start talking, and the aggregate waste of time on a day's working becomes enormous. So do the effects of a fundamental error become cumulative.

Turning now to the manner in which the evolution of the modern telephone system has proceeded, we find that the efforts of inventors have chiefly been directed to the production of devices which cut down the time of operating the average connection and which provide signals of definite meaning. The earlier improvements were aimed at reducing the amount of time and labour involved in operating the connection at the exchange. The indicator shutters were made self-restoring, that is, were automatically restored by the insertion or withdrawal of the plug, thus eliminating two steps from the work of the operator on each connection.

A radical improvement was made by the introduction of lamp signals as a substitute for electro-magnetic indicators. The lamp signals have many advantages. They are automatic in action, as they light when current is applied and go out when it is cut off. They occupy much less space than indicators, so that they can be placed immediately adjacent to the parts of the switchboard which they control. They give a much more assertive and distinct signal than indicators. They are noiseless, and by the use of coloured glass caps over the lamp sockets or by special marks on the glass caps, an almost unlimited variety of signals can be obtained without changing the form or nature of the device.

A further important step was made in the evolution of the modern telephone signal when the lamp signal was caused to be automatically controlled by the movement of the switch-hook on the telephone instrument.

Another step of prime importance was the adoption of a separate lamp signal associated with each of the two connecting cords by which two lines are connected at the exchange, the operation of each of these signals being controlled by the telephone at the end of the line to which the corresponding cord is connected.

These two connecting cord signals, automatically operated by the switch-hooks of the two telephones, solve the difficulty once and for all of obtaining a definite disconnection signal, without requiring the telephone user to perform any special act other than the replacement of the telephone on the switch-hook after he has finished his conversation.

The method of telephone signalling just described is a part of the central battery system of telephone working, which in recent years has become the standard method of operating telephone exchanges. The supply of all power for working the system from a central power plant is a method which possesses many advantages. Local batteries, hand generators and push buttons disappear from the subscribers' instruments. The telephone instrument is thus simplified in its parts and is rendered easier to maintain in working order.

The modern telephone instrument consists only of the transmitter and receiver and the bell by which signals are received from the exchange. The signals to the exchange are transmitted by the movements of the switch-hook when the telephone is lifted and replaced. The necessary act of lifting the telephone for use automatically signals the exchange for connection, and the obvious act of replacing the telephone on the hook automatically signals the exchange for disconnection. The subscriber has nothing to do and nothing to remember but to take the telephone up when he wants to use it and to put it back when he has finished.

In the working at the exchange, the central battery lamp signal system has materially reduced and simplified the work of operating the average connection. When a call is made a lamp signal glows and remains glowing, together with a larger " pilot " lamp used for supervisory purposes, until the operator inserts the plug to answer the call. The insertion of the plug causes the line signal and the pilot lamp to be automatically extinguished.

When the operator completes the connection by inserting the second plug in the line of the subscriber wanted, she depresses a button, which, by an ingenious device, causes the bell of the called subscriber to be rung intermittently until he answers. When the called subscriber removes his telephone from the hook a relay is operated which cuts off the ringing machine and restores the ringing-key to its normal position. The connection is now governed by the two lamp signals associated with the two connecting cords. These are called " supervisory " signals, as they automatically supervise the connection.

While the two users have their telephones off the switch-hooks the two lamps are inert. If either user replaces the telephone on the switch-hook the corresponding lamp glows. The operator is thus kept constantly informed of the state of the connection by the two supervisory lamps. If either subscriber wishes to recall the operator he flashes his signal by working the switch-hook up and down a few times.

When both the supervisory lamps glow together they afford clear evidence that both users have replaced their telephones on the switch-hooks, and the operator then immediately withdraws the two plugs, thus setting both lines free for other calls within a moment or two after the conclusion of the conversation. The disconnection of the two connecting cords automatically extinguishes the two supervisory lamps.

It will be seen that in this system everything possible has been done to cut down the time of operating the average telephone connection. The subscriber automatically signals the exchange by taking up his telephone for use, the operator automatically resets the signal by the act of connecting to the calling line. She sets the ringing machine to work to ring the called subscriber's bell by a single pressure of a button. The two users at the end of the conversation automatically and positively signal the exchange for disconnection by the simple act of replacing their telephones in their normal position.

A comparison of the relatively slight amount of work required on each connection, and of the accuracy and certainty of the signals, with the much greater amount of work required and the lack of certainty of the signals under older methods of operation, shows that the automatic lamp signalling must accomplish a gain of several seconds in the time occupied in operating each average connection. In very large telephone systems this gain of several seconds on each connection must be multiplied by the daily traffic of several hundred thousand connections in order to obtain an adequate idea of the engineering importance of studying the telephone service from the point of view of the individual connection.

The gain in efficiency and in time of operating the average connection is manifest in an economy of plant in two directions. An economy results in the exchange plant and an economy results in the line plant. In the exchange the size of the switchboard is a function not of the number of subscribers, as is generally considered, but of the traffic. Each position at the switchboard can deal with a certain number of connections each day. If the work on each connection is diminished the number of connections which can be handled in a day at a position will be increased.

The number of subscribers' lines terminating at any given position is necessarily determined by the traffic arising from the individual lines. The result of the increased efficiency of operating the individual connection is that the modern telephone switchboard accommodates in a given space a much greater number of lines than its immediate predecessor. The exact amount of gain in this particular direction varies according to local conditions, ranging in individual cases from 30 to 50 per cent. In one particular case with which I am familiar, a switchboard on the new system for 9600 lines occupies exactly the same space as a switchboard on the old system formerly occupied for 5000 lines.

An economy in exchange plant results in economies in various directions. The capital expenditure is reduced in proportion to the traffic handled, and the operating expense is also reduced. As less space is occupied for the machinery for doing a given amount of work, the rent, or investment in land and buildings, is also reduced proportionately, and all such expenses as taxes, light, heat, ventilation, etc., are proportionately reduced.

Since less plant is required to handle a given amount of traffic, the charges for maintenance and depreciation of plant in proportion to traffic are lessened. From these considerations it is seen that a whole train of economies results from the simplification of the work and the reduction of the time in handling each individual telephone connection.

The second important direction in which economy is effected by the same causes is in the line plant. The economy of use of the subscriber's line is not an important matter as far as the direct financial value of the traffic carrying capacity of that line is concerned, for the reason that very few subscribers' lines are fully occupied during the working hours of the day. It is not, indeed, a desirable condition that an ordinary subscriber's line should be fully occupied, for the reason that it is the line over-burdened with traffic which is the most prolific source of annoyance to subscribers in general by being always " engaged " when wanted.

Where a heavy traffic is required to be handled it should be handled by a special arrangement of lines and stations, usually termed a private branch exchange. This arrangement, consisting of several junction lines connecting a small switchboard at the subscribers' premises with the nearest main exchange, enables the telephone facilities to be kept always in proper proportion to the telephone traffic, which is not possible with direct lines terminating in individual telephones.

The gain to the subscriber's line by the improvement of the efficiency of the average telephone connection is particularly manifest in the reduction of the " engaged " trouble. If the time occupied by the average connection is reduced, as described above, it is clear that each line in the system will be free during a certain time when previously, owing to the longer duration of the average connection, it was " engaged."

As two lines are concerned in every connection, there clearly must result a great aggregate gain of time during which lines are free, when under previous methods of working they would be " engaged." This results in letting some calls through that under former conditions would have been blocked by the " engaged " report. In this way the saving of time on the average connection increases the traffic carrying capacity of the subscriber's line.

In considering this gain (upon which it would be difficult to place any actual figure) it must be borne in mind that a very large proportion of the daily telephone traffic occurs during a few hours of each day. During those few hours the busier telephones are constantly in demand, so that it is quite evident that a gain of a very few seconds in the duration of each telephone connection would suffice to admit of a certain number of calls each day for those busy telephones being made effective that previously would have been ineffective.

When we come to the junction line plant, a part of the line plant quite distinct from the subscribers' lines proper, it is evident that a reduction in the time of operating each connection must have a distinct bearing on the economy of the plant. Junction lines are those lines which connect the various exchanges of a city telephone system one to another.

In every city telephone system it is requisite, in order that all subscribers may communicate speedily with any other, that each exchange in the system shall be directly connected with every other exchange. This involves the provision of a large number of lines entirely distinct from the subscribers' lines, and of switchboards at each exchange which are distinct from the switchboards employed for answering subscribers' calls. These junction lines and junction switchboards are the part of the telephone system known as the junction plant.

It is evident that the provision of junction lines is dependent entirely upon the volume of traffic. The subscriber requires at least one line, whether he sends one message a day or 100 messages a day; but junction lines between exchanges must be provided in proportion to the number of daily messages passing between those exchanges. Each junction line can carry so many messages a day, the number depending on the rate of flow of the traffic during the different hours of the day and on the average time occupied by each message. If the average duration of the message is diminished, the number of daily messages per junction line is increased.

The practical capacity of a junction line in daily traffic is very much less than its real capacity, owing to the fact that telephone traffic flows in great volume only during a comparatively short period of the day. This means that the junction line plant is working at its full capacity during certain hours, and is relatively idle and superabundant during the rest of the day. Owing to this concentration of load during a short period of the day, it is urgent to cut down the duration of the average telephone connection in order to secure the greatest possible economy in the use of the junction line plant. An important gain, therefore, in the time of operating each connection is directly reflected in economy of junction line plant by giving each junction line a greater carrying capacity during the busiest hours of the day.

The method of automatic signalling has been extended to the working of junction lines so that when the originating operator, in response to the subscribers' supervisory signals, withdraws the plug from the outgoing end of the junction line, a lamp is automatically lighted in front of the operator at the incoming end of the junction line. This is a positive signal to disconnect the junction line, a signal which was absent from the older method of working junctions. The absence of such a signal was the cause of great waste of time and of great uncertainty in operating junction lines.

By the most modern method of working, then, the economy of the junction line plant has been increased both by the reduction in time of operating the average connection and by the improved methods of signalling adapted to the junction lines themselves.

MESSAGE RATES

It has been shown that the study of the telephone service from the point of view of the individual telephone connection has resulted in improved efficiency and economy of working. It can also be shown that the study of the individual telephone connection or message affords the true basis for arriving at telephone rates.

It is obviously just that telephone rates should be based upon the individual use of the service, that is, upon the message instead of upon the subscriber's line. There have been many modifications in different parts of the world of the method originally adopted of charging a subscription rate for telephone service, but the subscription rate became so universal that it is still generally regarded as the proper way of charging for telephone service.

No other service is charged for by a fixed annual rate, regardless of the amount of service required by the consumer, and the method is obviously unjust and unbusiness-like. If applied to any other business or means of communication its absurdity would at once be apparent. In telegraphy we charge by the word or by the message. In postage by the ounce or by the letter. In railway travelling by the mile. In electricity supply by the kilowatt-hour. It is true that in most of these services the customer does not require special facilities for using the service, or if he does exceptionally require them, such as a private telegraph wire, for example, he pays special rates for such facilities.

In the telephone service, however, each individual customer does not require special facilities for using the service. Each regular customer must have his line and telephone station. The rates in the beginning were based upon the line and station, and the existence of the individual line and station has popularly justified the maintenance of the subscription rate.

In very small systems, where the facilities supplied to each subscriber and the work required to be done for each subscriber average fairly equally, the subscription rate is quite justified; but in large systems, where the demands of the subscribers vary widely both as to the permanent facilities which they require and the amount of work which they originate, the subscription rate is illogical and unpractical.

The service which a telephone user gets each time that he uses the telephone system is the use of a certain amount of plant for a certain amount of time. The charge for that service, therefore, ought to vary with the amount of plant which is used and with the length of time for which it is used. This principle is the basis of all toll and long-distance telephone rates, and, generally speaking, of telegraph and submarine cable rates.

In long-distance telephony the rate varies with the length of line and with the time for which it is used. There is no reason why the same principle should not be applied, with certain modifications, to the local telephone service of cities. The value of the service to the customer is certainly in proportion to the use he makes of it and in proportion to the range of the facilities afforded. The cost of the service in respect to any individual customer is proportionate to the time he uses it and to the distance over which his messages are carried.

The scientific unit of the cost of telephone service is the "minute-mile." In long-distance telephone working this is clearly recognised by the adoption of rates which vary with the number of miles over which conversation is held and with the number of minutes which the conversation occupies. In local service it is impracticable to measure minute-miles, although the fact that the number of minute-miles used largely determines both the value and the cost of the service, is incontestable.

In the local service we must depart from the exact measurement which is possible in the long-distance service and depend upon averages. The minutes practically take care of themselves, because the vast majority of local telephone conversations are very short. In places where message rates obtain it is usual to define a local message as a conversation not exceeding five minutes in duration; but as a matter of practice it is rarely necessary to insist on the five minutes' limit as the basis of the charge for a message, for the reason that local conversations which exceed five minutes are an extremely small proportion of the total daily messages. As far as the time element in the local telephone message is concerned, therefore, there is in practice no necessity to insist rigorously upon a limit, and consequently no necessity to measure.

As regards the distance element, it is, in the local telephone service of a city, impracticable to measure, because of the great variety of distances over which local messages are carried. Here, again, we must depend on the unscientific average and adopt the message as the unit, the message being a conversation between any two points served by the system.

Notwithstanding that it is impracticable to measure the distance which each local telephone message traverses and charge for it accordingly, the fact remains that the distance over which local telephone messages are carried has a very real bearing on the cost of furnishing the service.

It is well known that large areas are, for telephonic purposes, divided up into districts, each district being served by an exchange, and all the exchanges being connected together by junction line plant, as already referred to. The extent of this junction line plant, as previously described, depends upon the volume of daily traffic; but it also depends upon the average distance over which this traffic has to be carried. In other words, the extent of the junction line plant is a function of the area to be served as well as of the traffic to be carried. In a large area, with many exchanges and some exchanges separated by great distances, the junction line plant assumes a considerable proportion of the total plant required for furnishing the service.

The most extreme illustration of these conditions is the London telephone system, in which there are over sixty exchanges, some of them thirty miles apart. At the present time these exchanges serve subscribers who, for a certain fixed yearly sum, may talk as much as they like and as often as they like over the whole London telephone area. It is easy to see that a subscriber connected to one of the outlying exchanges and requiring frequent communication with the centre of the city may practically monopolise a junction line many miles long.

It is obvious that the part of the cost of furnishing local telephone service which is dependent on the maintenance and operation of the junction line plant must vary with the size of the area served. To reach all parts of a large area requires a very much more extensive junction line plant than to reach all parts of a small area. It is equally obvious that the average distance over which messages are carried is greater in the large area than in the small, and consequently the service performed in the large area is the more valuable of the two.

It has already been said that it is impracticable to record the distance over which each local message in a city telephone system is carried for the purpose of varying the charge in accordance with the distance. To suit the public convenience and to comply with the conditions of speed under which the service is conducted it is necessary to adopt the message as the unit of charge, but in fixing the price of the message the effect of the average distance over which it is carried on the cost of carrying it must not be ignored; in a large city the cost of the average message is higher and its value to the user is greater than in a small city.

Reference was made above to certain modifications of scientific principles which must be borne in mind in determining rates for local telephone service. While the scientific unit of cost is the minute-mile, we have already admitted that, in respect to local telephone messages, it is unnecessary to regard strictly the minutes and impracticable to measure accurately the miles in each individual message. By force of circumstances, while recognising the bearing of minute-miles on cost, we are driven to base charges on an average unit which we term the message. Even with the convenient message as the unit, we are unable at present to adopt the message exclusively.

The telephone user requires a line and station in order to be able to use the service at all. This line and station, with its share of exchange plant, involves a certain capital expenditure and a certain yearly charge for interest, maintenance and depreciation. If we charged exclusively by the message, there would be many subscribers who would use so few messages that they would be unprofitable customers.

Therefore, we must have a minimum rate, which preferably should cover a minimum number of messages.

This tends to give the customer the telephone habit. If the minimum rate does not cover a certain number of messages, the customer. feeling that he has to pay for each and every message from the start, is apt to be very economical in his use of messages, and he acquires the telephone habit but slowly.

After the minimum rate, the charge should vary solely with the number of messages. In determining what should be the base rate per message, or the minimum rate for a minimum amount of service, it is necessary to study in detail the cost of construction, maintenance and operation of the plant according to the local conditions; and in fixing the rate per message, while the extent of the area is the first point to be considered, there are also various other considerations, such as the general operating cost as modified by proportion of junction working, the cost of night service, of monitor service and of general supervision.

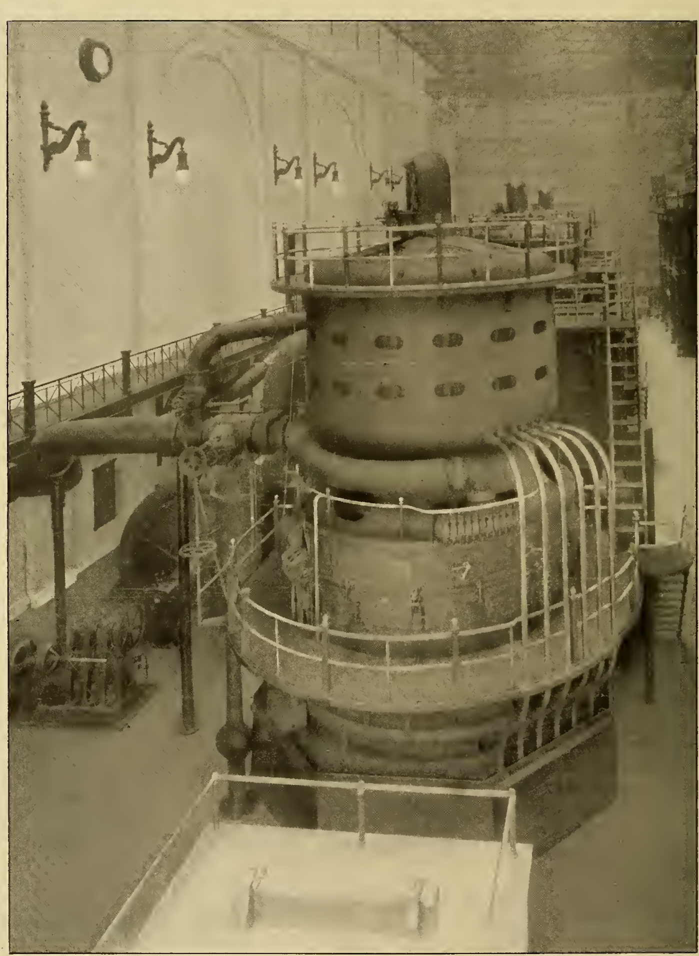
STEAM ENGINEERING IN 1904

By Charles Hurst

IN future years, when another history of the development of steam and its applications comes to be written, it is probable that the year 1904 will be conspicuous for the strides made in steam turbine manufacture. The decision of the committee appointed by the Cunard Company to consider the advisability of employing turbines for the new Atlantic liners now approaching completion is a notable event in engineering history, for if the proposed type of engine realises the expectations of the designers, there is little doubt that the turbine will soon be largely adopted for ocean mail and passenger services, and at no distant period for cargo steamers.

On land the use of the steam turbine has extended considerably in the past year, but it cannot yet be said that it is displacing the reciprocating high-speed engine. In certain situations, where condensing water and superheated steam are available, and where space is limited, turbines have many advantages; but, on the other hand, the reciprocating engine is, without doubt, the better type where condensing apparatus is not used, and where superheated steam is not continuously available.

It is a curious circumstance that both turbines and the practice of superheating are merely revivals of inventions which, up to a few years ago, had long been discarded as not offering any prospect of success, and that at the present time they give greater promise of advancement than any other features of steam engineering. The genius of Watt was directed to the improvement of the pis-



ONE OF THE 5000-K. W. CURTIS STEAM TURBINE ALTERNATORS, BUILT BY THE GENERAL ELECTRIC COMPANY, SCHENECTADY, NEW YORK, IN THE STATION OF THE COMMONWEALTH ELECTRIC COMPANY AT CHICAGO. TOTAL HEIGHT, 35 FEET 6 INCHES. DIAMETER OF ARMATURE, 14 FEET 3 INCHES. THREE SUCH UNITS ARE NOW IN OPERATION AT THIS STATION, WHICH IS DESIGNED FOR AN ULTIMATE CAPACITY OF 60,000 K. W.

ton engine, and thus led engineers' thoughts away from the possibilities of the turbine; and at a certain stage in the development of the piston engine, the fascinations of high boiler pressures, multiple cylinders, and the difficulties of lubrication and packing under high temperatures diverted attention from a practice which was practically discarded from the year 1865 to within the last five years. Now, however, lubrication and packing difficulties have been in great degree surmounted, with the result that superheating has again been taken up with great success.

Turning to the high-speed reciprocating steam engine, a feature of the past year has been the comparative decline of the single-acting, constant-thrust engine. This was inevitable from the moment forced lubrication became a practical success. For a given power the single-acting engine is of about twice the weight of the double-acting engine; it occupies greater space, it is more costly, and its internal friction is greater. The air buffer is also a drawback. At the best, a considerable loss is incurred by the compression of the air in the buffer following closely on the adiabatic curve, whilst in expanding, the curve falls below this, thus enclosing an area which represents dead loss to the engine. In addition to this there is the friction loss, as well as the waste due to leakage. It is not remarkable, therefore, that to-day the single-acting engine is out of the running for large powers, and its use is rapidly declining even for small units.

In slow-speed engines a notable feature has been the increased favour of the drop-valve type,—doubtless a consequence of the extending practice of superheating. The drop valve, as its name implies, closes by falling upon its seat, and, therefore, there is no danger of abrasion of the valve faces whatever the degree of superheat. The valve is also independent of lubrication.

In horizontal engines, considerable improvement has, of late, been effected in the design of bedframes, particularly in the manner of carrying the crosshead slides. In the old type of Corliss or trunk frame it was the practice to leave the slides unsupported, except for a small stool at the crank end; the main journals were supported by feet of no great size, and the bedplate had no other bearing upon the foundations. This type is rapidly giving place to a more substantial design in which the bearing on the foundation is continuous throughout the whole length of the bed. Such a design is well able to preserve alignment of the engine in case of subsidence of the foundations, and is, in a great measure, unaffected by local sinking.

With the old Corliss trunk design the least variation or settling in the foundations becomes a serious matter and throws the engine out of line. Increased attention has also been given to the disposition of the metal in the bedplate, so as to distribute it fairly equally around the axis of the piston rod, thereby avoiding objectionable bending and twisting effects. This has for many years been the practice in rolling mill engines, and gas engine makers have long been compelled to give attention to the matter. The old type of box bed was very faulty in this respect, all the metal being arranged below the centre line of the engine.

In the matter of valve gears there is little of a novel character to notice. Improvements in minor details have been made, particularly in the matter of avoiding overhanging pins in Corliss and drop valve gears.

The past year has seen little change in steam locomotive practice. In some quarters the compound system has found favour; but, on the other hand, the saving in fuel over the non-compound system has not. in some cases, appeared to balance the extra first cost and the repair and upkeep charges. Pressures appear to be slowly increasing, and the tendency is to build heavier engines, but nothing sensational has been attempted in the past twelve months.

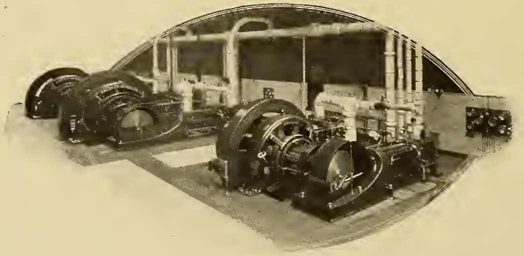
So far as steam boilers are concerned, the year 1904 has been in no way remarkable. The water-tube type has grown steadily in favour, and, as pressures rise, this class will undoubtedly displace those which carry large volumes of water, and consequently require thick plates to resist the pressure. Experience has removed the defects which at one time seemed inseparable from the water-tube boiler, and much of the prejudice against it has disappeared.

The developments of the past few years have placed the disappearance of the steam engine, which has of late been such a frequent prophecy, at an indefinitely remote period. The steam turbine has undoubtedly done something to bring about this new lease of life, and it will require much advance in gas and oil engine design and construction to supplant the steam engine.

Modern methods of disposing of town refuse will also call for steam engines as the best means for utilising the heat generated by the combustion of the refuse. In many places the combination of refuse destructor and power plant is in successful operation. Destruction by fire is, beyond all doubt, the best method of dealing with the rubbish and offal of large towns, and at the present time there seems to be only one practical manner of utilising the heat generated, and that is by raising steam in boilers. Roughly speaking, one pound of steam can be obtained per pound of refuse burnt. It is clear, therefore, that there is a vast potential energy in mere rubbish, which only the steam engine can transform into useful energy with practical success.

In considering the steam engine the question which every engineer asks himself is this,—Has it reached finality, and if not, in what direction is improvement to be sought?

That finality has been attained is not credible. All experience is against such a conclusion. Further improvement will come mainly from increased boiler pressure, increased superheat, and, with respect to reciprocating engines, reduced clearance spaces, carefully drained cylinders and reduced friction.



THE DIVINING ROD AGAIN

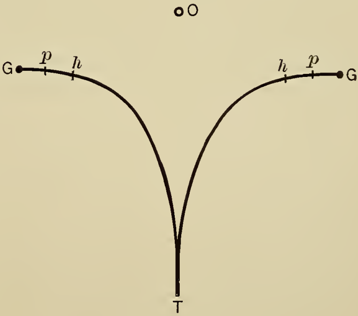
By Rossiter W. Raymond

AN illustrated article in the *American Machinist*, of July 21, 1904, entitled "A Water Diviner and His Work," revives again the subject of the divining-rod, which has been for more than four hundred years the theme of controversy. This particular contribution presents no special novelty. It resembles hundreds of others, which, singly and in the aggregate, have failed thus far to prove the validity of the claims of the practitioners of the occult art concerned.

Of its three illustrations, one shows the boring tools used to bore the well located by the diviner, and another, the stream of water afterwards pumped from the said well. These are, of course, quite irrelevant to the previous operations with the rod. The remaining illustration is from a photograph showing a test experiment, made after a well had been bored, in which two gentlemen are endeavouring in vain to prevent the twig from turning in the hands of the diviner as he stands over the subterranean stream.

The picture and text suggest forcibly the unscientific nature of such tests as usually conducted. The two gentlemen are on the two sides of the operator, each holding with one hand a pair of pincers, nipping the end of a branch of the forked twig, each branch being firmly grasped by the full hand of the operator. The annexed diagram illustrates the mechanical situation.

The photograph does not show what kind of pincers was employed, or how they were applied. From the circumstance that they are completely hidden in the picture by the hands holding them, it may be inferred that they were small instruments with flat jaws, such as are used for twisting wire. Moreover, the picture intimates that the forked stick had no bark on it. At all events, it is evident that this is a case of applying a brake on the axle of revolution (the place where it can have the smallest effect), and of giving to this brake the smallest surface of contact with the axle,—to wit, a short line of tangency to the curved surface,—while the fingers of the operator clasp the entire circumference of the same axle. In other words, the resisting force is reduced to its smallest



THE OPERATOR'S POSITION IS MARKED *O*; *G G* ARE THE POSITIONS OF THE TWO MEN HANDLING THE PINCERS *p p*; *T* IS THE TIP OF THE FORKED TWIG; AND *h h* ARE THE POSITIONS OF THE OPERATOR'S HANDS

USING THE DIVINING ROD FOUR HUNDRED YEARS AGO, AS PICTURED BY AGRICOLA

efficiency, besides being left uncertain as to effective amount, being dependent upon the shape of the pincers, the nature of their jaw-surfaces, and of the surface to which they are applied, and the amount of energy actually exerted by the hands which hold them.

As to the last item, I must say that I would expect much more from the two hands of the stalwart operator than from the pair of hands contributed respectively by the youthful and the venerable champions of inertia shown in the picture. It seems clear to me that the conditions of this test were arranged by the diviner and politely accepted by the visitors; otherwise, it would have been easy and obvious to measure directly the strength of the movement of the point *T* by attaching it to a spring balance, or otherwise determining the weight which it could lift by "dipping."

This reported test, declared to be "the most interesting part of the demonstration" described, is not at all novel in general nature; but it is decidedly inferior in spectacular features to innumerable predecessors of its class. The form with which students of the subject are familiar involves the statement that the energy with which the twig dips is so great that the resistance applied, brake-wise, on the axle of revolution is overcome at the cost of stripping the bark from the arms constituting that axle.

The amount of energy required to strip off bark under such circumstances is, of course, variable; but I feel sure that even ordinary pincers held with respectable pressure would not allow a bark surface to revolve without damage. The omission, in the present case, of this usual phenomenon, therefore, confirms my inference from the picture that the twig was denuded and smooth. Yet, even under these circumstances, a moderate grip with pincers should have twisted the twig before permitting its revolution. The absence of even this small effect is pretty conclusive proof either that the twig employed was very hard and smooth, and that the pincers employed took no substantial hold on it, or else that the aggregate energy exerted by the two gentlemen was very small.

But the report of this exhibitory "test" declares that, in spite of the resistance of the "two gentlemen with pincers," the point of the *V* "made two revolutions around" the hands of the operator. Now, it is self-evident that any continuous outside force from below, acting upon "the point of the *V*," while it might (if a force of attraction) produce a dip, could not produce a revolution, but would resist such a revolution as soon as the said point had passed the line connecting its axis of revolution with the locus of such a force. It would be absurd to suppose that the subterranean force acted alternately in attraction and repulsion so as to produce a revolution around a distant axis, and, consequently, it is reasonably proved that such a revolution, if due to such a cause at all, is not a direct, but an indirect effect; in other words, that the energy producing such a revolution proceeded immediately from the operator, through his hands, clasping the axle-arms of the forked stick. This conclusion is corroborated by the indications of a large majority of the instances of such divination reported on respectable authority.

There is another significant statement in the article referred to, namely, the reported section of the bore-hole made to reach the deep water supply indicated by the diviner. This section indicates that the hole was driven through permeable strata to a deep lying artesian floor. It follows:—(1) That a person sufficiently familiar with the local geology could have predicted the occurrence of water at this horizon without any preliminary ceremonies with a twig; (2) that any well located in the vicinity and sunk to this horizon would probably tap the same supply.

Experience has shown that there are cases in which water supplies can be reached by sinking at a given spot, when sinking at another spot, not far away, is unsuccessful; but these cases do not, as a rule, occur in such formations as the one here shown by the section of the boring. On the contrary, the continuous and familiar practice of engineers in this department proves and utilises the existence of subterranean water upon certain horizons of impervious rock. Water thus stored could not, upon any conceivable theory, exercise a special influence at one spot on the surface hundreds of feet above.

Moreover, the picture representing the conditions of this test shows a considerable stream of water flowing from a pipe close by the group of testers. I presume this is the stream coming from the subterranean sources previously discovered by divination. But whether it is or is not that, its presence on the surface totally invalidates the test as a demonstration of the dynamic effect of a deep subterranean stream.

Finally, it is incidentally mentioned that the operator in this case offered the terms "no water, no pay." This is the recognised formula of the quack; and reasonable men are well-nigh justified in rejecting, as not worth serious investigation, any evidence with which it is tainted. The reasons of such distrust I will not here set forth at length. Among them are:—(1) The great difficulty of investigating evidence presented by a pecuniarily interested party; (2) the certainty (historically well established) that practitioners of such an art will claim for it much more than the possible nucleus of truth which could be impartially claimed; (3) the similarly established certainty that both operators and their patrons will report successes and ignore or forget failures; and (4) the unquestionable fact that successes which may have been due to fortunate coincidence or to knowledge otherwise obtained are popularly credited to the occult art.

So much for the article here taken as a text and criticised at some length because it is a sample of the statements advanced from time to time concerning this vague and fascinating controversy. Hundreds of such contributions, added to the thousands already embalmed in the literature of the subject, would add nothing to our real knowledge of it. Some people seem to think that a vast accumulation of defective or suspicious testimony amounts to proof. I cannot agree with them.

More than twenty years ago I read before the American Institute of Mining Engineers a paper on the divining-rod,* in which I summed up the literature of the subject, and suggested my own view as to the possible residuum of truth included in the claims now advanced by diviners. Since that time the principal additional contributions to the English literature of this subject have been two papers by W. F. Barrett, Professor of Experimental Physics in the Royal College of Science for Ireland, both entitled " On the So-Called Divining-Rod," and published in Vol. XIII. (1897-8) and Vol. XV. (1900-1), respectively, of the " Proceedings of the Society for Psychical Research." These papers comprise a more thorough analysis of historical materials than my own earlier treatise; and they present a large number of recent cases, more or less weighty, as evidence. But I find nothing in them to change the opinion I expressed in 1883. I then showed that nine-tenths of the science of the divining-rod, as it was taught in the Middle Ages, relating to its material, its astrological relations, the ritual attending its use,—indeed, the inherent virtue of any rod whatever,—must be regarded as completely disproved by overwhelming experience. Even the most famous experts have declared that the rod is merely an index, revealing and magnifying in visible results the peculiar inner sensations of the diviner; and hundreds of such experts have worked, and now work, without it. We may also unhesitatingly consign to the limbo of vanity the use of this instrument to discover criminals, stolen goods, buried treasure, petroleum, metals, and coal.

With regard to the discovery of springs of water, and of ore deposits, when (as is frequently the case) these are still channels for water, the case is somewhat different. There is undoubtedly a practical art of discovering springs. Indians or frontiersmen can find water in the desert when a " tenderfoot " cannot. Mexicans and experienced prospectors can similarly find ore. These arts consist mainly in the recognition of superficial signs which escape the ordinary observer.

It is not necessary that the operator should consciously note these signs separately and reason upon them. No doubt he frequently does so, though he may not give away the secret of his method to others. But in many instances he recognises, by association and memory, the presence of a group of indications, great or small, which he has repeatedly found to attend springs or ore deposits. This skill, due to habit, is often almost unerring for a given limited district; but under new conditions it breaks down. Old miners from California or Australia have often started in other regions the most foolish and hopeless attempts to find gold, because they thought this or that place " looked just like " some other place in which they had mined successfully.

Apart from the magnetic minerals, there is no proof that ore deposits exhibit their presence and nature by any attraction or other active force. With regard to water, however, there may be an action affecting the temperature and moisture of the overlying surface. Even here, however, it seems more likely that such effects are manifested visibly to a close observer, rather than by direct affection of his nervous or muscular system. The favourite fields for water-diviners are regions in which

---

* Annual Meeting, Boston, February, 1883, Trans., Vol. XI., p. 411.

water is abundant, but not gathered upon given horizons of impermeable strata underlying porous rocks.

Thus in New England it is well known that water-courses follow in defined channels the surface of the bed-rock, or fissures therein, so that a well may be dug at one point without success, while at another point, not many yards away, water is struck at small depth. Now, there is abundant evidence that the places where water comes nearest to the surface in such localities frequently carry superficial indications of the fact. They gather heavier dews, give out more vapour, show the effects of frost earlier, or grow special varieties of grasses, etc. A recent experiment made in New England showed several scores of species of grass growing on an area six inches square. The predominance of certain species over the rest might well be indicative of subterranean moisture conditions.

Moreover, the relative dampness of such a spot, —produced by the drawing-up of moisture through the roots of plants,—may conceivably be detected, consciously or unconsciously, by a sensitive person walking over it; and this sensation may possibly be emphasised to the observer and indicated to others by a rod, acting as a lever, and registering in magnified motion a minute muscular action. This is the small possible residuum of all the claims put forward during four centuries past in behalf of the occult science of divining.

Referring the reader to my former treatise for a more extended exposition of my views, I take the liberty of quoting here its final paragraph,* which still expresses my deliberate conclusion:—

"To this, then, the rod of Moses, of Jacob, of Mercury, of Circe, of Valentine, of Beausoleil, of Vallemont, of Aymar, of Bleton, of Pennet, of Campetti,—even of Mr. Latimer,—has come at last. In itself it is nothing. Its claims to virtue derived from Deity, from Satan, from affinities and sympathies, from corpuscular effluvia, from electrical currents, from passive perturbatory qualities of organo-electric force, are hopelessly collapsed and discarded. A whole library of learned rubbish about it, which remains to us, furnishes jargon for charlatans, marvellous tales for fools, and amusement for antiquarians; otherwise it is only fit to constitute part of Mr. Caxton's 'History of Human Error.' And the sphere of the divining-rod has shrunk with its authority. In one department after another it has been found useless.

"Even in the one application left to it with any show of reason, it is nothing unless held in skillful hands, and whoever has the skill may dispense with the rod. It belongs, with 'the magic pendulum' and 'Planchette,' among the toys of children. Or, if it be worthy the attention of scientific students, it is the students of psychology and biology, not of geology and hydroscopy and the science of ore deposits, who can profitably consider it. For us miners and prospectors, the advice holds good which was given us three hundred years ago by the wise Agricola, the father of our profession, who says the believers in the rod find some veins with it by accident. 'Sed idem multo soepius perdunt operam, et ut venas invenire possint, nihilominus in fossis agendis defatigantur, quam adversae partis metallici.' (But the same people much more frequently lose their pains, and in order to discover veins have to fatigue themselves with digging, not less than the miners of the opposite school.)

"As a piece of sorcery, he goes on to say, the virtuous and respectable miner will avoid it; as a piece of science, it is inferior to the study of nature, following the indications of which the skillful and prudent miner selects a good place for exploration, and 'ibi metallicus agit fossas,'—there the miner digs, —to which business, rod or no rod, he is bound to come at last."

The obstinate superstition connected with this subject dies hard, and it is not likely to be killed by such investigations as have been heretofore directed upon it. But there is a cause at work which, in my judgment, will banish it from the minds of educated men. I refer to the

---

*Trans. Am. Inst. of Min. Engrs., Vol. XI., p. 445.

recent growth of a real science of the laws of underground water-currents, and the application of those laws in the location of artesian and other wells, and the planning of schemes of irrigation.

The United States Geological Survey has already done much in this department; and I know men to-day, both in and out of its service, whose opinions on the underground water-supply of a given locality would be more precise and more trustworthy than those of any diviner that ever dowsed a twig. I have before me, at this time, the report of such a man, stating with perfect frankness all the accessible evidence, geological, topographical, and historical; the method of his reasoning thereon; the results at which he has arrived; and the practical recommendations which his conclusions lead him to offer. This man knows thoroughly his own geographical field, which comprises at least a hundred square miles; and he might easily go about with a forked stick, telling people where and how far to dig or bore for water, how much they would get, and at what depth they would get it. I have no doubt that he could similarly master the conditions of any other district, if sufficient time for the study of it were allowed him; and I am equally sure that, without such time and study, he would not undertake to give professional advice in a region new to him.

The increased number of such scientific experts will ultimately do away with the " intuitive " experts and the cloud of irrelevant or delusive appurtenances with which their operations are surrounded. This is the way in which all superstitions, half-knowledges and pseudo-sciences have been conquered, —not by direct frontal attack, but by flanking movements, which drive them from one position to another, and ultimately, by occupying the whole field under a new flag, reduce its previous occupants to the position of ousted, superfluous, and insignificant fugitives.

NAVAL ASPECTS OF THE WAR IN THE FAR EAST

By Archibald S. Hurd

WHAT are the lessons to be drawn from the naval conflicts in the Far East? The world has seen the newest and least powerful of the seven navies of the East and West cripple and paralyse one of the greatest fleets of Europe, a fleet with high prestige and not undistinguished history. The sea force founded by Peter the Great has been crushed without having the opportunity of showing what it could do, with fairly equal odds, in one of those fleet actions, big ships battering big ships at a range of several miles, which have been frequently prophesied since the highly scientific and destructive weapons of the present day were perfected.

The running fight of the Port Arthur squadron, when it tried to dash through Admiral Togo's blockading force and find refuge in some neutral port, cannot be regarded as coming within this category, for the object of the Russians was not to fight, but to get away. As a matter of fact, the gun has had little part in the naval warfare in the Pacific, though battleships and cruisers are built exclusively as platforms for its effective use. Almost all the damage has been done by high explosives in mine or torpedo. This, in itself, is a remarkable fact, and it has not unnaturally suggested to some casual observers that the mastery of the sea might be obtained merely by the skillful use of mines and mosquito craft,—torpedo-boats, destroyers and submarines,—and that battleships, if not cruisers also, are obsolete.

In the matter of a few days from the opening of hostilities, the upstart navy of Japan secured a command of the seas adjacent to her territories sufficient to enable her to move in safety thousands of troops great distances by water and land them dry-shod and fully equipped with horses, guns, and stores for the invasion of Korea and the passage of the Yalu River into Manchuria. In all the long history of warfare there is no parallel to the initial success of the Japanese,—a people with the indomitable persistence of fanatics, and with all the aid that science could lend them.

The methods adopted by Japan, a nation with a genius for sea power only lately discovered and even now but partially developed,—as we shall see in future years,—must be of special interest to the British and American peoples. America is Japan's near neighbour in the Pacific.

In several respects there is a curious similarity between the geographical situation of the United Kingdom and that of Japan. The British Isles are placed in respect to Europe very much as Japan is situated in relation to Asia. There is this difference, however, that whereas at the point where Japan lies closest to the mainland there flows a strip of water 200 miles broad, only 20 miles separate Dover from France, and even between Hull and Wihelmshaven, the great base of the German navy, the distance is but 160 miles. The Japanese Government, but not the nation at large, recognised this parallel soon after the new constitution had been set up, and, with a full knowledge of the political development of the British Empire, they decided to take the British fleet as the type to be copied in providing the Japanese nation with a naval force adequate to its policy and the dangers which threatened it.

They were not slavish imitators, however, of the British model. They went about the creation of a modern fleet in a manner entirely their own. Their first consideration was the provision of an adequate number of officers and men trained to a high standard of war efficiency, and when their training schools and colleges and their dockyards for repairs were in working order they gave orders for the building of big men-of-war. They delayed building armoured ships for many years, and even as late as 1894, when the war with China occurred, they had no sea going battleships, while the Chinese had such vessels. The Japanese won because they had learnt how to employ their weak ships to better advantage than their opponents could use superior ones. The Japanese realised that in modern war the efficiency of the crews in their war duties is the first essential, and without this the finer the vessels, the more delicate the weapon of defence, the more likely are the decks to become revolting shambles as soon as the first clash of battle comes.

From the very first Japan built her navy with the belief that it would be used against Russia, while Russia built her Pacific squadron in the anticipation that it might be used against Great Britain. From the first to last in the development of their " advanced policy " the advisers of the Czar refused to believe that they had any reason to fear Japan. Reasoning from their experience of the harmless character of British protests, and the exaggerated importance which British opinion attached to the fighting power of the Russian fleet, they bluffed Great Britain in the same way as they bluffed the Asiatic peoples on whom they were pressing.

Naval officers who have served during the past three or four years in the Red Sea relate that Russia discovered that it was the funnels, blackly silhouetted on the horizon, which impressed Asiatics rather than the number of guns mounted. As a result of this discovery they introduced into the Red Sea and into Far Eastern waters ships with three, four, and even five funnels. They all helped to deceive.

On somewhat similar lines the Pacific squadron was developed. As quickly as ships could be built in America, France, Germany, and even Great Britain, to a very small extent, they were hastily manned, and despatched on their way to the Pacific, not rapidly, but in leisurely fashion, touching at all intermediate ports of importance, in order that the fame of the ships and their menacing guns,—or funnels,—might sink deep into the minds of the people of the world.

Russian naval policy was the antithesis of that of Japan; they built ships, but they failed to provide adequate complements of trained officers and men. The result was that ships were ready before the Russian Admiralty had trained crews with which to man them. Vessels went out to the Far East powerful in appearance, but deplorably deficient for warlike purposes. They lacked sufficient staff in the engine rooms and necessary trained executive officers, and in place of trained men, whom in the British and American service it takes several years to produce from the raw material on board the training ships, the Russians drafted the odds and ends of humanity, whom, under conscriptive law, they had dragged from agricultural districts, men unfamiliar with the simplest mechanical devices, unused to the sea, and remarkable only for a high courage which would have made them excellent sailors had they lived a hundred years ago. There was a leaven of skilled officers and men, but it was too small.

In St. Petersburg and in every naval centre in Russia, at Port Arthur, at Vladivostok and elsewhere, Japanese officers, openly or in disguise, closely watched the lines along which Russia was strengthening her Port Arthur squadron. They alone realised that the Pacific squadron of Russia was largely a sham. Between April, 1903, and the outbreak of the war, Russia despatched to the Pacific four battleships, two armoured cruisers, seven cruisers, about twelve torpedo craft, two mining ships and a gunboat, with a total displacement of 113,155 tons.

The Naval Department at Tokio learnt that even after these ships had joined at Port Arthur and Vladivostok no change occurred in the character of the crews or in the easy routine to which officers and men had become accustomed. The huge fleet seldom carried out tactical exercises or other manœuvers at sea, and small attention was devoted to gun and torpedo training. To the very last it was apparently the belief of practically all the officers in control of the forces of Russia that the menacing display of ships would be sufficient to prevent war.

In consequence of the extraordinary measures taken by the Russian authorities to add to the number of ships in the Far East, they had in these waters in the early part of 1904 a naval force nominally equal to the whole fleet of Japan, as may be seen from the table on page 122. Japan, it is true, had an advantage in armoured cruisers, but this was counterbalanced by the fact that Russia had seven battleships to oppose the six possessed by Japan. In ships of the line Russia consequently had an apparent advantage, and on the estimate most favourable to Japan it was concluded that the odds were so evenly matched that it was impossible to foresee the outcome of hostilities.

The Japanese had no reserves which they could bring forward in case of any loss, while Russia had in the Baltic, either ready for sea or nearing completion, a fleet of men-of-war, making allowances for the obsolescent character of some of the units, almost as powerful as the whole resources of Japan.

In the early days of the war a great deal was heard of the "might" of Russia, and the newspapers were full of reports of the ships which she could send to the Far East. These men-of-war, though their number was exaggerated, were no myths. Apart from the vessels "walled" into the Black Sea by the Treaty of Berlin, the following were in the Baltic when war broke out:—

THE RUSSIAN BALTIC FLEET

Battleships (8)

	Date of Launch	Displacement Tons	Main Armament	Speed Knots
Alexander II	'87	9,927	4 12-in., 12 6-in.	16
Nicolai I	'89	9,244		
Sissoi Veliky	'94	8,880	4 12.in., 6 6-in.	16
Navarin	'91	9,476	4 12-in., 8 6-in.	16
Alexander III (*a*)	'01	13,516	4 12-in., 12 6-in.	18
Kniaz Suvaroff (*a*)	'02			
Borodino (*a*)	'01			
Orel (*a*)	'02			
Cruisers (7)				
Adm. Nakhimoff	'85	8,524	8 8-in., 10 6-in.,	18
Vladimir Monomach	'82	5,593	5 6-in., 6 4.7 in.,	15
Svyetlana	'96	3,862	6 6-in.,	20
Adm. Karainloff	'87	5,800	14 6-in.,	18
Rynda	'85	3,508	10 6 in.,	15
Oleg (*a*)	'03	6,750	12 6-in.,	23
Jemtchug (*a*)	'03	3,000	6 7-in.,	25

(*a*) These ships were nearing completion when the war began.

In addition, when war broke out there was a Russian squadron passing through the Suez Canal, commanded by Admiral Wirenius, consisting of a new battleship, an armoured cruiser, two small protected cruisers, and seven torpedo craft. These reinforcements were well on their way from the Baltic when Japan suddenly purchased two new cruisers building at Genoa, hastily manned them with scratch crews, and successfully ran the gauntlet in the Mediterranean and the Red Sea. The negotiations were continued by the Japanese until the very hour that they received news that these two important additions to the fleet had left Singapore in safety and were about to begin the last stage of their voyage to Japan.

On the night prior to the sailing of these ships, Admiral Togo, who for some weeks past had been superintend-

FLEETS OF BELLIGERENTS AT THE BEGINNING OF THE RUSSO-JAPANESE WAR

RUSSIA

Battleships (7)

Name	Displacement. Tons	Nominal Speed Knots	Heavy Guns
Poltava	10,960	17.3	4 12-in., 12 6-in.
Petropavlovsk			
Sevastepol			
Peresviet	12,674	19.0	4 10-in., 11 6-in.
Pobieda			
Retvizan	12,700	18.0	4 12-in., 12 6-in.
Tsarevitch	13,100	18.0	4 12-in., 12 6-in

Armoured Cruisers (4)

Name	Displacement. Tons	Nominal Speed Knots	Heavy Guns
Gromoboi	12,366	20.0	4 8-in., 10 6-in.
Bayan	7,800	22.0	2 8-in., 8 6-in.
Rossia	12,200	20.0	4 8-in., 10 6-in.
Rurik	10,940	18.0	4 8-in., 16 6-in.

Protected Cruisers (7)

Name	Displacement. Tons	Nominal Speed Knots	Heavy Guns
Bogatyr	6,750	23.0	12 6-in.
Askold	5,905	23.0	12 6-in.
Varyag	6,500	23.0	12 6-in.
Diana	6,630	20.0	8 6-in.
Pallada			
Boyarin	3,200	25.0	6 4.7-in.
Novik	3,200	25.0	6 4.7-in.

Unprotected Cruisers and Despatch Vessels	8
Torpedo Boat Destroyers	24
Torpedo Boats	12

Reinforcements en Route

Battleships

Name	Displacement. Tons	Nominal Speed Knots	Heavy Guns
*Osliabia	12,674	19.0	4 10-in., 11 6-in.

Armoured Cruiser

Name	Displacement. Tons	Nominal Speed Knots	Heavy Guns
Dmitri Donskoi	5,893	16.5	6 6-in.

Protected Cruisers

Name	Displacement. Tons	Nominal Speed Knots	Heavy Guns
Aurora	6,630	20	8 6-in.
Almaz	3,200	20	6 4.7 in.

Several torpedo craft.

---

* This vessel and her consorts were in the Red Sea when war began, and after some delay were ordered to return to the Baltic.

JAPAN

Battleships (6)

Name	Displacement Tons	Nominal Speed Knots	Heavy Guns
*Hatsuse	15,000	18.0	4 12-in., 14 6-in.
*Asahi			
*Shikishima			
*Mikasa	15,200	18.0	4 11-in., 14 6-in.
*Yashima	12,300	18.0	4 12-in., 10 6-in
*Fuji			

Armoured Cruisers (6)

Name	Displacement Tons	Nominal Speed Knots	Heavy Guns
*Tokiawa	9,750	23.6	4 8-in., 14 6-in.
*Asama			
*Yakumo	9,850	20.0	4 8-in., 12 6-in.
*Adzuma	9,436	21.0	4 8-in., 12 6-in.
*Idzumo	9,750	21.0	4 8-in., 14 6-in
*Iwate			

Protected Cruisers (20)

Name	Displacement Tons	Nominal Speed Knots	Heavy Guns
*Takasago	4,300	21.0	2 8-in., 10 4.7-in.
*Kasag	4,784	22.5	2 8-in., 10 4.7-in.
Chitose			
Itsukushima	4,898		
Mashidate	4,210	16.7	1 12.5-in ,11 4.7-in.
Matsushima			
Yoshino	4,180	23.0	4 6-in., 8 4.7-in.
Naniwa	3,727	17.8	8 6-in.
Takachiho			2 10.2-in., 6 6-in.
Akitsushima	3,150	19.0	4 6-in., 6 4.7-in.
Niitaka	3,420	20.0	6 6-in.
Tsushima			
Suma	2,700	20.0	2 6-in., 6 4.7 in.
Akashi			
Chihaya	1,250	21.0	2 4.7-in.
Chiyoda	2,450	20.0	10 4.7-in.
Izumi	2,920	17.5 17.4	2 10-in., 6 4.7-in.
Say-Yen(captured from the Chinese)	2,264	14.5	2 8.2-in., 1 6-in.
Hi-yei (old)	2,248	13.5	3 6.7-in., 6 6-in.
Kingo (old)			

Unprotected Cruisers & Despatch Vessels, etc.	9
Torpedo Boat Destroyers	19
Torpedo Boats	82

---

* Ships completed since the war with China.

Reinforcements en Route

Armoured Cruisers

Name	Displacement Tons	Nominal Speed Knots	Heavy Guns
Kasuga	†7,294	20	1 10-in., 2 8-in. 14 6-in.
Nisshin			4 8 in., 14 6-in.

---

† Purchased from Argentina when building in Italy and reached Japan in safety.

ing the mobilisation of the fleet and exercising it at sea, received orders to prepare for war. He had the whole of his fleet concentrated at Sasaho, the southern dockyard of Japan. The night was spent in conference with his officers, and the following morning the fleet, divided into four homogeneous squadrons, steamed away from Japan. Within a couple of days the Pacific squadron of Russia had been so weakened that Admiral Wirenius received orders to return to the Baltic.

What of the Japanese Navy? Down to the outbreak of the war with China the meaning of sea power was not appreciated by even the most thoughtful section of the civilian population. Japan had existed for centuries as a military power, glorying in the prowess of her two-sworded land fighters, and the expenditure which was made in constructing even small ships and training necessary naval officers and men was begrudged by the larger section of the educated people of the Island Kingdom. They asked continually "What is the use of a navy"? After the struggle with China their eyes began to open to the influence which sea power was to have on their future history. In the last five or six years this knowledge has spread and developed without any artificial aid or propagandism such as has been practised in Germany. The result is that to-day the Japanese navy stands in the forefront of the naval forces of the world as one of the most scientific, cautious and courageous fighting bodies in existence.

While taking advantage of all the instruction and guidance which could be obtained from western nations, particularly Great Britain, the Japanese evolved a navy absolutely unique in its character. From the first they decided that, while defensive qualities should have due weight in the working-out of the design of their ships, the first requisite was heavy gun power, so as to inflict the greatest damage upon the foe, and the highest speed obtainable. Quickness is one of the most striking characteristics of the Japanese people, and the fleet was developed in the belief that this quality would enable the officers and men to get in the first decisive blows before an enemy was prepared.

At a time when even in Great Britain the rôle of a fleet in defending an island kingdom was only inadequately understood, the Japanese Navy Department realised the fact that ships of war are merely floating gun platforms, developed in the history of ages of warfare in order to enable guns to be carried to, and fought on, the sea coasts of the enemy. By this means the frontier of the foe becomes the scene of hostilities, and the country which the navy has been designed to defend is left in enjoyment of most of the advantages of peace.

As may be seen from the tabulated statement on page 122, the main units of the Japanese navy were built since the war with China, and, apart from heavy gun power and thick armoured protection, the feature of the ships which is possibly most remarkable is the speed attained. In every class of ship the Japanese aimed to obtain a higher rate of steaming than that of contemporary ships of each class in other fleets.

The creators of the Japanese navy realised two points, first, that speed had a high tactical value in all classes of men-of-war, since superior speed enables the swifter vessel to accept or avoid battle, and to fix the range; and, secondly, that the Japanese, with their peculiar mental quickness, were specially well equipped to avail themselves of whatever advantage could be gained in war by swift manœuvering.

The Japanese resources were limited, and Japan might have been influenced by a French school of thought, of which a great deal was heard five or six years ago, and might have decided not to invest large sums in big armoured ships. On the contrary, they spent upon large armoured men-of-war more in proportion to the total outlay than any other fleet in the world. In addition to half a dozen battleships, they had six armoured cruisers of the most powerful type built. Never before had such a large proportion of the latter class of men-of-war been embodied in a small navy; but in this instance, as in others, Japan was merely in advance of general opinion.

Since these six armoured cruisers were ordered the British Admiralty have put in hand thirty-eight ships of the same general character. At the time when Japan embarked on this new policy the British authorities were still building ships without armoured belts,—protected cruisers. Japan decided that she had no need and could not afford such vessels, and for general scouting service she acquired twenty quite small cruisers and nine despatch boats. Speed was the watchword of the Japanese fleet, and all her ships, big and small, were swift. In the design of scouting ships, speed had the first place.

Admiral Ingles, who for several years was naval adviser to the Japanese Government, has stated that soon after he settled at Tokio he realised the character of the people and advised the Minister of Marine to develop in every way he could the torpedo flotillas, because they represented a sphere of warfare specially suited to the genius of the young Japanese officer, small in build and wiry, quick of mind, and able to exist in circumstances which injuriously affect Europeans. Out of proportion to the number of other ships, the Japanese created a great number of torpedo craft, —created is hardly the word, for practically all the ships, big and small, were built in Great Britain, but Japan chose the types.

The Japanese saw that torpedo warfare was merely an adaptation of an old form of attack, namely, those cutting-out expeditions which form the most stirring pages in the history of the British fleet. They determined that they must have a large number of torpedo craft, and built nineteen torpedo-boat destroyers, ships of the same build as those British boats which came to grief a few years ago, and they also built eighty-two torpedo-boats. While fifteen of the latter ranged from 150 to 200 tons displacement, forty were of only 80 to 109 tons displacement each, and the remainder were even smaller.

Europeans, accustomed to large ships, and forgetful of the size of the little craft in which Drake, Raleigh, Hawkins and others fought the elements, and unmindful of the cockle-shells in which the Danes roamed the seas and raided British shores, would have condemned these small craft for anything but the most limited coast defence. Believing in the genius of those who were to have charge of these gingerbread ships, the Naval Department at Tokio was satisfied with the character of its torpedo ships, so long as they were swift.

What has been the experience of war? The battleships and cruisers were split up by Admiral Togo into four squadrons, and the torpedo craft into a large number of flotillas, fourteen or fifteen in all, each with four or five units, grouped according to speed and radius of action. Contrary to all the advice which European officers would have given, Admiral Togo took with him, when he set out for Port Arthur, a crowd of flimsy torpedo-boats. Such small men-of-war are cheap anywhere, and lives do not count for much in Japan. Wallowing in the waves, these little ships were taken away from the coast in the track of the fleet of great ships. Of course, such torpedo-boats carry only sufficient coal to steam for a comparatively short distance, and they soon show signs of weakness if kept at sea for long periods.

The secret which underlay the decision of Admiral Togo to employ these little ships was that he had already selected among the Elliot Islands, to the southeast of Port Arthur, two "flying bases"; the advanced base was devoted to the mosquito ships. The days of close blockade are probably gone forever, owing to the influence of torpedo craft; but Admiral Togo was able to keep Port Arthur under close observation by means of his little mosquito vessels at this advanced base, ready at shortest notice to send warning to the commander-in-chief, at the second and more distant base, of any occurrence of importance at the Russian fortress.

It was the depth of winter, the thermometer so low,—there were 20 degrees of frost when the attack of April 12, 1904, was made,—that at places even the sea itself was fast frozen when these delicate craft, built on the slenderest lines, were detailed for this duty, extremely trying even in summer. Japanese officers and men are far less susceptible to cold than Europeans, and by working their boats in reliefs they managed to carry out the arduous task entrusted to them. It is the first time in the history of warfare that little torpedo craft, ships of less than a hundred tons displacement, have been used for offensive operations. It was admitted in older navies that they might prove of service for harbour defence, but the Japanese have utilised them 500 miles from the nearest dockyard. From time to time, as necessity has dictated, they have been able to have repairs carried out in the sheltered waters of the flying base.

Fortunately, the Japanese,—again showing their foresight and wisdom,—had provided the fleet with two "mother ships" for destroyers, vessels with tools for all kinds for repairs not necessitating docking, stores of every description, fuel and food, so that the small craft were revictualled, repaired and stored as necessity demanded. At the other flying base other ships for the service of the fleet were stationed. No fleet in the world, in proportion to its size, is as well provided with auxiliaries as that of Japan. Directly war began, four hospital

82291

ships, the *Saikyo*, *Kobe*, *Hakuai* and *Kosai*, completely fitted for the treatment of the sick and wounded and their conveyance to one of the shore hospitals; a cable ship for picking up and cutting submarine cables; colliers, and store ships were ready to accompany the fleet.

When America went to war against Spain she had to hurriedly improvise these most necessary auxiliaries to the fleet, and this took some time. Japan had not only these antennæ prepared for the opening of hostilities, but she had equipped a number of her ships with wireless telegraphy, so that she was able to link up the various sections of her fleet and obtain a unity of action to the one end, the defeat of the enemy, which would have been unobtainable otherwise.

In the method in which she has employed torpedo craft of the smallest size and lightest build, and in the completeness of her equipment of auxiliary vessels, Japan has supplied the world with a remarkable object lesson of the way in which, in these days of surgical triumph, mechanical ingenuity and scientific development, a nation should go into action. Her completeness in these respects has never been approached, and she has had her reward in the marvellous efficiency maintained by her ships, especially the torpedo craft; in the manner in which the wounded have been rapidly treated and removed to hospital, and the smoothness in which the whole scheme of naval operations has been carried out. Every joint in the armour of defence was studied with patient, intelligent care, and made as secure as foresight and a patriotism, amounting to fanaticism, could make it.

In the early days of the war the statement of those who knew the Japanese people, that they had inventive genius of a high order, was not believed, so repeatedly had Europe been assured by casual and superficial observers that they were imitators. When war came it was discovered that they used a powder of extraordinary power, the invention of Dr. Shitose; that a special system of wireless telegraphy, invented by a commission representing Tokio University and the Navy and Army, had been installed in the fleet; that the mines with which the Russian flagship *Petropavlovsk* was sunk with practically all on board, including Admiral Makharoff, and the battleship *Pobieda* was badly injured, were of special construction, over the details of which Commander Oda, whose name it bears, and a number of other officers had spent a long time; that the boilers of the water-tube type in some of the ships were the invention of Admiral Miyahara; that they used a percussion cap, the invention of Admiral Ijuin; and that the torpedoes which were being employed with such deadly effect by the Japanese ships were of a more powerful character than those adopted in western navies.

All the details of the fighting machine which had been created at such great sacrifice had been reviewed, point by point, in the endeavour to perfect its equipment and improve its efficiency. We have learnt to admire the thoroughness of the Germans; but nothing that we know of their readiness and war training equals the standard of preparedness for war which the Japanese evolved, working on lines they believed fitted to the peculiar mental bent of their population.

The British and American method of going to war is to hope for the best, to keep a tight hold of the purse strings until hostilities have actually broken out, and then to pour out money like water in the hope of retrieving the errors due to lack of previous preparation. The result is that waste of all kinds occurs. We may take a lesson from the Japanese in this matter. For six or seven years they were preparing for this war, for they realised that they were being "cornered" by Russia, and that if a struggle came, it would be a life-and-death grapple so far as Japan was concerned, and that defeat meant the doom of all hopes of future greatness and expansion under the national flag for the teeming millions of Japan. On the slenderest resources they created the army and navy which are fighting to-day. The total expenditure on these forces was only 7½ millions sterling last year; Russia in the same period spent over 48 millions.

There is no corruption in Japan. The departments of war are the sport of neither dishonest officials nor grasping contractors. For every yen which was invested in war materials the Japanese insisted upon having full value. In the preparations during those years when white people all the world over were talking, with many smiles, of " the little Japs," these people were preparing an object lesson in war-like efficiency which has had no parallel in modern times.

They spent grudgingly, for they realised that the more they laid out beyond what was absolutely essential, the more the financial resources of the country would be exhausted when the struggle came. The statesmen determined to put no grievous burdens on the people, so that when the crisis developed and money was required for a long campaign they should be in a position to get it at home. When negotiations were broken off and hostilities began, the nation was prosperous, far more so than were our forefathers when the wars of the early years of the nineteenth century began, and all the money that has been required since has been obtained within the Island Kingdom. Ten millions sterling were raised in London and New York for special reasons. The people believe in their destiny, and consequently have advanced money on better terms than could have been obtained abroad. The financial resources of Japan, backed up by the patriotism of the people, have been among the surprises of the war.

If European officers had known the character of the orders issued to Admiral Togo by the Naval Board of Control, presided over by Admiral Baron Ito, they would hardly have failed to regard them with amazement. It was essential that he should achieve two apparently conflicting objects. He was told that he must destroy the Russian fleet in the Pacific, or at least " contain " it, in order to enable transports to move freely to Korea, and to prevent it from co-operating with reinforcements from Europe; but, at the same time, he must, he was also informed, on no account endanger his ships, since Japan had no reserves on which she could draw.

Such orders seem to be paralleled by instructions to a cook to make an omelette without breaking eggs. Admiral Togo, however, succeeded in carrying out his orders to the letter, owing to the fact that he was placed in possession of complete knowledge of the disposition, efficiency, and character of the units composing the Russian squadron, and because he adopted the only correct principle of strategy which such knowledge could dictate. His information convinced him that Russia was unprepared for war and did not, even to the last, expect war.

For several days the main squadron at Port Arthur had been cruising for short distances and anchoring at night in the open roadstead under the Golden Hill batteries. The entrance to the harbour being difficult, tortuous, and dangerous for big ships, Admiral Stark had been content to leave them in this position night after night. A cruiser, a gunboat, and a transport were at Chemulpo, while three armoured cruisers and a protected ship of great speed lay in Vladivostok harbour, with a channel cut through the ice to enable them to go to sea at any moment. A small gunboat was at Shanghai. The distance from Sasaho Dockyard to Vladivostok on the one hand, and Port Arthur on the other, is between 500 and 600 miles, the northern base being comparatively close to the shores of the Japanese Island of Yesso.

Admiral Togo might have decided to divide his forces so as to provide a superior fleet to watch the ships at Vladivostok, while he himself engaged the Port Arthur squadron; in that event, owing to the limited number of ships at his disposal, he would have been in inferior force at one or the other point, and the probability is that the whole course of the war would have been changed.

It was realised that the Vladivostok ships might issue forth and raid some of the coast towns of Japan, and it was also realised that, apart from the questionable right of belligerents to fire upon undefended places, such an operation could not affect the main results of the war; sooner or later such raiders would be caught, as indeed proved to be the case. Consequently the whole Japanese fleet, attended by a crowd of torpedo craft, steamed away from Japan, leaving the islands without any local defence.

At this date a strict censorship of the press had been established, and even if the population of the coast towns had protested they would have had no channel for complaint, while at the same time the cables were in the hands of the Naval Department, and no news of the direction taken by the fleet could consequently reach the Vladivostok ships to inform them of the unprotected state of Northern Japan.

The situation recalls the events which occurred when the United States declared war upon Spain in 1898. Admiral Cervera had a squadron in the Atlantic which was supposed to be off Cape Verde Islands. A cry was immediately raised that these ships might appear off the American towns on the Atlantic coast. Nervous people were able to give expression to all their forebodings in the press, with the result that before a blow had been struck those who were responsible for the disposition of the squadrons of the United States were face to face with an agitation which in a democratic country demanded attention.

Captain Mahan has stigmatised the outcry as " unworthy of men, unmeasured, irreflective, and therefore irrational." It could not be ignored, and consequently the plans of the Strategy Board had to be amended in order that a portion of the naval strength might be stationed off the American coast. Had the Spanish Navy been other than it was, the ability of the United States to inflict defeat would have been jeopardised.

The danger to the United States of coast raiding by the Spaniards was far less than in the case of Japan, because at the time these fears were expressed there was no squadron close to the American continent, while in the case of the present war Admiral Togo knew that the powerful ships at Vladivostok were within a few hours' steaming of Hakodate and other places on the coast. Nevertheless, he took all his ships into the Yellow Sea, and not until he had crippled the Port Arthur squadron and sunk the ships at Chemulpo, thus paralysing Russia's sea-arms in the Far East, in the Red Sea, and in the Baltic, did he send any men-of-war to search out the cruisers at Vladivostok. The Russians had left their navy in a condition to be defeated in detail, and Admiral Togo did not risk his success by imitating their example with the idea of saving a few towns on the coast from the problematical injury due to bombardment.

In the first forty-eight hours of the war, apart from the ships at Chemulpo, which the Russians sank rather than let them fall into the hands of the Japanese, two battleships and a cruiser had been torpedoed and rendered useless for further fighting at sea, and later on the battleship *Petropavlovsk* was sunk and the battleship *Pobieda* injured by submarine mines. On the other side, Japan, later on, lost, by mines, the battleship *Hatsuse*, and the cruiser *Yoshino* in collision. All the vital injury which ships of either belligerent suffered in these early engagements was due to high explosives, used in torpedo or mine. The weapons are so similar that in the Russian dispatches the same word " minna " has been used for both indiscriminately. Two points in connection with these events deserve attention.

The loss of the *Hatsuse*, representing one-sixth of the battleship strength of Japan, had it occurred in the first week of the war, might have altered the whole course of events. It happened after the Japanese had completely reduced the Russian fleet to impotence. The Japanese fleet had already done the main part of its work, and Russia had been so weakened that she could not take advantage of the improvement in the fighting equation thus brought about. Had the fatal mines pierced the *Hatsuse* in the early days of February, the Japanese would have been weakened for the work that still lay ahead, for they had no ships in reserve to be manned and sent to sea.

The destruction of the Japanese battleships may be commended to those who are now urging that the British and American naval authorities are building too many battleships. This incident serves to illustrate why Lord Selborne insists that the British fleet must be superior to that of any two European powers, " with a margin over." This margin is to provide for such unforeseen disasters as may occur at any time during hostilities when ships run on mines or collide, as in the case of the *Kasuga* and *Yoshina*. If Great Britain maintained only a bare superiority over a possible coalition, what would be the position of the fleet if it were robbed of one or two battleships, which would render it inferior to the forces of the enemy? It would be too late to lay down additional men of-war. Great Britain must have a fleet superior to any probable combination, with "the margin over" to provide against accidents, since the Navy is her all in all.

But the main lesson which some observers have drawn from the destruction which has overtaken these ships by the action of the torpedo and the mine is that the battleship has been rendered obsolete. This view has been put forward by Senator Hale, chairman of the Naval Committee of the American Senate.

Such opinions arise from an inaccurate comprehension of the manner in which the Japanese have waged this war. It is true that the success of the Japanese and the fate of the *Hatsuse* have revealed in a lurid light the ease with which even the most powerful ships may be destroyed, under favourable circumstances. There is no gainsaying the vulnerability of the battleship to torpedo and mine attack; but this is not new. Late events have merely served to drive home in a dramatic way facts which were familiar before the disasters off Port Arthur.

Big ships cannot safely be left in an open roadstead by night, but must be kept either at sea, continually moving, or must rest behind breakwaters, boom defences, or other protecting screen. The initial success of the Japanese with the torpedo was due to the fact that they were on the spot with the weapon exactly suited to the opportunity given to them on the night of February 8 by Admiral Stark in leaving his ships open to attack in the outer roadstead of Port Arthur. Had they left their torpedo craft at home for coast defence purposes and not carried them these 500 miles to the enemy's very door, the story of the war might have been very different.

If the ships at Port Arthur had been manned by crews of the same calibre as the Japanese, the ships would not have been in a position of danger that night, and in subsequent days the fleet would have issued forth, and the enemy's torpedo craft would have had their work cut out in avoiding big ships under steam, and would have been too busy to try to launch torpedoes against a moving and well-disposed fleet. In " the blue," torpedo craft have little chance by daylight against a fleet under steam.

After that one night attack the strength of the Russian fleet was so greatly reduced that they could not venture to cruise far from their base, not because of the menace of the torpedo craft, but because of the menace of the big ships,—battleships and cruisers,—which they knew to be hovering near in such immensely superior power that they could not hope to secure victory as the result of a fleet action. Admiral Togo held the command of the seas because he had intact his fleet of heavily armoured and gunned ships; but he could never have gained that command merely with torpedo craft,—ships which are the children of the big ships, needing to be fed, nursed, and supported and rested.

In many of the Japanese despatches this realisation of the proper method of employing torpedo craft is revealed. The torpedo vessels advanced to make their attack, but always the big ships were behind, first coming the light, swift cruisers, and further away, ready to render aid if need be, were the battleships. On no occasion, so far as we have details of the fights, did the torpedo craft advance unsupported.

The battleship is now, and, so far as can be seen at present, must remain, the essential unit in naval warfare, and without it no country can hope to secure command of the sea. It is not an arbitrary creation, but a development to meet the needs of warfare as they have been discovered during many hundred years of sea fighting. It was found that it was impossible to get all the desirable fighting power in each individual ship; that for some work speed was essential, and that could be obtained only in light ships, and that with less speed heavier guns could be mounted. In this fashion navies became divided into two great classes, ships of the line and frigates, corresponding to the battleships and cruisers of to-day. What the fire-ship and other like devices were to the big ships of the sail era, the torpedo craft is to their successors.

The modern battleship may never fire her guns at the ships of her opponents, but the knowledge of her presence is the force which must keep a weaker opponent inactive. Even in a fleet action the small craft would be held in reserve until the right moment came for them to dash forward,—it may be under the very guns of shore batteries, for they are small and difficult to hit,—and deliver their deadly weapons. Such a rush is one of the possible uses of torpedo craft in the later stages of a fleet action. When one side has obtained some advantage, and the ships and morale of the foe have suffered and disorder reigns, the mosquito craft might be ordered to go into the midst of the decimated fleet and complete its destruction.

When the history of the war in the Far East comes to be written, the verdict will be that the Russians lost the command by their unpreparedness for war, and that the Japanese gained it, not by the torpedo *per se*,—for the Russians had torpedo-boats and destroyers,—but because the Japanese admiral was on the spot at the exact moment when an opportunity occurred of using his mosquito ships with advantage, and he took it, remaining himself over the dip of the horizon with his big ships, and with a screen of fast cruisers thrown out in front of his priceless ironclads,—priceless because incapable of being replaced.

But although the success of the Japanese has not shown the unwisdom of building battleships, it may lead to some question as to desirability of continuing to build battleships of such immense size as those which are now being constructed for the great powers. Japan has lately ordered in Great Britain two ships of upwards of 16,000 tons, while the British fleet has eight under construction.

The facts as stated by Senator Hale are beyond denial; the battleship is liable to be destroyed by torpedoes or mines under circumstances favourable to this form of attack. Consequently, the larger the battleships and cruisers, the greater the disaster when one or more meets the fate of the *Petropavlovsk* and the *Hatsuse*. Big ships are economical to build and to maintain; for their size, torpedo craft are the most expensive men-of-war afloat,—expensive to build and expensive to maintain. For these and other reasons the tendency is always towards greater size. Commander Kelley, of the United States Navy, in a discussion on the development of the ship of the line in the old sailing days, has remarked:—

"With the great number of vessels gathered in the fleets of the sail era the single-line formation was sure to prove too extended for easy handling, notably in a shift of wind, when miles of sea room separated the van and rear. To escape the dilemma, the line was kept handy and navigable by decreasing the number and increasing the size and power of individual ships. Hulls grew in dimension, solidity and strength; batteries lifted in frowning tiers; masts towered and yards spread until at last the fleet included ships mounting as many as 120 guns of various classes. These maximum displacements proved soon to be too cumbersome for vessels driven by the wind, and, therefore, impotent in calms or against currents and tide streams. A reaction set in, and nimbler types, smaller in size and with guns fewer in number, but greater in energy, were accepted as the tactical solution of a desperate game. By Nelson's time the crack fighter was found in the 74-gun ships of the line.''

It is not improbable that somewhat the same reasoning, allied with the fear of ''putting too many eggs in one basket,'' may lead to a limitation in the size of battleships and cruisers.

By the time one of the new battleships of the British fleet of the *King Edward VII.* class of 16,350 tons each is commissioned and at sea with one of the permanent squadrons, she will have cost a million and a half sterling, and it may well be held that so great a sum is too much to place at the mercy of a lucky torpedo striking her in the region of the forward magazines. No nation can have many of such monsters, and consequently by investing so much of fighting capital in one hull and limiting the number most seriously, the loss of one of the fighting units would become a national disaster, instead of being an untoward incident unlikely to have any sinister influence on the power of a great nation, were the vessel of moderate dimensions and one of a large number.

No country can avoid building battleships; it is the truest economy to build them big, because only thus can we get good value for our money; but in view of the vulnerability of all big ships, it would seem that there is a point at which the increase in size becomes a wrong and foolish policy. In connection with this subject the views of Sir Edward Reed, a former Director of British Naval Construction, and the designer of the battleships *Triumph* and *Swiftsure*, of 12,000 tons, lately added by purchase from Chili to the British fleet, are of special interest. He is a naval architect of recognised ability and the highest standing, and he believes that the case for huge ships has not been proved.

Discussing the qualities of his two wonderful men-of-war in comparison with other larger ships of the fleet, he instituted recently some comparisons which may be recalled with advantage in a discussion of the virtues of modern displacements. Writing in the *Times*, of London, of the battleship *King Edward VII.*, of 16,350 tons, and the battleship *Prince of Wales*, of 15,000 tons, he said:—

'' I find the broadside power of the *King Edward VII.* to be substantially, but not very largely, superior to the broadside power of the *Triumph*, while the latter greatly exceeds in broadside power the *Prince of Wales.* Whether I work downwards in tonnage from the *King Edward VII.* or upwards from the *Prince of Wales*, I find that a ship of about 16,000 tons, designed as the Admiralty ships have been, would be requisite for carrying a broadside equivalent to that of the *Triumph.* Taking the estimated cost of the two government ships as bases of comparison, it will be found that this 16,000-ton ship would cost, without armament, about £1,250,000.

'' In the same estimates are given the cost of the *Triumph*, without armament, as £839,990, or a difference of about £410,000. In a return just presented to Parliament the tonnage of battleships building this year for our government is given at 184,400 tons, so that, if all this tonnage had been built approximately of the *Triumph* type, we should be sending the same broadside power to sea on ships of even greater speed than those building, and with an aggregate saving of £4,725,000 upon our battleships alone.

'' We are building rather a larger tonnage of cruisers than of battleships this year, and without going into details I believe that the saving, broadside power for broadside power, would have been equal in the case of the cruisers to that of the battleships; so that, in my view, we are spending about 9½ millions more upon the ships now building than we need have spent if the ships had been kept within what I regard as proper limits. At a moment when we are all seeking naval and military economy without loss of power, I cannot help thinking that this question well deserves the consideration of the Admiralty as regards the future design of ships.''

In these words Sir Edward Reed,

trained from earliest years in Admiralty methods, suggests that we may have powerful ships, as powerful as those of 16,350 tons, on a displacement over 4000 tons less. The Japanese were told this when they were creating their navy, and they accepted the statements, with the result that the ships with which they have been fighting so well of late may be claimed to be representative of the class of man-of-war in which Sir Edward Reed believes,—the man-of-war with all but essential weights eliminated. So far as evidence is available, it is in favour of the type of battleship represented by the *Triumph* and *Swiftsure*, ships of great speed and gun power and good defence on a moderate displacement. Even the pocket of the British taxpayer is not unlimited, and if an economy of the character indicated by Sir Edward Reed, and supported by many experienced naval officers, is possible, it will result in great saving, and will also enable Great Britain to have more of these floating forts which we call battleships.

The position of the battleship has not been affected by the disasters off Port Arthur. The loss and disablement of the Russian ships has served merely to illustrate the truth that, under favourable circumstances, the torpedo and the mine are deadly weapons of warfare; but they are the weapons of opportunity, and the gun remains the weapon for general use. Guns of high power can be sent to sea only in big ships, so we must have big, but not too big, battleships.

In general, the result of the Japanese naval operations reveals the old truth that the mere possession of ships of the most powerful types, such as Russia possessed, does not mean naval power. In spite of all the assistance which science has rendered in perfecting weapons of attack and in improving the mode of defence by armour protection and high speed, the character of the personnel,—admiral, officers, and men,—and their war efficiency, are the deciding factors in warfare. The Japanese exhibited this dominating fact in their contest of ten years ago against China; now they have illustrated it in an even more striking manner by crushing the Russian fleet in the Far East. In warfare the man is greater than his weapon. President Roosevelt put the matter well when he wrote, a few years ago:—

" There is unquestionably a great difference in fighting capacity, as there is a great difference in intelligence, between certain races. But there are a number of races, each of which is intelligent, each of which has the fighting edge. Among these races the victory in any contest will go to the man or nation that has earned it by thorough preparation. This preparation was absolutely necessary in the day of sailing-ships; but the need of it is even greater now, if it be intended to get full benefit from the delicate and complicated mechanism of the formidable war-engines of the present day. The officers must spend many years, and the men not a few, in unwearied and intelligent training, before they are fit to do all that is possible with themselves and their weapons. Those who do this, whether they be Americans or British, Frenchmen, Germans, or Russians, will win the victory over those who do not. When the day of battle comes, the difference of race will be found as nothing when compared with differences in thorough and practical training in advance."

The Japanese have proved afloat as well as ashore that they have the fighting edge. The racial factors,—indifference to death, simplicity of life, the high courage of fanatical patriotism,—have all helped; but, above all, their success spells " War-readiness."

MODERN PLANERS

By Joseph Horner

THE planing machine followed the lathe in the evolution of engineer's machine tools, and became the precursor of the shaper and slotter. From about 1814 to 1820 it appears to have been simultaneously invented by four men,—Fox, of Derby; Murray, of Leeds; Roberts, of Manchester; and Clement, of London, England. It is interesting to note that the last named machine was double-cutting on the forward and reverse movements of the table, and it embodies the germ of the planer centre. Roberts' machine was operated by a chain and rack. Vertical planing machines were used in the old Soho Foundry, Birmingham, England.

Rudely constructed though these earlier machines were, by comparison with their present-day descendants, yet they marked an immense advance on the lathe, chisel, and file as means for producing plane surfaces. The invention of these reciprocating machines produced probably a greater revolution in the millwrights' shops of that period than all the improvements in their derived types have accomplished since.

Even within living memory the traditions of that earlier period survived, for a tremendous amount of hand chipping and filing had been done in the old shops but imperfectly equipped with planers, or destitute of planers of large capacity. Those who are able to recall that work, tedious and blistering to the hands, can realise something of the condition of things that existed in the pre-planer days.

Then for many years the planer became crystallised in set designs, which still survive in unprogressive shops. It embodied the ratchet and click feed, with its limitations, the return stroke of two, two and a half, or sometimes three to one, and these, it must be remembered, over slow cutting speeds; the ill designed housings and cross rails, the broad, slowly-moving belts and slow reversals,—with a swish that was heard all over the shop,—the small rack pinion and the rattle of the rack and spur gears. Planers received a bad reputation in consequence, and then came the opportunity of the milling machines.

Latterly planers, however, have taken a new lease of life. When the rapid growth of the milling machine began, many people predicted that the planer would fall nearly into disuse; but what has happened is that it has enlarged its sphere of usefulness. True, the old styles of planers are disappearing; but the principle of the machine is far too valuable to permit of its extinction. Planers to-day are as much in evidence as ever, not indeed the old ones, but their modernised and much improved offspring. These improvements occur both in details and in the growth of new types, or of types which, if not exactly new, have been lying neglected for a long period.

Modern planers may be considered as sub-types of the two broad groups into which the machine, *sui generis*, is divided. These are, first, the common machine, in which the work is traversed horizontally under a tool which is rigid during the act of cutting, and is fed at the intervals at the end of the stroke, during non-cutting, in connection with the act of reversal. This type has been a source of much trouble, due to the frequent reversal of a heavy table carrying massive work, and to the fact that the tool cuts only on one traverse, the return stroke being wasted.

The second large group is that in which the tool moves while the work remains stationary. An important point

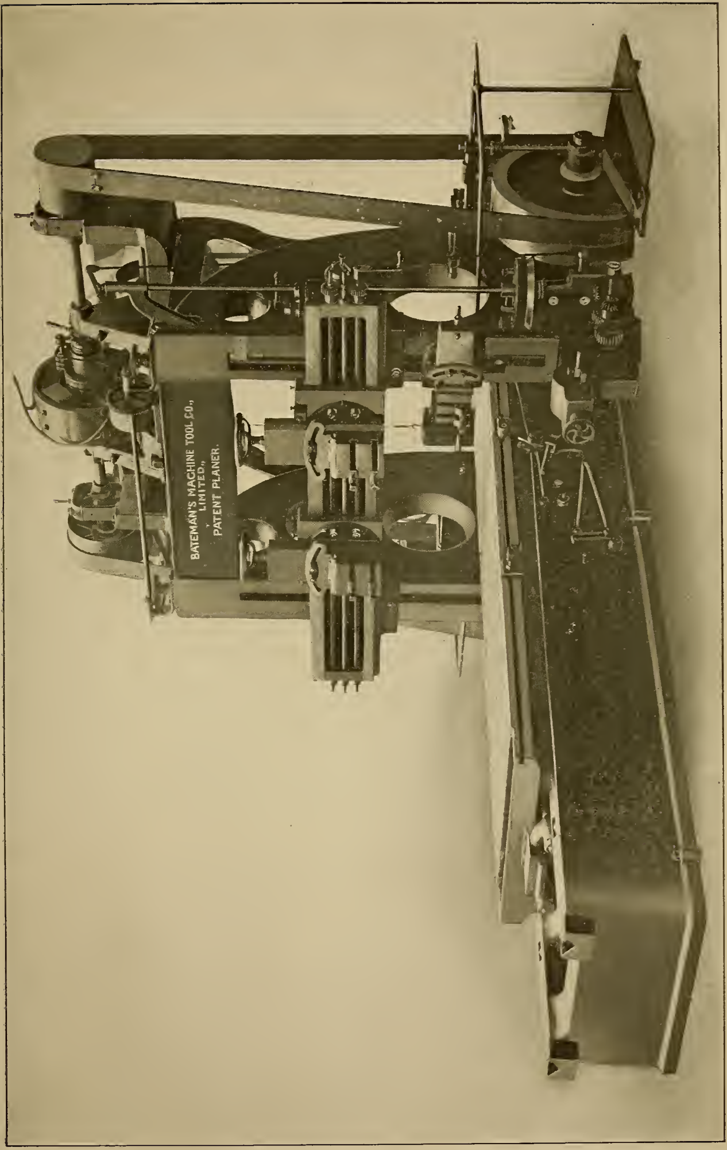


FIG. 1.—A PLANER BUILT BY BATEMAN'S MACHINE TOOL COMPANY, LTD., HUNSLET, LEEDS, ENGLAND

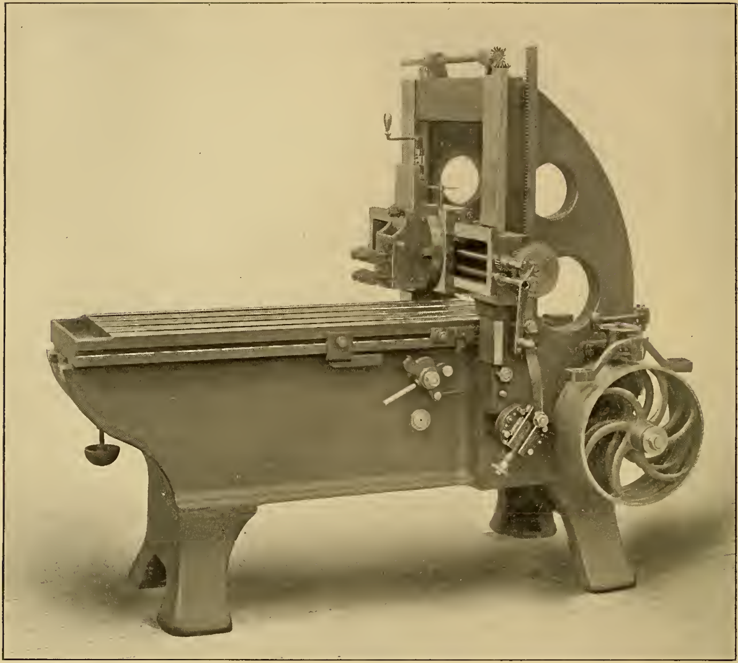


FIG. 2.—PLANING MACHINE. MADE BY MESSRS. C. REDMAN & SONS, HALIFAX, ENGLAND

in favour of this is, that the mass moved remains constant, for when the work moves, the mass varies with every job, from a few hundredweights to many tons. In most cases this arrangement is adopted when it is practically unavoidable, by reason of the massive character of the work.

In a plate edge planer, for example, the overhang of the long and wide plates would be exceedingly inconvenient, and, therefore, it is almost necessary to traverse the tool box, or boxes. In the vertical planers and the pit planers the problem is that of mass, more often than great length and width, or both may be combined. In the side planers it may or may not be a simple alternative, but just as a matter of convenience.

The old trouble of the reversal of common planing machine tables with fixed tool boxes on a cross rail has given rise to diverse designs. One is the acceleration of the quick return stroke, the other, the reversible tool boxes for cutting in both directions; a third, separate tool boxes for cutting in both strokes. In the two last the rate of travel is alike in both strokes.

The experiments of Captain Tresidder at the Atlas Works, Sheffield, England, showed that while the power absorbed in the return stroke of planers was practically the same as that during cutting, the power absorbed at the instant of reversal ranged from about double to treble those amounts.

Thus, in one experiment with a screw-driven planer, the cutting absorbed 7½ H. P., the return 12 H. P., and the reversals from 22½ to 24 H. P. In one of the experiments at the Baldwin Locomotive Works, a planer absorbed 47 H. P. at the moment of reversal, against 23 H. P. when taking a cut ⅝ inch deep by ¼ inch wide. At the same time a new tool with quick return of 4 to 1 only took 18 H. P. at reversals and 21 H. P. with the same cut as above. No more striking testimony could be afforded of the necessity for improved methods in view of the high speeds now in demand. Among the difficulties which it opens up is that of motor driving in the face of such overloads.

In improved machines, reversing and cushioning arrangements appear to produce better results, irrespective of mode of driving, since some high-speeded machines give excellent results with stepped racks and cushioning arrangements, equally with the Sellers inclined screw and rack drive.

Among the devices which have been attempted is that of a fly-wheel on the motor shaft, spring buffers at the end of the table or in the driving nut of screw machines or elsewhere, or a fly-wheel in connection with the fast and loose pulleys. The fly-wheel as a storehouse of energy is essential in punching and shearing machines and in some shaping and slotting machines. It has been applied in some cases to planers with success.

One example of this kind occurs in the high-speed planers of Bateman's Machine Tool Company, Ltd., notable because the quick return ranges from 170 feet to 210 feet a minute. Here the rack is retained, but instead of bolting it to the table, it is attached to a sliding bar which has a limited longitudinal movement in a groove on the under side of the table. Spindles are attached to a crosshead at one end of the bar, carrying adjustable compression springs, which absorb the shocks due to reversal. The springs also help to start

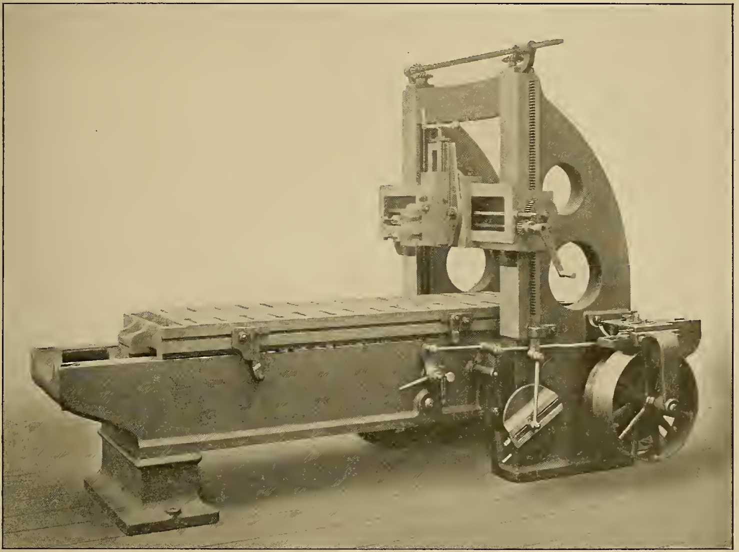


FIG. 3.—DOUBLE-BELT PLANING MACHINE. MADE BY MESSRS. POLLOCK & MACNAB, LTD., MANCHESTER, ENGLAND

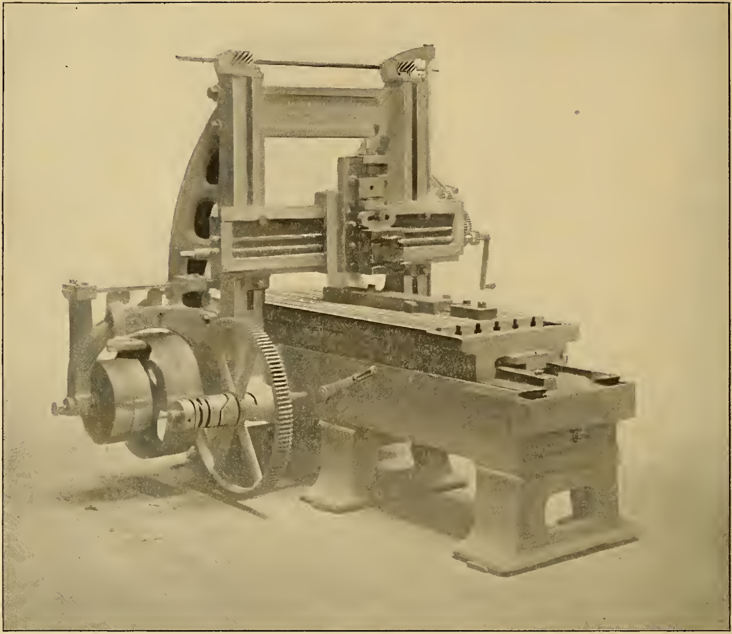


FIG. 4.—A PLANER WITH CUSHION DRIVE FOR EFFECTING REVERSAL AND RETURN EASILY AT HIGH SPEEDS. MADE BY MESSRS. SMITH & COVENTRY, LTD., MANCHESTER, ENGLAND

the table on reversal, and so relieve the belts of some strain. An illustration of a Bateman Company planer is given in Fig. 1.

By means of "fly-wheel loose pulleys," energy is held in store for reversal. The belts are wider than the fixed pulleys, and overlap on the fly-wheel pulleys when thrown off. By this means much of the energy of the fly-wheel is transmitted to the fast pulley. Friction clutches actuated by the belt shifting arrangements also assist the fast pulleys to obtain energy conserved in the fly-wheel loose pulleys. It will readily be seen that planers working at these high speeds will be capable of a much increased output compared with the older types, and this firm advertise their 60″ × 60″ machines to plane an area of 25 square feet per tool per hour.

In a planing machine by Smith & Coventry, Ltd., Manchester, England, a cushioning spring is inserted on the table-driving shaft, pressing against one of a pair of clutches having sloping teeth, which, therefore, slide on each other as in Fig. 4. The compression of the spring by the inertia resistance offered to the reversal of the shaft, absorbs some portion of the energy of that resistance, which is given off on the reversal.

With increase in speed, the difficulties of reverse and cushioning increase also. From this point of view the double cutting systems acquire new interest.

Double cutting tool boxes have been designed from the time when the "Jim Crow" or rotating box was invented by Whitworth. There are a good many tool boxes of different patterns in which double cutting is embodied, but their employment is still rather limited. A relieving attachment is necessary to their full efficiency.

It is also most desirable that feed shall be put on at each end of the table, in order to let each tool cut its own separate furrow. The object sought may be attained either by the rotation of a single tool, with its box, as in the first model, or by the employment of two, set back to back, or by a double-edged rocking tool.

The alternative to reversing tool boxes is to have separate boxes attached to separate heads, so making a double-headed machine, in which case the table travels at equal rates in both directions. Here two heads may be cutting alternatively on the same, or on different pieces of work, the latter being bolted to a slide bed at one side. The heads are

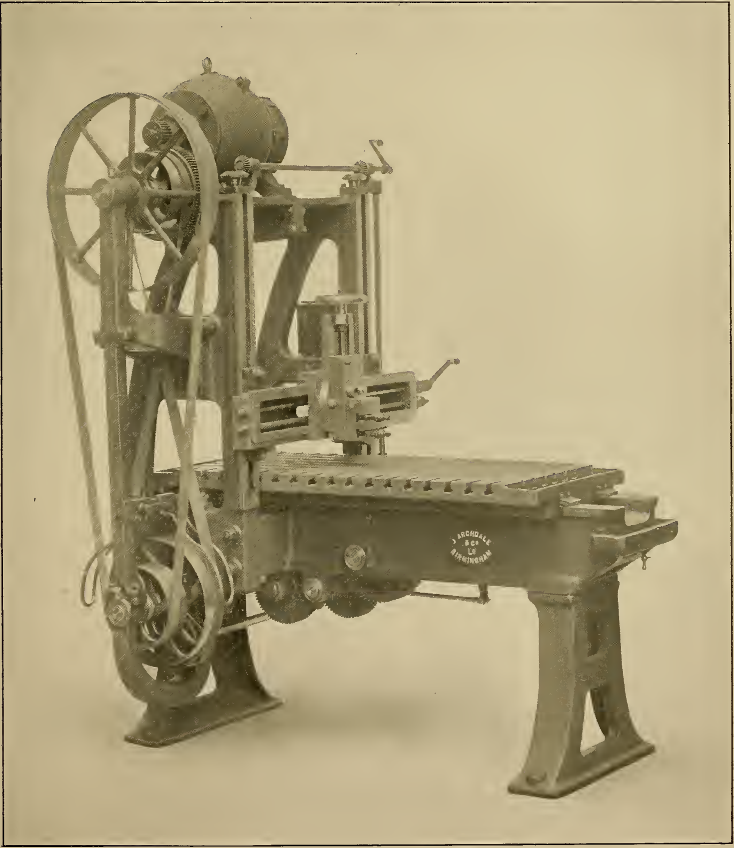


FIG. 5.—AN ELECTRICALLY DRIVEN PLANING MACHINE. MADE BY MESSRS. J. ARCHDALE & CO., LTD., BIRMINGHAM, ENGLAND

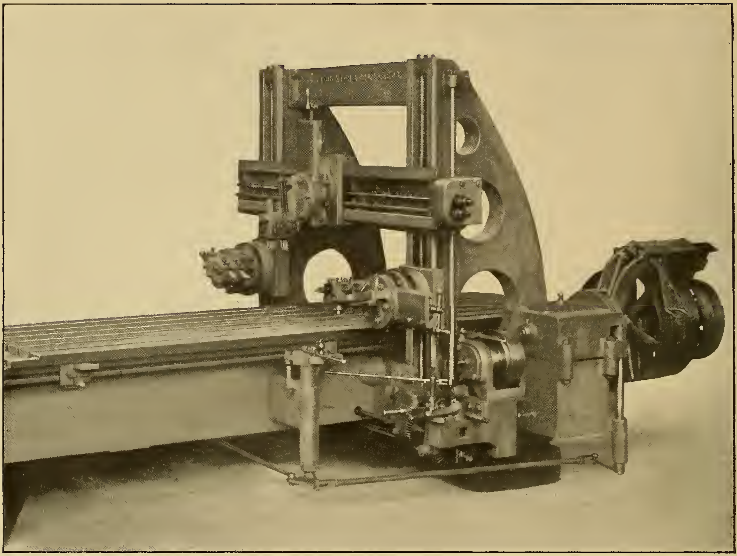


FIG. 6.—A PLANING MACHINE WITH THREE DOUBLE-CUTTING TOOL BOXES. MADE BY MESSRS. JOSHUA, BUCKTON & CO., LTD., LEEDS, ENGLAND

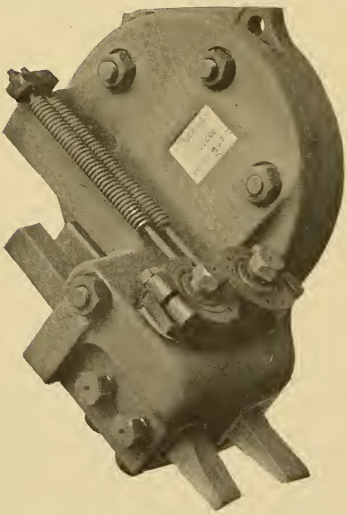


FIG. 7.—AN ENLARGED VIEW OF ONE OF THE DOUBLE-CUTTING TOOL BOXES ON THE ABOVE PLANER

screw-driven, and are rigidly connected.

These are not serious rivals to the double-cutting tool boxes, because they can only operate on one vertical face without resetting the work, while completely equipped ordinary machines will cover three faces. They are simply duplex, vertical side planers, rivals to the single cutting planers of pillar type.

In other directions duplex cutting is employed rather extensively, less, however, for general work than for specialties. In one group of machines the work table travels under fixed tool heads, which possess a range of adjustment towards and from each other to accommodate different lengths of work. The housings slide against the planed vertical faces of the bed, and when adjusted are clamped thereto with tee-headed bolts. Machines of this kind are used to tool both ends of locomotive or other rods at one time, the adjustment being adaptable for rods of different lengths as in Fig. 9. Some machines of this kind have a double set of housings, and tool boxes on the housings in addition to those on the cross slide.

The multiplication of cutters on planers, beyond those on housings and cross rails, and on duplex machines, is mostly limited to the tooling of articles, such as fluted rolls, rail points, nuts, etc. The rule is nearly always, one tool box, one tool, the case of back to back tools in reversing holders excepted. An exception, however, occurs in the Armstrong tool holder for planers, in which four tools operate in succession, the width of feed traverse being equally divided among the four, the principle being the same as that of the cutters in a boring head. The result is that the feed can be increased directly as the number of tools.

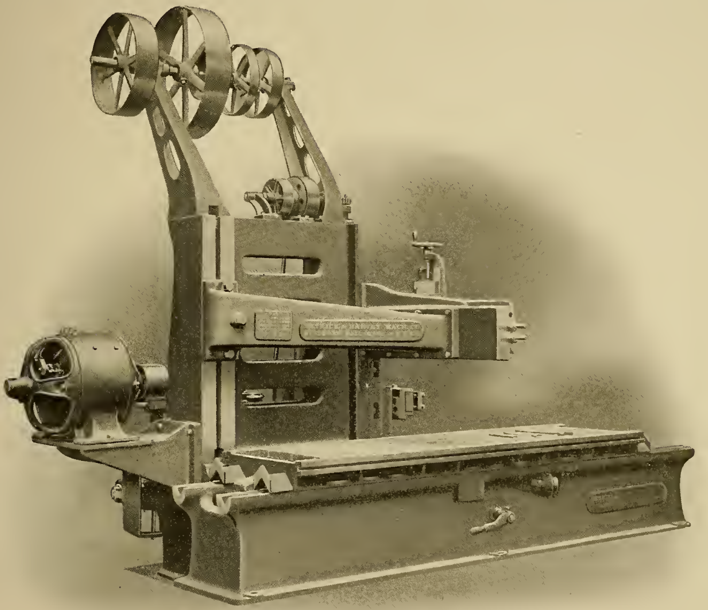


FIG. 8.—AN ELECTRICALLY DRIVEN OPEN-SIDE PLANER. MADE BY THE DETRICK & HARVEY MACHINE CO., BALTIMORE, MARYLAND, U. S. A.

Modern planing machines are superior to the older ones in the improved feeds. Where ⅜ inch or ½ inch was once considered a broad finishing cut, from 1 inch to 1½ inches or more is now required. The old error lay also in making the feed dependent on the reverse of the table, and on a certain amount of overrunning. The modern method is to make it independent of reversal, and also in some cases to put it on at either end of the stroke, and to make it capable of alteration while the machine is running. The old ratchet and click is, therefore, an obsolete device.

A special device which is of considerable value from the point of setting planing machines down in a shop is that of fixed *versus* adjustable striking forks.

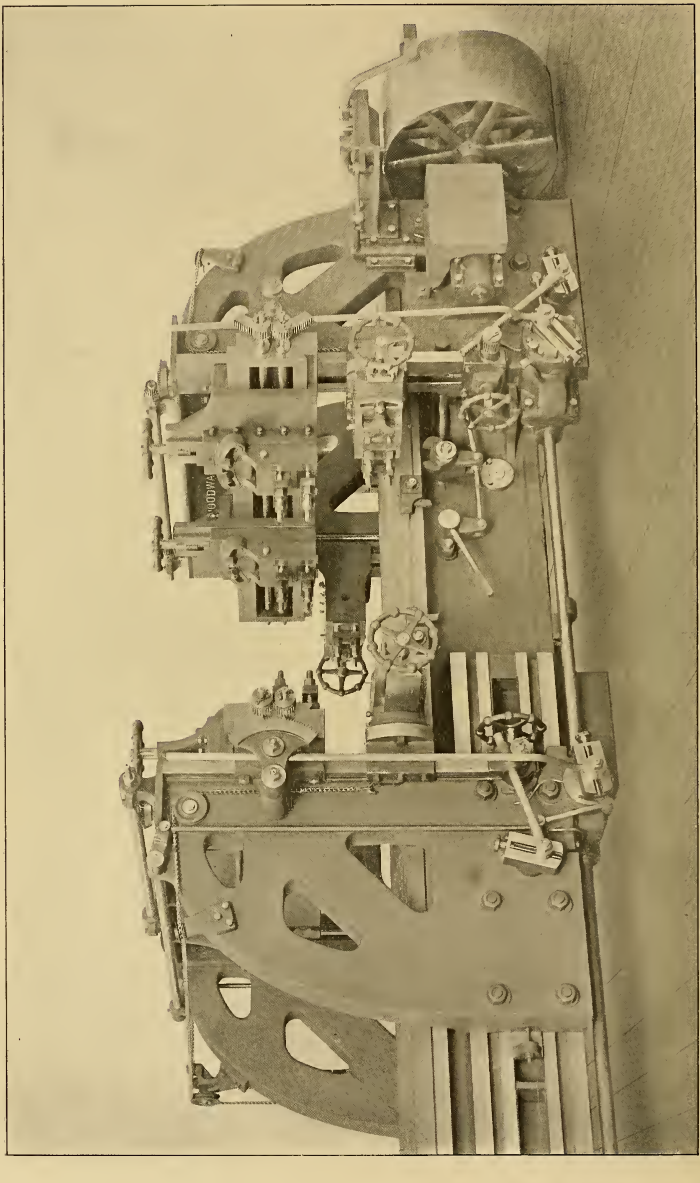


FIG. 9.—CONNECTING ROD PLANING MACHINE FOR RODS UP TO 11 FEET LONG. BUILT BY THE WOODWARD & POWELL PLANER CO., WORCESTER, MASS.. ONE HOUSING IS ADJUSTABLE ALONG THE BED

In all ordinary machines these are fixed in one position, so that very little latitude is left for the angle of the belt drive. In the device patented by Cunliffe & Croom, Ltd., of Manchester, England, the whole of the belt reversing gear is movable round a quadrant face on which it can be set, and clamped at any angle from the vertical to the horizontal. This machine is shown in Fig. 11.

The problem of vee *versus* flat slides for the table has long exercised the minds of manufacturers. The vee is the early form, and at one time the only one adopted. The greater ease of fitting and maintaining the truth of the flat design induced some makers to adopt it; but conservatism, as well as the obvious advantages on the side of the vee, have been the reasons why the flat fitting has made but slow headway.

The flat slides are easier to machine and fit, and the take-up strips prevent side movements. Vee guides prevent risk of such movement, as well as lifting, to a certain extent; but these give more trouble when wear takes place, and, therefore, practice favours the flat slides to an increasing extent, so that at the present time the flat ways run the vees very closely.

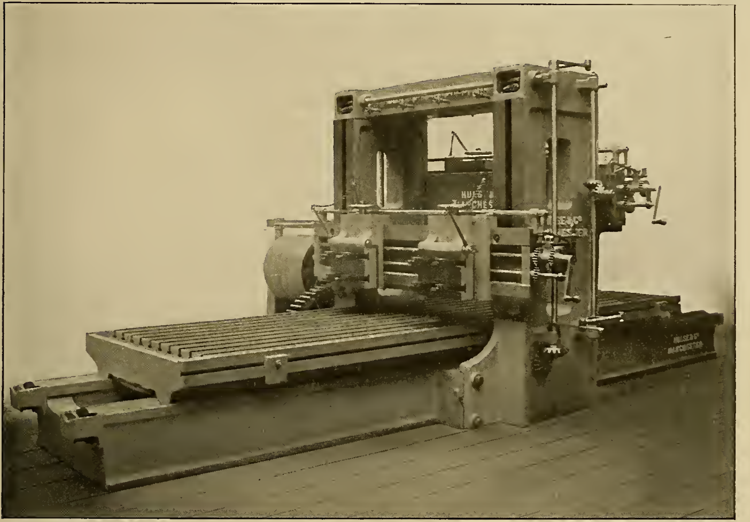


FIG. 10.—A DOUBLE-RAIL PLANING MACHINE. MADE BY MESSRS. HULSE & CO., LTD., MANCHESTER, ENGLAND. EIGHT RAILS CAN BE TAKEN IN AT ONE TIME

They afford a good basis for levelling the machines on their foundations, as well as being easy to correct, and their lubrication is more readily kept efficient, because the oil does not run away, as it does down the sides of a vee. Whether the higher speeds now demanded will in any way tend to the survival of one form over the other cannot be foreseen, but the present tendency appears to be all in favour of the flat type.

More attention is given to the self-acting relieving motion of tool boxes than formerly. A familiar sight is the dragging of the tool on the work during the return stroke. There is little objection to this in roughing cuts, except that it looks slovenly, and dulls the keen tool edge. Sometimes men lift the tool

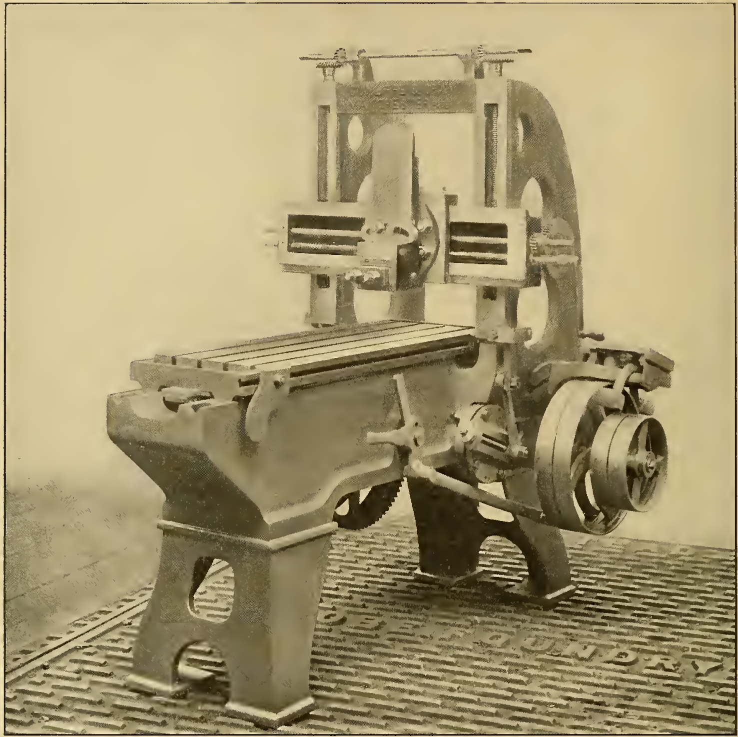


FIG. II. —A PLANING MACHINE. MADE BY MESSRS. CUNLIFFE & CROOM, LTD., MANCHESTER, ENGLAND

on the return stroke, but that can only be done on the smaller machines where one can reach over; it is a tedious job, however. As it is easy to fit a relieving device it should be done more often than is the case.

The limitations of width of work imposed by the fixed housings of the ordinary machine have brought into prominence two special sub-forms,—the open-side planing machine, with or without a temporary removable housing, and the side planer, built broadly after the shaper model, with its vertical equivalent, the wall creeper. The first belongs to the fixed tool type, the second to the class in which the work is fixed.

In the general model in which the open side planing machine is built, the bed, the moving work table and the fixed tool are retained; but one housing is omitted, and the design of the other is allied to that of a post supporting the cross rail at one end only. The problem here is to obtain ample rigidity of the post and arm under heavy cuts. This has been secured by broad and liberal proportioning, and by the cantilever form of arm with tapering thicknesses and ribbing.

The post is usually of rectangular section; but in the Billeter machines, which appear to have been the earliest of this design, the pillar is of circular section, and the arm is kept at right angles with the bed by a key groove. A machine of this type, made by Billeter & Klung, A. G., of Aschersleben, Germany, is shown on page 144. In case of exceptionally heavy cutting being required, an outer support is fitted for the arm. One, two, or three tool boxes are fitted, —one or two on the arm, and one at the side. In machines of this class the advantage is that of open-sidedness, since the problems of quick return and moving work remain as in the common type.

Machines in which the tool moves while the work remains stationary comprise several sub-types, most of which are also open-sided, though several are not. We will discuss these first briefly.

There are some Continental machines of the latter class which have a close general resemblance to the common planer, but in which the housings,—screw-driven,—slide on vertical ways that flank the table, and the attendant is travelled with them on a platform, as in heavy plate, edge-planing machines.

More massive than these are the pit planers, the special feature of which is that housings and cross rail travel over the work, bolted down below in a pit. This is a bold design, of which few examples occur in England. The moving mass is large, and the broad bases and slides require very perfect fitting, with provision for taking up wear, to ensure steady movement. It is an example of one among many attempts to tool massive work while stationary. This planer is shown in Fig. 15.

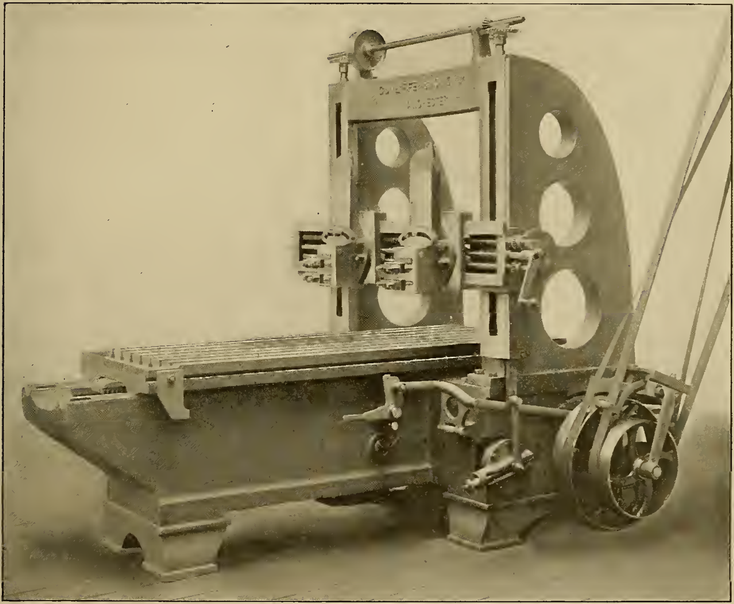


FIG. 12.—ANOTHER CUNLIFFE & CROOM DESIGN

In these pit planers the height of the cross rail is subject to much variation, being low down or high up in different machines. The former is better for

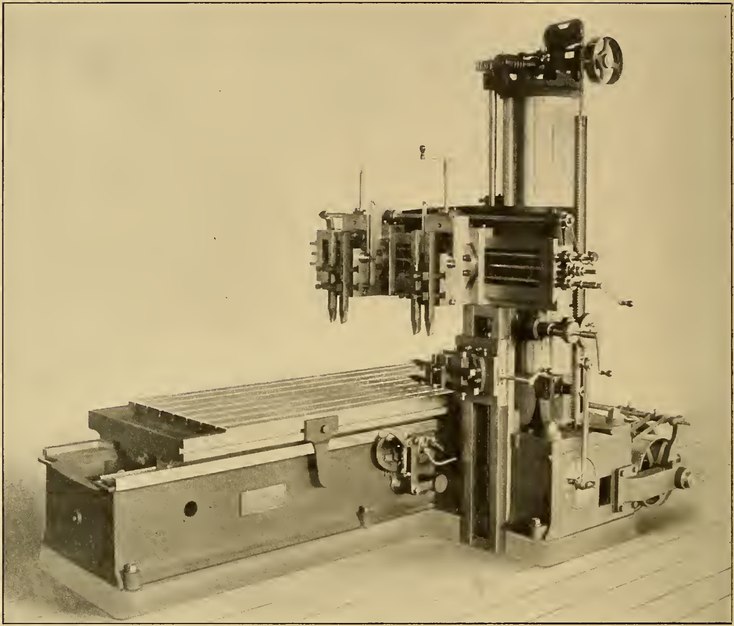


FIG. 13.—A SINGLE PILLAR PLANER. MADE BY MESSRS. BILLETER & KLUNZ, LTD., ASCHERSLEBEN, GERMANY. REPRESENTED BY MESSRS. PFEIL & CO., LONDON

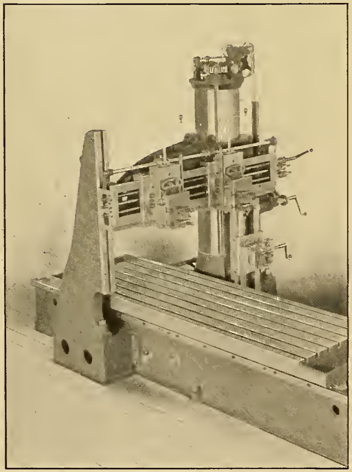


FIG. 14.—THE ABOVE PLANER ARRANGED WITH AN AUXILIARY SUPPORT FOR THE ARM

stability, but the exigencies of work require the latter also. In some designs the rail has no capacity for vertical adjustment, in others it has, being carried on turned pillars, braced together with a cross beam above.

The side planers, of shaper model, form an extensive goup for the moving tool type. They have several practical advantages over the regular kinds, but some limitations also. They resemble shapers with traversing heads in their general build, but differ from them in the direction of cutting, being longitudinal instead of transverse. The tables of the knee type are raised and lowered like those of shapers, to suit the depth of the work, the height of the tool box being fixed, except for a small amount of feed imparted to the holder. The difference in the floor space occupied is a distinction of considerable importance, being the difference between the area of the machine in the open-side type and that of double the length of the table in the fixed tool group. In the latter the table runs over the ends to a distance equal to about half its own length, and this makes demands on the shop room.

In connection with this there is one point which is seldom noticed except in the shops, and that is the danger of the moving table catching a passer-by in a tight corner. To prevent this risk the space at the end is sometimes roped off. If this precaution is not taken, men must look out when they are passing the ends of a planer table having movement in a confined space.

An advantage of the side planer is that if it is provided with a deep brick-lined pit in front, deeper work can be received than ordinary planing machines will take, unless they are fitted with a separate housing and tool box for planing ends. In this case the work is laid across the table and the end planed with the supplementary tool box on the housing, or in some cases with a cross traversing box running on the cross slide. Such a job can be up-ended in the pit and planed, just as similar jobs are treated in big shaping machines provided with a pit. A planer provided with a pit is shown in Fig. 17.

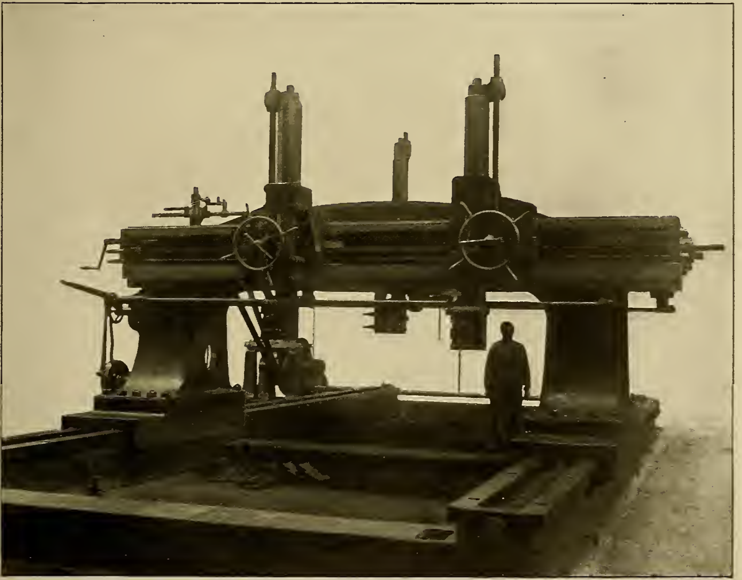


FIG. 15.—PLANING MACHINE WITH CROSS RAIL AND UPRIGHTS TRAVELLING ON SIDE WAYS. MADE BY M. M. SCULFORT & FOCKEDEY, MAUBEUGE, FRANCE

It is well known that the shaper does not operate satisfactorily on its longer strokes. This is due to the fact that the ram springs slightly, and to an increasing amount as it gets farther away from its support. In a machine in which wear of the slides is not well taken up, this becomes apparent to the

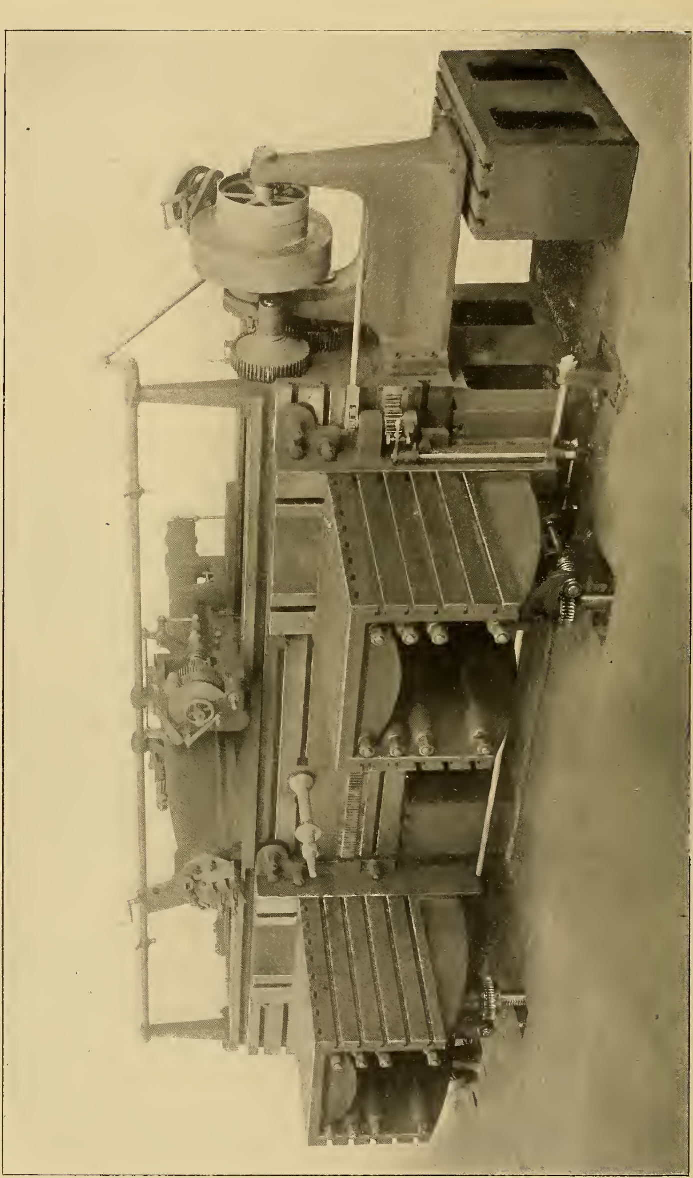


FIG. 16.—COMBINED SHAPING AND SIDE PLANING MACHINE. MADE BY MESSRS DE FRIES & CO., LTD., DUSSELDORF, GERMANY. REPRESENTED IN ENGLAND BY ALFRED HERBERT, LTD., COVENTRY, ENGLAND

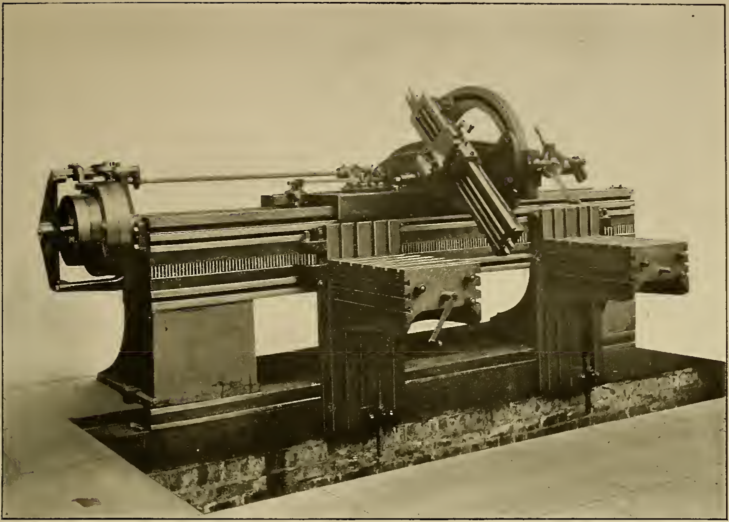


FIG. 17.—A SIDE-PLANING MACHINE WITH SWIVELLING ARM. MADE BY MESSRS. GEORGE RICHARDS & CO., LTD., MANCHESTER, ENGLAND

eye without the test of measurement. In a side planer cutting longitudinally, the tool operates throughout a single stroke at the same distance from the bed, because it is parallel therewith. And while the side planer arm has but one slide, that on the bed, the shaper has two to suffer from slackness,—the one just named, and also that of the ram working across the saddle.

There is also an advantage in the side planer from the point of view of setting the work and observing the progress of cutting. It is a little awkward to effect adjustments on a common planer table, sometimes leaning over it, or climbing on it. The tables of a side planer, like those of shapers, can be got round easily.

When deep pieces are being tooled in the common planer, the cross rail is so high up that the cut cannot be seen or the work checked so readily as when it is on the level of the tables of the side planer, where the height of the cutting tools is practically constant for all jobs. Moreover, the vertical faces of the latter permit of the attachment of work which requires the aid of the angle plate on the common planer table.

The larger side planing machines are fitted with two angle bracket tables, the advantages of which are that in doing small or medium pieces, the attendant can be setting work on one table while cutting is going on on the other. Also, that a large piece can be clamped between or upon two tables which could not be carried on one alone. Examples of side-planers are given in Figs. 8, 16, 17 and 21.

The capacity of the tables does not represent the full capacity of these machines, since work can be attached to the tables by one end and extend out over the floor at the other, being levelled on suitable blocking. In this way facings of relatively small area on big castings or forgings can be planed. A good arrangement with the tables of some side planers is that of combining provision for raising and lowering them

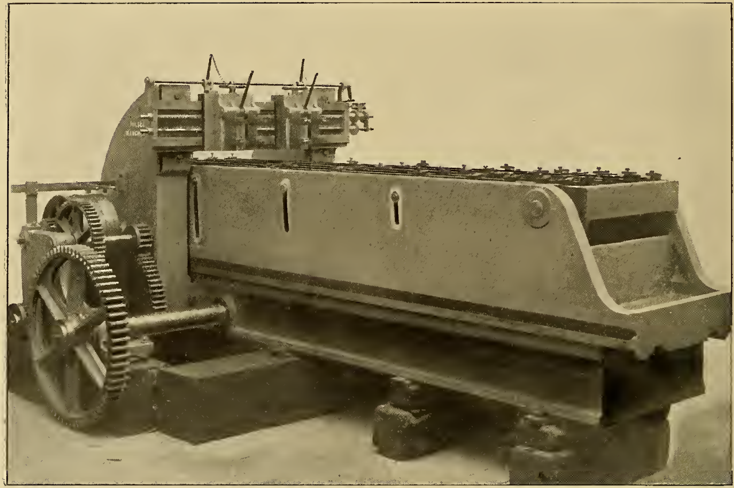


FIG. 18.—PLANING MACHINE FOR RAILWAY POINTS. MADE BY MESSRS. HULSE & CO., LTD., MANCHESTER. WILL TAKE FOUR AT ONE TIME

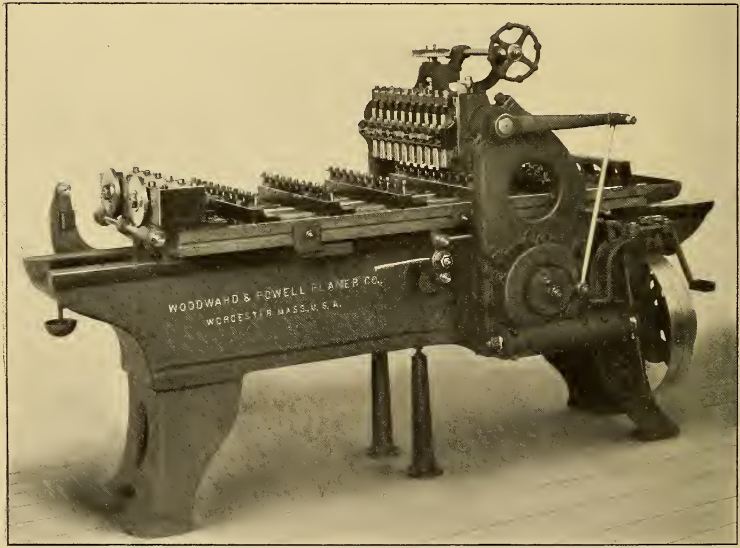


FIG. 19—A PLANER WITH TEN TOOL HOLDERS FOR FLUTING FEED ROLLS FOR TEXTILE MACHINES. THE MACHINE WILL TAKE IN TEN ROLLS SIDE BY SIDE, AND TWO LENGTHS OF ROLLS, MAKING TWENTY ROLLS IN ALL. MADE BY THE WOODWARD & POWELL PLANER CO., WORCESTER, MASS, U. S. A.

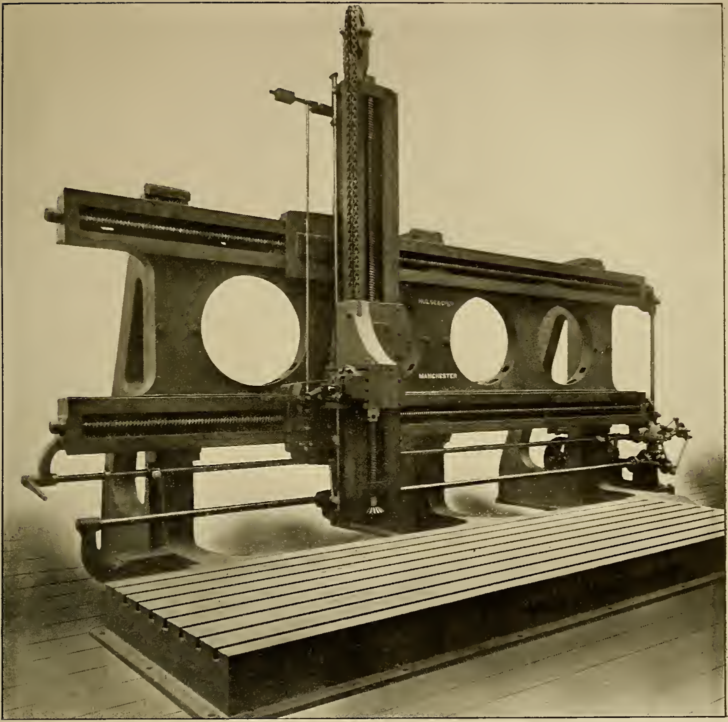


FIG. 20.—COMBINED VERTICAL AND HORIZONTAL PLANING MACHINE TAKING IN WORK 20 FEET HORIZONTALLY AND 10 FEET VERTICALLY. MADE BY MESSRS. HULSE & CO., LTD., MANCHESTER

together, as well as independently, by power. The advantage is, that once set, vertical movements can be effected without disturbing their alignment.

Many side planers include shaping movements, the distinction being that planing takes place along the bed, shaping transversely. The two sets of motions are interlocked in the machines of this class, made by de Fries & Co., of Düsseldorf, Germany, so that they cannot both be in operation at the same time. An intermediate angle bracket is necessary at the end of the arm to change the position of the tool box. The planing movement is actuated by a screw, the shaping by a rack and pinion. The tables are adjustable longitudinally by rack and pinion, and vertically by screws fitted with roller bearings. Feeds can be changed while the machine is running. When to these a circular shaping attachment is added, the range of these machines is rendered practically universal. A combined shaping and side-planing machine is illustrated in Fig. 16.

The limitation to the use of side planers is the width which can be surfaced, which is usually limited to 40 or 50 inches, due to the overhang. But no extra shop room is required for the work to move over, and the reversal is only that of the mass of the tool holder

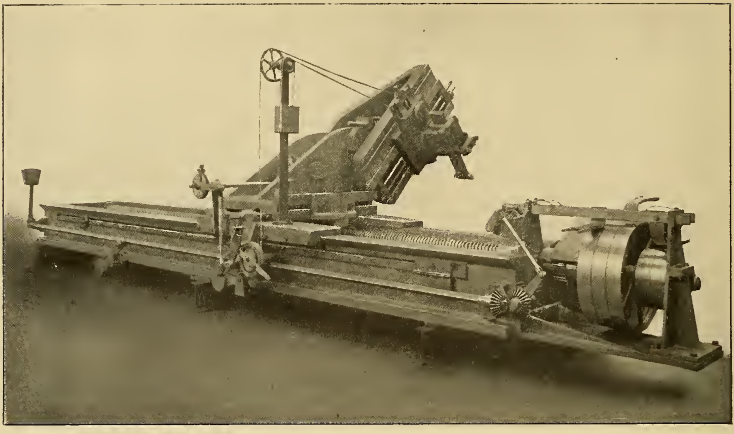


FIG. 21.—SPECIAL SIDE PLANER FOR ARMOUR PLATES, WITH ARM ADJUSTABLE TO ANY ANGLE. MADE BY MESSRS. CRAVEN BROS., LTD., MANCHESTER, ENGLAND

and its arm. As the arm is operated by a screw, its motion can be arrested with closer precision than that of the mass of a rack-driven table. Within its limitations the side planer has, therefore, much in its favour, and for work beyond its range we have the more massive class of wall creeper model.

The familiar vertical planing machine, or wall creeper, has been a most valuable aid in the tooling of heavy marine castings and forgings, and for massive pieces generally which cannot be placed on the table of any ordinary machine.

The work is attached to a tee-grooved table alongside which the tool post travels. The faces to be operated on must, therefore, be set vertically, and if more than one face has to be planed, the work must be shifted round for each face. The tool boxes are screw-driven. In fact, the machine is the mechanism of the old boilermakers' plate edge planer adapted to another class of work.

A great many machines of this kind plane both horizontally and vertically, the former being the longer traverse. The whole of the vertical slide partakes of the horizontal movement. It is, therefore, carried on two faces set several feet apart on the uprights. An example of this machine is given in Fig. 20.

In some vertical planers the vertical tool slide or column traverses on a base plate, instead of on slides, arranged in a vertical plane. At first sight it appears as though a moving pillar is an unmechanical arrangement, but the broad fitting of the tool post and its tapering outlines render it steady for moderate areas. For the most massive work the other is more suitable.

In this great group there is no obstruction to the tooling of the most massive pieces of work, attached to a table, plain or compound in type, while the movements of the tool box command a large vertical and horizontal area. Such machines are either independent or the tool box slides are fixed to a wall.

The requirements of marine work make great demands on the big planing machine, and here the vertical and horizontal planers abound in many modifications. The immense cranks, the connecting-rods, as well as the cylinders and frames, involve tooling of more than one kind, and it is desirable to do as much as possible with the least shifting and resetting of the work.

This is the reason why some big planers embody provision for vertical slotting also, together with the circular table and compound slides of the slotting machine. In such a machine the cross slide and ram have to be lifted by power to clear deep objects on the table.

Some machines for planing armour plates include three directions of operation,—the usual longitudinal, a cross traverse for ends, without resetting the work, and the vertical or slotting,—horizontal and vertical screws, respectively, being used for the last two.

A variation from the standard form of planing machine is that in which the cross rail can be set at an angle from the horizontal for planing bevels. Instead of sliding directly on the housings the rail is attached to back sliding plates, being pivoted to one of these and adjusted for angle on the other by a segmental rack and worm and then clamped.

The capacity of a common planer can be increased by rigging up planer centres and headstocks on the table. The latter are admirably suited for shaping curved segments of work, or complete curves on sections of pieces that cannot be conveniently swung in the lathe. All that is necessary is to impart a rotary feed to the head through worm gear. Dividing heads can be utilised, or a face plate can be fitted to the head, as well as point centres, and when the heads are removed from the table the machine is ready for ordinary duty.

Many special machines fall under none of these great groups beyond the feature of reciprocating movement.

The tooling of the points of rails has given rise to planing machines of special design, having tables capable of being set to vertical angles. The table, therefore, comprises the sliding portion or base, and the upper portion, hinged, on which the work is bolted. Several tools operate at one time. The general proportions are necessarily rigid to withstand the strains of such multiple cutting. This machine is shown in Fig. 18.

Another special planer is made for fluting feed rolls. These are carried on point centres, a multiplication of the planer centres, ten in the width of the machine and two sets in length, making twenty rolls in all, being fluted at one time. The centres in the centre head are connected by spur gears. Two of the centres have notched dials which regulate the distance between the grooves in the rolls automatically. This planer is illustrated in Fig. 19.

A novelty in planing machines is made for producing concave faces for domes, boiler seatings, etc. In this case the tool box is carried on a saddle which receives a vertical motion from a radius bar above. The effect of traverse, therefore, is to alter the height of the tool box, and so produce curvature.

Beyond these there are special portable machines for planing work in place, one of the best known of which is that for truing up the valve faces of cylinders. Others are employed for working on large engine beds and frames of various kinds, on which it is cheaper and quicker to fasten the portable planer and do the work than to take the job to a fixed planer.

In many cases but a small area has to be tooled in any one locality, and the portable machine excels in this class of work. The machine generally takes the form of a stiff beam, upon which the planing head slides, and also has a slotting motion. The beam being bolted to the job, the head can operate on any portion of the work within reach.

It may be driven by ropes or electrically, the latter being more convenient. Variations in this design are always increasing, and with the growing mass and sizes of castings and forgings now employed, especially in engine and electrical work, the demand for such portable machines is bound to become greater and greater.

It is thus abundantly evident that if the planing machine is having considerable portions of its work appropriated by the milling machines, its capabilities are being enlarged in other directions, and the planers appear to be as firmly established as ever. This is partly due to improved and specialised designs, but largely also to improvements in the details of the older types on the lines indicated in the preceding pages.

THE COMMERCIAL DEVELOPMENT OF WATER POWER

By Alton D. Adams

UNDEVELOPED water power is sometimes regarded like a rich gold mine, that is, as a property that has only to be worked in order to yield large profits. Nothing could be further from the facts in some cases. The mere circumstance that a stream with a considerable volume of water flows between high banks or some miles, so that it may be readily dammed up, or that it plunges over a rather high fall, does not necessarily give it any value whatever for power purposes. In other words, engineering practicability is no sufficient test of commercial expediency in the development of water power.

For the successful development of water power from the financial point of view, it is a prime necessity that there be population by which, or industries in which, the energy can be utilised. The next important question relates to the cost of the development and the income that can be obtained by the sale of power. Both of these matters depend to a large extent on the constancy of the power, and on its minimum rather than on its maximum volume. It might seem superfluous to call attention to these fundamental facts were they not so often lost sight of by promoters of water power development, and even in some cases by engineers who are called on to advise in such matters. Electrical transmission and distribution have done much to make practicable the development of unused water powers, but transmission of power in any save very large units soon finds commercial limits, and distribution can supply, but cannot create, consumers.

An interesting illustration of these principles recently came to light in the investigation of a proposed development of water power for electrical supply, and the main facts of the case are given below, save that all names which might serve to identify the power site are omitted.

The site in question is located in the western half of the United States, in an agricultural and stock-raising section, and is several hundred miles from any city of considerable size. A river that has cut for itself a gorge of 60 to more than 100 feet in depth through the soft rock of its bed, and of varying width, for a length of several miles, is the proposed source of the water power. Where the steep sides of the river gorge approach each other to within a distance of about 200 feet, it was proposed to erect a masonry dam with a height of nearly 60 feet above bedrock, from bank to bank. By this dam a reservoir more than 5 miles long would be created, and a head of 50 feet of water would be made effective for the wheels.

Near one end of this dam an electric generating station was to be located, and the energy there developed by the water was to be distributed in two settlements not more than 5 miles apart, and lying on opposite sides of the water power site. It was thought that the entire flow of the river, with an effective head of 50 feet at the wheels, would enable the delivery of 4000 H. P. regularly for twenty-four hours per day, and that in the driest times this output need never drop much below 3000 H. P.

This power was to be sold in the two settlements already mentioned, each of which has a population of about 1000 persons. One of these settlements is located on the only railway line in that part of the country, and is a trade centre for the territory to a distance of 100 miles round about. As the two settlements mentioned, when taken together, have a population larger than any place within nearly 200 miles, there seemed to be no opportunity for profitable transmission of the power to distant points.

One of the first steps in the investigation of this problem was to determine the volume of water and consequently the power that would be available at different times of the year. Fortunately, the daily discharge of the river, in cubic feet per second, had been recorded during several years for a point a little above the site of the proposed dam. From these records for a recent year it appeared that the minimum rate of discharge on the days of nine months was not less than 600 cubic feet per second, taking averages of two days together. In these months the maximum discharge never fell below 750 feet per second, and in two of them it rose to more than 1500 per second. During the remaining three months of the year the records were mostly lacking because of ice in the river.

A survey of the power site and of the river above showed that the reservoir formed by the dam would extend up stream more than 5 miles, would have an area of nearly 1 square mile, and would contain about 7000 acre-feet of water. For the nine recorded months of the year in question, the lowest monthly discharge of the river was more than 38,000 acre-feet, and the highest was less than 54,000 acre-feet. This uniformity of discharge seemed to be due to the fact that the river flows through a sandy country and is supplied mainly by springs. It should be noted that the storage capacity of the reservoir behind the dam would equal nearly one-fifth of the minimum monthly discharge of the river. On the foregoing facts it seemed that the minimum discharge of water available for power production might safely be taken at 600 cubic feet per second throughout the entire year.

With this discharge of water under an effective head of 50 feet, its rate of work would be represented by $(600 \times 62 \times 50) \div 550 = 3380$ H. P. Fair efficiencies for water-wheels, electric generators, distribution lines and transformers, at full load, may be taken at 74, 93, 92 and 95 per cent., respectively. On the basis of these figures the electric system would deliver to consumers $0.74 \times 0.93 \times 0.92 \times 0.95$, or fully 60 per cent. of the total energy of the falling water, and this would amount to $3380 \times 0.60 = 2028$ H. P., or very nealry 1500 KW. This power, it is to be noted, represents a large reduction from the 3000 to 4000 H. P. which it was thought the river might furnish. If operated continuously throughout the year for twenty-four hours per day, the minimum discharge of the river would yield $1500 \times 8760 = 13{,}140{,}000$ kilowatt-hours for the use of consumers on the electric lines.

With a population of only 2000 to be served, it would thus be necessary that each should consume $13{,}140{,}000 \div 2000 = 6570$ kilowatt-hours on an average, in order that the continuous output of the plant might be sold. That such a rate of consumption would be most unusual was seen by comparison with the numbers of kilowatt-hours sold per inhabitant on an average in several cities during past years. In one city, where there is a large and prosperous electric system, operated mainly by water power, the average amount of electrical energy sold per person in the population, as determined by the census of 1900, was 107 kilowatt-hours during 1901. This energy was absorbed by a large lighting load, and stationary motors of more than 3000 H. P. rated capacity, besides a relatively small amount of electric heating apparatus.

Another city, where most of the energy distributed by the electrical supply system comes from water power, used 158 kilowatt-hours on an average per inhabitant, in 1903, on the basis of its population in 1900. In this city the load of stationary motors had a rating of nearly 3000 H. P., and there was a large lighting load, but comparatively little electric heating. Neither of these cases includes the energy used by the local electric car lines

From these illustrations it was at once evident that 13,140,000 kilowatt-hours per year could be sold to a population of 2000 persons only under some extraordinary conditions. Such conditions, it was thought, might be found in the offer of electric energy at very low rates in a place where soft coal of only moderate quality sells for $8 per ton, and where ordinary kerosene for lamps costs 25 cents per gallon. These are the current prices for the commodities named in the places where the electric energy from the water power was to be sold.

It appeared on investigation that the population of 2000 persons consumed annually more than 7000 tons of the soft coal at a cost of more than $56,000 and approximately 30,000 gallons of kerosene, costing nearly $7500. A very large electric load in proportion to the population might be obtained, it was thought, by making the rates for light, heat and power as low as the cost of coal and oil for corresponding results.

The conclusion reached as to lighting was that at the rate of 3 cents per kilowatt-hour the number of these units that could be sold per year for lighting would reach 150,000. From this source the probable income was thus 150,000 × 0.03 = $4500 annually. Stationary motors, it seemed, would absorb as much as 300,000 kilowatt-hours per year if the rate for power service was also put at 3 cents per unit, and the resulting income would be 300,000 × 0.03 = $9,000. An electric railway from the depot to the settlement, about 4 miles distant, over which there would be a large freight as well as passenger traffic, was estimated to consume fully 200,000 kilowatt-hours yearly at a rate of 2 cents, so as to yield an income of 200,000 × 0.02 = $4000 to the electric supply system.

On these estimates these three lines of service, that is, lighting, stationary motors and electric railway, would give the supply system an income of $17,500, and would consume only 650,000 kilowatt-hours of its energy per annum. As the possible output of the proposed plant when making continuously at the rate of 1500 KW, on an average, was 13,140,000 kilowatt-hours yearly, the lines of service just considered left 12,490,000 kilowatt-hours of this output unsold.

Electric heating was thus the only service to which the great bulk of the energy from the proposed plant could be devoted. One pound of only moderately good soft coal contains about 12,000 latent heat units, but hardly more than 6000 of these units are usually made available for warming and cooking, because of imperfect combustion and the losses due to high temperature of flue gases. On this basis a ton of 2000 pounds yields 12,000,000 units of heat for useful purposes. As a kilowatt-hour is the equivalent of 3412 heat units, all of which are available at an electric heater in warming or cooking, it seems that 12,000,000 ÷ 3412 = 3517 kilowatt-hours will equal 1 ton of this coal in useful heating effect. The entire yearly output of the plant would thus do the work in heating of 13,140,000 ÷ 3517 = 3736 tons of coal, or about one-half of the amount consumed by the population to be served. There was, therefore, an ample market for the electric heat if it could be sold at a rate that would displace coal.

It was found that during the month of July, 1903, the consumption of coal was not less than 250 tons, or about 670 pounds per hour for the twenty-four hours of each day on an average. This rate of coal consumption would yield 4,020,000 heat units per hour, on the basis of 6000 units per pound. If carried by the electric system, the heating load thus presented even in July would represent a continuous output of 4,020,000 ÷ 3412, or 1178 kilowatts.

As 1 ton of the coal in question, costing $8, equals 3517 kilowatt-hours in useful heating effect, the electrical energy must be sold at 800 ÷ 3517, or 0.22 cents per kilowatt-hour, in order to just equal the bare full cost of the heat from coal. To make the electric heat slightly cheaper than the bare cost of coal for an equal effect, the rate may be put at 0.2 cents per kilowatt-hour, so that the output of the plant may all be sold. As shown above, after all of the probable demand for light and power has been supplied, there will remain more than 12,000,000 kilowatt-hours of the possible yearly output that may be sold for heating. On the rate for heating just mentioned, the annual revenue from this output would amount to 12,000,000 × 0.002 = $24,000. Combining with this sum the estimated earnings from the supply of light and power, it seems that the annual income of the electric supply system would amount to $41,500 if its entire output were sold.

In order that the electric station may yield a continuous output of 1500 kilowatts for consumers, on an average, its generator capacity should be at least 2000 kilowatts, so that machines may be shut down for inspection and repairs, and so that a maximum load of more than 1500 kilowatts may be carried. The dam of more than 200 feet in length and nearly 60 feet high above the bedrock should be of cement concrete, and so also should the foundations for the power stations.

Above its foundations the power station should be constructed entirely of brick, slate and steel, save at the doors and windows, and its height should be one story. The location of this station close to one end of the dam will cut the cost of penstocks and hydraulic work to the lowest figure consistent with first-class construction. Distribution lines for the electric system were designed to be entirely overhead, and to be connected with transformers and meters for the delivery of the output of 1500 KW to consumers. Owing to the fact that 80 per cent. of this energy was to be used for heating, the cost of distribution lines was found to be somewhat below that which would be necessary with a light and power load. To construct the above dam and generating station with complete equipment and to build and supply with transformers and meters the distribution system, the total cost was estimated at $450,000.

Comparing this cost of construction with the $41,000 of estimated annual earnings for the electric system, it seems that the latter amounts to only 9.1 per cent. of the former. In a system like the one under consideration, where all the electric energy is developed by water power, and most of it is sold for heating, the expense of operation will be comparatively low. Even with this advantage, however, it is very evident that operating expenses, interest and depreciation, to say nothing of profits or dividends, cannot be paid out of a gross earning that amounts to only 9.1 per cent. annually on the investment.

Having found that the plans of the promoters of the above plant could not be carried out at a profit, it remained to be seen what could be done on a sound financial basis. A little consideration was sufficient to show that an electric plant under the circumstances of this case could not hope to show a good return on its cost so long as the greater part of its income was derived from heating in competition with coal at $8 per ton. The next step was to reduce the capacity of the entire plant to a point where light and electric motive power would become the more important loads. In order to provide for all the light and power service that would probably be required for many years to come, it was decided to give the dam a height that would maintain an effective head of 20 feet of water on the wheels instead of 50 feet, as had been proposed.

With this head the minimum rate of discharge in the river and the efficiency of 60 per cent. between the power of the water and distribution system, there would be a constant output of 600 KW available for consumers. At present most of this output could be sold only for heating; but as the demand for light and power increases, some of heating can be omitted. Twenty feet was fixed on for the head of water, because lower heads cost more to develop and because it is much more economical to give a dam its maximum height at first than to increase the height and thickness after a plant is in operation. Moreover, the head of water fixes both the power and speed of the wheels, and consequently the frequency, capacity and voltage of their direct-connected generators, so that any considerable change in the working head after a plant is in operation requires expensive changes in electric generators and transformers.

With a constant load, on an average, of 60 KW, the output of the electric station would reach 5,256,000 kilowatt-hours annually. As shown above, 650,000 kilowatt-hours could probably be sold per year for light and power purposes at once. This would leave 4,600,000 kilowatt-hours to be sold for warming and cooking, instead of the 12,000,000 kilowatt-hours that would be offered for these purposes from the larger plant. Because of its limited quantity this smaller amount of energy could probably be sold for 0.3 cent per kilowatt-hour, which would make its heat 1.5 times as expensive as that from coal. The income from heating and cooking on this basis would amount to $4,600,000 \times 0.003 = \$13,800$ annually. The addition of this sum to the $17,500 to be derived from the light and power service raises the probable gross earnings of the 800-KW system to $31,300 annually. From year to year the demand for light and power will increase, and the price for energy used in heating can be gradually raised, so that the gross and net income would grow larger because of both more business and higher prices.

To construct the dam for a water head of 20 feet, build and completely equip the electric generating station for a maximum output of 800 KW, and erect a distribution system with transformers and meters for the delivery of 600 KW regularly to consumers, was estimated to cost $170,000 in condition to operate. Of this sum the probable annual earnings of $31,300 in sight at the start form 18.4 per cent. of the investment. Such a percentage of the earnings to investment would hardly be satisfactory as a permanent matter; but in the case under consideration, it seemed advisable to make the hydraulic development great enough for all future demands. Having done this it was better to install the generating and distributing apparatus and sell the surplus energy for electric heating than to let the water go idly over the dam.

Had present requirements alone been considered, the height of the dam would have been designed for a head of 10 or 12 feet, and a generating station and distributing system of about 300 KW capacity would have been constructed. Such a plant could have been enlarged at some later date only with a relatively great expense.

The chief value of this illustration from actual practice is that it shows some of the conditions that are met and some of the considerations that govern in the development of water powers for electrical supply.

THE INCH VERSUS THE METRE

FOR A UNIVERSAL METRIC SYSTEM

By George Moores, F. S. S.

UP to the beginning of the nineteenth century every nation had its own systems of weights and measures, but with the rapidly increasing international intercourse, and the advent of mechanical means for manufacturing, the desirability was foreseen of having some simple system of weighing and measuring which could be used by all nations and which should be established for all time. The movement for reform on these lines began to take shape in the latter part of the eighteenth century. Great Britain was in the van, closely followed by America and France, the other nations of Europe bringing up the rear.

In Great Britain the initiatory movement was taken in 1789, in which year Sir John Riggs Miller, member for Newport Borough, Cornwall, gave notice in Parliament that in the next session he would bring forward a resolution aiming at reform of weights and measures. In the following year he carried out his intention, and, in two powerful speeches, brought his proposals before the House. In the interval of those speeches the French Bishop of Autun wrote to Sir John, stating, in effect, that he was bringing the question of weights and measures reform before the British House of Commons, and he (the Bishop), being a firm believer himself of the need of such a reform in France, he would likewise bring the question before the National Assembly,—a body then just formed,—of France. In the same year President Washington in the second session of his first Congress also urged the reform of weights and measures.

Only one of these three attempts at reform was carried out. In Great Britain Sir J. R. Miller ceased to represent Newport, and after returns had been obtained from all over the country, the subject was allowed to drop. In America a commission reported in favour of a decimal, but not metric, system, which was introduced by Secretary of State Jefferson, but no action was taken on the report. In France the National Assembly appointed a commission which subsequently reported, and in 1793 the commission's recommendation of a metric system, operated decimally, was adopted and became law.

The reason why neither Great Britain nor America took action may be gathered from the writings of Sir James Stuart, the well-known political economist, who, years before, had pointed out that "anyone speculating for the public welfare in introducing reform of weights and measures must be very confident of success, owing to the undertaking being so difficult of accomplishment." And, in the report of a subsequent enquiry made in America, Mr. John Quincy Adams said "he stood appalled by the difficulties in the way of the introduction of a reform of weights and measures." Neither country saw its way to combat the difficulties,—and those difficulties have been increasing ever since and will accumulate as time goes on,—which would be raised by a radical change in its weights and measures.

But France had no such fears. It

was then in the throes of the Revolution. It had just beheaded its king and queen, banished religion from the realm, and declared war against Great Britain. The reform of weights and measures was comparatively a slight matter. Freeman, the historian, writing of these days, says:—

> "The centre of everything during this time was France; and in France men did what had never been done before; that is, they went on the fixed principle of changing everything, whether it was good or bad, wherever their power reached, both in their own country and elsewhere. There was a general change of everything, often out of a mere love of change, and there was in particular a silly way of imitating old Greek and Roman ways and names, even when they were nothing to the purpose. But in this general crash the evils of the olden times were largely swept away, as well as the good, and means were at least given for a better state of things to begin in our own times."

THE PRINCIPLES OF A METRIC SYSTEM

The British and French reformers sought not merely to correct abuses of a system, but to improve the system itself. They recognised that the ancient systems of Rome and Egypt, in which the volume measures were based on the linear measures, and the measures of weight on those of volume, had greater advantages than any system in which length, weight and volume had no relation to each other. And at this point let us make perfectly clear what the principles of the metric system are, since there is such widespread confusion and misunderstanding of it, owing to the name of " Metre " having been given to the unit adopted by the French.

A succinct definition of a metric system is a system of weights and measures based on a single measurement of length. Any length will do to produce a metric system,—an inch, a foot, a yard, a metre, or anything else. The value of the system lies in the corelation of volume and weight and the length. That is, if we take a foot for a " single measurement " on which to build a system, that foot becomes the unit of length; cubed, it is the unit of volume measure, and the weight of water which the cube will hold becomes the unit of weight. Contrast this system with the yard, gallon* and pound, which have no common measure, or metre, and, therefore, do not constitute a scientific or metric system.

WHY THE METRE LENGTH WAS ADOPTED

As we have seen, it is not essential to a metric system that any particular length should be chosen; the great point to be observed in choosing a unit is to have something which is constant,—always the same under similar conditions. The British idea of the unit for a metric system was the length of a seconds pendulum at the equator, or any other place to be mutually agreed upon.

To this question of unit the French Academy of Sciences, to whom the National Assembly had referred the duty of preparing a new system of weights and measures, gave long and learned attention. But they handicapped themselves at the outset by laying it down as a principle that the unit of length to be chosen should be unlike any existing unit of length; because they argued if it happened to be the same, or nearly the same, as that of any country, the jealousy which would thereby be produced would prevent its adoption by others. It would probably have occurred to a commission of business men that if the unit selected had been identical, or nearly identical, with that in common use by one people, its adoption would have been secured by that nation; and if it has been arranged so as not to vary too much from the units of other nations the probability of its early adoption by all would have enormously increased.

It has ever been a pity that the quintet of distinguished mathematicians who adopted the metric unit were not joined by an equal or larger number of business men, or that their chosen unit had been subject to revision by another commission who were in close touch with the everyday wants of the people. The fundamental excellence of the system would then, doubtless, have been separated from the fundamental defect of the proposal before them,—the inconvenience of the unit of length selected. As it is, the metre unit is quite unworthy of the system.

The British idea of adopting the

---

* Many years ago Great Britain did effect a slight reform in making a gallon "a vessel holding 10 lbs. weight of water," but in America the old gallon of uneven ratio is still retained.

length of a pendulum beating seconds in some given locality as the unit of the system was for a considerable time favoured by the French savants. It conformed to the condition they had laid down, and it was a constant, and easily recoverable in case of necessity. Eventually, however, it was decided that the unit should be based on a measurement of the earth itself, and it was determined to take the distance from the pole to the equator for that purpose. By actual measurement of the arc between Barcelona and Dunkirk the length of the quadrant was established, and a ten-millionth part of this length became the unit, which was given the name of "metre."

WHO HAVE ADOPTED THE METRE AND WHO HAVE NOT

So far, and for various reasons, one of the strongest of which is that it has no competitor, the French metric system has held, and still holds, the field. Nation after nation has adopted it or had it thrust upon it. Russia, America and the British Empire alone of civilised nations have stood aloof. The argument that thirty-six nations have adopted it and only three have not is often used by those who seek to make its use compulsory in the British Empire and America. Let us analyse the figures of those thirty-six nations and compare them with those of the other three, and in doing this we will assume,—what is very, very far from the fact,—that in all those thirty-six countries the metric system is used by all the inhabitants.

The figures in the table on this page are those given in evidence before the Select Commission of 1895, in respect to the thirty-six countries, and those referring to the three are round figures from Blue Book returns of corresponding dates. In the British Empire India is included, in which country though, by the Indian Acts No. XI. of 1870 and No. XXXI. of 1871, the French metric system was introduced, but never established for use in trade; the "Measure of Length" Act, 1899, adopted the English yard (not the metre) as the standard of length. China is not included in either set of figures. Its system is decimal, but not metric.

	COUNTRIES USING THE FRENCH METRIC SYSTEM.	
1.	Mauritius	371,655
2.	Hayti	570,000
3.	St. Domingo	610,000
4.	Uruguay	[a] 728,447
5.	Bolivia	1,192,162
6.	Ecuador	1,271,861
7.	Greece	2,187,208
8.	Servia	2,226,741
9.	Venezuela	2,323,527
10.	Finland	2,380,140
11.	Peru	2,621,844
12.	Switzerland	2,933,334
13.	Central America	3,053,000
14.	Bulgaria	3,305,458
15.	Chili	3,317,264
16.	Columbia	3,878,600
17.	Argentine	4,257,000
18.	Portugal	[b] 4,360,554
19.	Holland	4,669,576
20.	Portugese Dependencies	5,772,824
21.	Roumania	5,800,000
22.	Belgium	6,195,355
23.	Italian Dependencies	6,258,800
24.	Norway and Sweden	[c] 6,817,782
25.	Spanish Dependencies	[d] 9,695,567
26.	Mexico	11,642,720
27.	Brazil	14,002,335
28.	Spain	[e] 17,565,632
29.	Italy	30,535,848
30.	Java	32,000,000
31.	France	38,343,192
32.	Ottoman Empire	39,212,000
33.	Japan	40,718,677
34.	Austrian Territory	[f] 41,358,886
35.	French Dependencies	43,741,544
36.	Germany	49,428,470
	Total	445,296,003
	COUNTRIES NOT USING THE FRENCH METRIC SYSTEM.	
37.	United States of America	76,000,000
38.	Russian Empire	135,000,000
39.	British Empire	356,000,000
	Total	567,000,000

---

[a] None of the first four are equal to the population of Liverpool.

[b] Lancashire alone in England had more inhabitants than any of the first 18.

[c] The total population of the first 24 is about equal that of the United States of America.

[d] None of the first 25 equal the population within 50 miles of Manchester.

[e] The total population of the first 28 is equal to that of the Russian Empire.

[f] The British Empire alone has 4,000,000 more people than the whole of the first 34.

SHALL WE ADOPT THE INCH UNIT OR THE METRE?

When every other argument fails, the advocates of the metre fall back upon what they consider as their strongest point,—the universality of the metre,—The 36 to 3 argument. Possibly the foregoing analysis of those states will put another construction, and the right one, on that aspect of the question. We are, however, far from upholding the present methods of weighing and measuring in the three non-conforming countries. The metric system is bound to be adopted by us sooner or later, for the reasons that enforce the adoption of all other improvements. It is a scientifically sound system, whereas we are now using an agglomeration of systems,—wasting our time, our money, and our brains for naught.

But whilst our forefathers stood by the length of the seconds pendulum as a unit, it would be unwise to adopt either that or the metre. Both are nearly 40 inches long and present unnecessary difficulties in calculations which would be obviated by taking an inch as the unit of the system. Even if the inch was not known in practice, and though we were a new nation, with no vested interests, no literature, and no industrial reputation behind us, we should still have to go to the inch length to obtain a base for a perfect metric system, so great are the improvements it would give us in mental manipulation, and in practical computation of all kinds.

The idea of a natural constant which the metre was supposed to be has not been realised. Later science has shown the measurements on which it was based to be incorrect, and no one now claims that it is anything more than a piece of metal well preserved and used as a standard, just as our own yard standard is used.

It has been said, and with some force, that the French metric system is already universally used by scientific men, and especially by electrical engineers. We grant this, but in doing so we feel that it is no credit to our race that it is so. If our scientific men have fed themselves on French and German books, and our electricians have been content to have their formulæ made for them by foreigners, it is a subject perhaps not so much for praise of the metre and its derivatives, as it is for regret that Anglo-Saxons have been behind in the world of research and invention.

One of these days we shall have an industrious member of our race coming forward and converting the centi-metre,—gram,—second system into an inch-mil,—second equivalent,—for the mil (one-thousandth inch) is to-day used more in mechanical and electrical manufacturing than is the millimetre, and all the power of the French Academy of Sciences was not found strong enough to alter the divisions of time, though it was part of their system to decimalise the day and to give us a second equal to 0.864 of our present second.

And, though we were to admit that the metre and its derivatives were perfect;* though we were to overlook the fact that there are 122,000,000† more people to-day using the inch and its derivatives than use the metre; though we were to grant that it were possible to compel Anglo-Saxon people on both sides of the Atlantic to adopt the unfortunate and badly conceived metre, the cost of the change alone would be an effective bar in preventing it. We are standardising our manufactures more and more; for centuries the English-speaking people have been, and are to-day, the greatest manufacturing people in the world, and all their calculations are based on the inch.

Our sea charts and land measures, our legal documents and our priceless literature, and, above all, our costly mechanical measures, tools, jigs, gauges, drawings, etc., are all fixed on the inch and its multiples or sub multiples. It is asking too much that we shall alter these for a mere sentiment.

---

* Prof. W. Foerster, president of the International Commission of Weights and Measures, in a long letter published in "The Times" (London) of September, 1902, admits imperfections which would be rectified by an inch unit.

† Not only in the British Empire and in America is the inch used, but the Russian standard, the "sagene," is a multiple (84) of the inch.

THE PREMIUM SYSTEM AND THE BRITISH SHIPBUILDING TRADE

By Benjamin Taylor

A GREAT deal of disappointment, and some apprehension, has been caused in British industrial circles by the recent issue of a circular on the Premium Bonus System from the head office of the Federation of Engineering and Shipbuilding Trades. This circular is, in effect, a manifesto addressed to the officers and members of the trades affiliated with that Federation. The Federation includes nearly all the trade unions connected with these industries, viz., the Boilermakers and Iron-Shipbuilders, Associated Ironmoulders, Patternmakers, Associated Blacksmiths, Enginemen, United Machine Workers, Braziers and Sheet Metal Workers, Brassfounders, Associated Shipwrights, Liverpool Shipwrights, Co-operative Smiths, Combined Smiths, Steam Engine Makers, Smiths and Strikers, Amalgamated Carpenters and Joiners, Associated Carpenters and Joiners, General Union of Carpenters and Joiners, Amalgamated Cabinetmakers, National Furnishing Trades, Woodcutting Machinists, Mill Sawyers, Operative Plumbers, Ship and House Painters, Scottish Painters, and Liverpool Ship Painters.

The Federation, therefore, includes several trade unions which are associated with many industries and occupations besides shipbuilding and engineering. And yet it does not include the greatest trade union of all, and one as closely associated with shipbuilding as even the Society of Boilermakers and Iron-Shipbuilders, namely, the Amalgamated Society of Engineers. The A. S. E. has hitherto refused to join the Federation, and is well known not to be on the most friendly terms with some of the trade unions within the Federation. And this has been mentioned in some quarters as one cause of the antagonism to the premium system now displayed by the Federation of Trade Unions; for the A. S. E. adopted the premium system by formal agreement with the Federation of Engineering Employers at a conference held at Carlisle in August, 1902.

Under that agreement the employers were notified that those who wished to introduce the premium system into their shops must do so on the understanding that the time-rate of wages for each job should in all cases be paid; that overtime and night-shift allowances be paid on the prevailing conditions; that time-limits, once established, should be fixed and not changed; and that the system should not be established by any firm which did not intend to adhere to it. And the men were notified that any members who refused to work under the premium system, where established under the conditions laid down by the Carlisle conference, would be refused donation benefit.

This was not, of course, the beginning of the premium system in Great Britain, for it had been in operation for some time previously in the works of Messrs. David Rowan & Co. and Messrs. G. & J. Weir & Co., Glasgow; but it was the beginning of it under the recognition of trade unionism, and ir this sense it seemed to be the beginning of something like an industrial revolution. It is not correct to say, as some of the newspapers have done, that "the premium or bonus system was imported into Great Britain from the United States by an agreement between the Amalgamated Society of Engineers and the Employers' Federation." As a matter of fact, the system practically adopted, though not specified in the agreement, was that devised and applied by Mr. James Rowan, of Glasgow, which differs materially from the American methods (though not from the principle of them) of premium paying for extra work. Under the Rowan system the hourly wage of the workman is augmented by the same percentage on the fixed hourly rate as the time he saves on the time allowance for the job.

That it has not operated without friction where it has since been introduced, one is not astonished to hear. No reform ever is effected without friction; no new industrial method ever has been established without the introductory grumbling and discontent. But that the A. S. E. as a society are cognisant of the advantages of the premium system is evident from the fact of their retaining it, and from their desire to prevent any employer from going back on it.

After the Carlisle conference a Lancashire firm adopted the premium system in their machine works. Two years' experience made them conclude that it was not profitable as applied in one branch of their works alone, and as restricted by the conditions of the Carlisle agreement. Therefore, they announced their intention of abandoning it and engaging on piece work rates instead. The local branch of the A. S. E. objected, and the local branch of the Federation of Employers was appealed to, on the contention that the firm could not now abandon the system without breach of the Carlisle agreement. The reply of the firm was that the system could not be looked upon as "established" with them, inasmuch as it had been in operation in only one portion of their works. The case has been referred to a conference of the central bodies of the Employers' Federation and of the A. S. E., and it concerns us here only as a practical illustration of the fact that the engineers, or machinists, are determined not to be deprived of the opportunity of working under the premium system,—once they have it.

What, then, is the position of the Federation of Engineering and Shipbuilding Trade Unions, apart from the A. S. E.? In May last at their annual meeting, held at Aberdeen, the desires of several employers to introduce the premium system into other branches of the industries than those of the A. S. E. were discussed, and a committee was appointed to go fully into the matter, and draw up a circular for presentation to the executive council with a view to its ultimate issue to the Federated Trades.

This is the circular that has lately been issued. It reports that the committee has carefully investigated every system of premium bonus available to them, and finds that the underlying principle in every case is the same,—"a time value in hours is put upon such work as this system applies to, and for all time saved upon the hours limit the workman receives a proportionate increase in his wages, which proportion varies under the different systems examined by your committee." It is objected that the time limit is "fixed by the firm without previous consultation with the workman,"—but, as a matter of fact, the time limit has been fixed by the action of the workmen themselves in the past. The employer does not invent a time limit for a job. He goes by the records of the time occupied by average competent workmen over similar jobs. Then, it is also objected that "no bonus is paid until the work has been passed as satisfactory by the employers' representatives." But in what business does a buyer pay for goods until or unless he is satisfied that he is getting what he ordered and requires?

Then, the circular goes deeper, thus:—"A further objection to this system is that the time allowance is frequently fixed by calculation from the piece-work basis. This means that the pace is set by the strongest and the most proficient workmen, and with the inevitable consequence that the weaker must go to the wall. The argument that the proficient workman should have an advantage over his less gifted fellow lacks the saving merit of originality (!) All recognise that degrees of proficiency exist, and that the superior has the right to benefit by his superior skill and industry; but we strongly object to the doctrine that the excellence of one man shall be made a medium for grinding down another who is not so gifted, and we recognise that the standard which one man may reach is quite impossible of attainment by his fellow workman. Under this system there is no recognition of degrees of ability, and any workman who cannot attain the standard fixed by officials with whom he never comes into personal contact is speedily sent to the right-about.''

All this, of course, is quite fallacious. The premium system provides special reward for special effort, but it does not prevent ordinary (trade union) reward for ordinary (trade union) effort. The statement that men who do not make special effort are dismissed by officials is without a shadow of proof; but, naturally, the men who show the most energy and develop the most proficiency have the preference. It would be monstrously unjust if it were not so.

The circular further states:—'' Your committee are of opinion that this system has absolutely nothing to recommend it; it is an adaptation of the most pernicious and degrading condition of employment in modern industrial history,—the task work system; it is uneven in its operation, and harsh and unjust in its application; it creates jealousy and ill-feeling in the workshop, and is the cause of endless bickering and misunderstanding, owing to the complicated and intricate character of the calculations involved in many of the systems; it has been the cause of more men being discharged than any strike which has yet taken place in the history of the engineering and shipbuilding industry; and it will have the effect of keeping men whose waning physical powers unfit them for the closest and hardest labour from obtaining employment, except when trade is at its busiest.''

One would like to take a plebiscite of American machinists, working on the premium system, about this sweeping deliverance. As to the displacement of men, the delusion is preserved by the trade unions in entire forgetfulness of the positive assurance of their own champion and historian, Mr. Sidney Webb, who has told them in set terms that this is a '' gross fallacy,'' and that '' if throughout the world every man's labour was suddenly rendered half as productive as it now is, we should be worse off, not better.''

But the fact is that the executive council of the Federation of Engineering and Shipbuilding Trade Unions '' are unanimous in condemning any system of payment of wages except by the hour, or, in cases where piece-work is recognised, by mutual arrangement between the workmen, or their representatives, and the employer,''—and strongly recommend the societies included in the Federation '' to do all in their power to prevent their members working under any premium bonus system,'' simply and plainly because premium working does not lend itself to trade union control and dictation. It is not the Rowan system, or the Weir system, that has to be opposed, but any premium system, whether British or American. The opposition of the Federation of Trades is all the more serious from its uncompromising character.

Current Topics

New York's famous subway was opened for regular passenger traffic on October 27,—that is, a length of about nine miles, leaving twelve miles yet to be completed, with a branch under construction leading to the borough of Brooklyn underneath one of the rivers skirting the city, and further extensions planned. Vast sums have been expended during the past few years in building underground railways in various large cities,—London, Paris, Berlin, Buda-Pest, Boston and Chicago, for example, though in this last instance goods traffic only is served,—and the accumulated experience from them all has been turned to account in this latest undertaking, which is thus illustrative of the best practice of the times in underground city passenger transportation. The New York subway is not of the deep-tunnel order, except along a restricted section; it is nearly everywhere immediately below the street surface, so that access to and exit from the trains are easily and quickly secured. The cost of the subway will figure up to something like $40,000,000, to which $18,000,000 must be added for electrical equipment, which includes cars and power station. Four years and seven months were needed to put the subway and accessories in their present working shape, and a daily working force of about 4000 men was employed, of whom only 50 lost their lives during the progress of the work,—a very satisfactory record when the magnitude of the undertaking is considered. The 100,000 H. P. station which supplies the operating current represents the most advanced type of large central station design. A sectional scheme was decided upon for the power house arrangement by which the structure was to consist of five generating sections, alike in all their mechanical details. Later a sixth section was added, with space for a seventh. Each section was to embrace one chimney, along with the following generating equipment:—Twelve boilers; two engines, each direct-connected to a 5000 KW alternator; and the detail apparatus necessary to make each section complete in itself. In one of the sections it was decided to omit a regular engine and generator and in its place put a 5000 KW lighting and exciter outfit. The present engine equipment comprises nine 8000 to 11,000 H. P. main engines direct connected to 5000 KW generators, as just noted; three steam turbines, connected to 1875 KW lighting generators, and two 400 H. P.

engines, direct-connected to 250 KW exciter generators. Three-phase current is generated at 11,000 volts, and is delivered to eight sub-stations along the line of the road, from which direct current is distributed to the third-rail conductors at 625 volts. The cables used for conveying energy from the power house to the several sub-stations aggregate about 150 miles in length.

SOMEWHAT suggestive of the historical Rainhill contest in the year 1829 between Stephenson's locomotive "Rocket" and Ericsson's "Novelty" was an electric locomotive exhibition given last month on an experimental section of track of the New York Central Railroad near Schenectady, N. Y. The locomotive was the first one of a lot of between thirty and fifty to be built for the above line by the General Electric Company and the American Locomotive Company, of Schenectady, and represented the beginning of what to-day is the most enterprising programme in existence for the conversion of an important section of a steam railway into an electric one. This provides for the electrical equipment of the New York terminal of the New York Central Railroad for a distance of 34 miles on the main line from New York to Croton, and for 24 miles on the Harlem Division as far as White Plains. It is the intention to handle all the traffic within this district electrically, the through passenger trains, ranging up to 875 tons in weight, to be hauled at maximum speeds of 60 to 65 miles an hour. In the design of the electric locomotive in question the best mechanical features of the high-speed steam loocomotive were secured, combined with the enormous power and simplicity in control made possible by the use of the electric drive, and the success of the trials thus far has led to the opinion that in the new locomotive a type has been found whose distinctive features may be accepted as a basis for future standardisation.

THE locomotive has four driving axles, on each of which is rigidly mounted, without intermediate gearing, the armature of an electric motor of a normal rating of 550 H. P. Thus the total rated capacity of the locomotive is 2200 H. P., although for short periods a considerably greater power may be

ONE OF THE 95-TON ELECTRIC LOCOMOTIVES BEING BUILT TO SUPPLANT STEAM LOCOMOTIVES ON TWO DIVISIONS OF THE NEW YORK CENTRAL RAILROAD developed, making it more powerful than the largest steam locomotive in existence. The motor has two poles with flat faces, so as to permit a large relative vertical movement between armature and poles as the latter move up and down with the riding of the frame upon the springs. By the use of the Sprague-General Electric multiple-unit system of control, two or more locomotives may be coupled together and operated from the leading cab as a single unit. The motive power may, therefore, be easily adapted to weight of train, with no complication in operation and with uniform make-up of train crew. A single electric locomotive will be able to maintain the schedule with a 450-ton train, and two locomotives will be coupled together for heavier trains. The locomotive superstructure consists of a central cab for the operator, containing master controllers, engineers' valves, and switches and valves required for operating sanding, whistling and bell-ringing devices. This apparatus is supplied in duplicate, one set on each side of the cab, and is arranged so as to be easily manipulated from the operator's seat, while at the same time a practically unobstructed view to the front and the rear may be obtained from the windows. A central corridor extends through the cab, permitting access to the cars behind, and the rheostats, reversers and other electrical accessories are arranged along the sides of the corridors in sheet steel boxes sheathed inside with fireproof insulating material.

THE control system permits three running connections, namely, four motors in series, two groups of two in parallel-series, and all four motors in parallel. Current is collected from the third rail by spring-actuated shoes,—four of them on each side of the locomotive. In the yards at the terminal the large number of switches and crossings will necessitate overhead construction at some places, and additional contacts are, therefore, mounted on the top of the locomotive for collecting current when passing such points. These devices may be raised and lowered by air pressure, controlled from the engineer's cab. The total weight of the locomotive is 95 tons, and the weight on the drivers amounts to 67 tons. The normal full load current will be 3050 ampères at 600 volts. In the starting tests a speed of 30 miles an hour was attained in 60 seconds with an eight-car train, weighing, with the locomotive, 431 tons, corresponding to an acceleration of half a mile per hour per second. The maximum current input recorded,—4200 ampères at 460 volts, or 1935 KW,—gives an output of the motor of 2200 H. P. available at the wheel. With 4200 ampères and a maintained voltage of 600, there would be an input of 2520 KW, corresponding to 2870 H. P. output of the motors. This may be secured without in any way exceeding the safe commutation limit of the motors and with a coefficient of traction of only 22.5 per cent. of the weight upon the drivers, thus placing this electric locomotive in advance of any steam locomotive yet built. Throughout both starting and running tests the locomotive has shown remarkable steadiness in running.

PERHAPS no more striking illustration could be afforded of the increase of luxury aboard trans-Atlantic passenger steamships of the most advanced type than the recent statement that two such vessels, shortly to be put on the stocks for the Hamburg-American Line, are to be fitted with passenger elevators. But such equipment is not indicative of luxury alone; it points as well to a growth in size of ship with which the public mind has become almost too familiar to be properly impressed, and which is not adequately pictured by feet and inches. Other comparisons are more expressive in these instances; hence the statement that from the lowest saloon deck to the boat deck of the two ships in question represents the height of an average five-story house. In the luxurious modern home of that height the elevator has become a well-established convenience, so that its addition to a luxurious steamship's equipment does not, on second thought, seem so radical a forerunner of the times; in fact, it is confidently expected to prove a very practical revenue producer in that it will make the lower tiers of staterooms quite as desirable to the physically inactive as those on the upper levels.

JOHN R. FREEMAN

The Next President of the American Society of Mechanical Engineers

A BIOGRAPHICAL SKETCH

WITH the election, this month, of Mr. John R. Freeman as the next president of the American Society of Mechanical Engineers practically assured, we are pleased to be able to present a portrait of him in this issue.

It has been stated more than once, semi humorously, that an essential qualification for prominence in later life seems to be country birth and early education, away from the atmosphere of large towns, and that qualification Mr. Freeman has, having been born in the little community of West Bridgeton, Me., in 1855, and having received his early training in the district school of that place. Later he attended the public schools at Portland, Me., and Lawrence, Mass., winding up finally at the Massachusetts Institute of Technology, where he took the civil engineering course and was graduated in 1876.

Hydraulic engineering from the first attracted him, and for the next ten years he was on the engineering staff of the Lawrence (Mass.) Water Power Company, rising there in a short time to the position of principal assistant to Mr. Hiram F. Mills, chief engineer. Opportunities for important and varied engineering experience were many in Mr. Mills' office, and the time which Mr. Freeman spent there furnished an excellent foundation for subsequent work as a consulting engineer in hydraulic engineering and mill work which he had in view.

Before opening an office on his own account, however, he received the offer of a position as inspector and hydraulic engineer for the Factory Mutual Fire Insurance Companies, which he accepted for a year only, in the belief that the acquaintance to be gained in this way with mill men and mill architecture would be a valuable asset later on when he undertook consulting practice. In this manner he entered the insurance field, in which he has since remained, although not to the exclusion of other business and engineering enterprises. He found a comparatively new specialty in fire protection engineering, which not even now receives the recognition it should.

In the course of this work he has been called upon to make tests of the efficiency of many public water works, as well as to investigate the new appliances for fire protection which are constantly coming out. His experiments on the discharge of fire nozzles and the hydraulics of fire streams are among the standard investigations of engineering and too well known to need more than mention.

In a short time he was called on to reorganise the inspection service of these companies, of which he was placed in charge, with the title of chief inspector and chief engineer. In this work he appreciated from the outset that it afforded good openings for the best engineering talent, and accordingly recruited his staff of draughtsmen, experimenters, inspectors and engineers from the graduates of engineering schools as far as possible. To show what a field exists in this line of work it is only necessary to state that more than two thousand large mills, valued at over a thousand million dollars, unite for fire protection purposes in the Factory Mutuals. Mr. Freeman has particularly sought to perfect standard methods and appliances for fire protection, and to unite manufacturers of fire appliances on certain standards of quality while preserving to each his individuality of detail.

The specifications almost universally adopted for underwriter fire pumps, underwriter nozzles, fire hose, and the like, were drawn up by him after much experimental work, and even since his advance in the companies to a position of larger responsibility, he keeps in close touch with all engineering work as chairman of the committee over the inspection department. It was in 1896 that he became president and treasurer of the Manufacturers' Rhode Island and Mechanics Mutual Fire Insurance Companies, which were virtually a consolidation of the oldest two organisations of this character. Under his charge their business has in about eight years increased more than three-fold. Mr. Freeman a little over a year ago was called upon to become president and treasurer of three more companies of this nature, the State, Enterprise and American. At the present time he is accordingly in charge of the fire-protection and insurance interests of manufacturing property valued at more than $330,000,000, making his office the largest of its kind, and thus bringing him into close business relations with many industrial leaders. Fondness for engineering work has caused him to steadfastly decline to devote his time exclusively to business interests, and he has reserved a portion of it for continuing his practice in the congenial fields of pure engineering.

In these fields water supply engineering has received probably most of his attention, and his chief labours there have been in connection with the new water works for the city of Boston and neighbouring towns as a member of the Massachusetts Metropolitan Water Board. This was in 1896. Three years later he was selected to investigate and report upon the water supply of the city of New York,—a work of exceeding importance and magnitude, which culminated in a report in the shape of a 600-page volume generally acknowledged to be the most elaborate water works report ever prepared by one engineer.

Mr. Freeman, in addition to his membership in the American Society of Mechanical Engineers, is a member of the American Society of Civil Engineers and of the Boston Society of Civil Engineers. The Norman Medal of the former society was twice awarded to him for papers of special merit,—one on the hydraulics of fire streams and the other on the nozzle as a water meter. Of the Boston Society he was president in 1893. At the present time he is identified as a director with several banking institutions; he is also a member of the corporation of the Massachusetts Institute of Technology, and a trustee of the Rhode Island School of Design. The honorary degree of Doctor of Science was conferred upon him this year by Brown University.

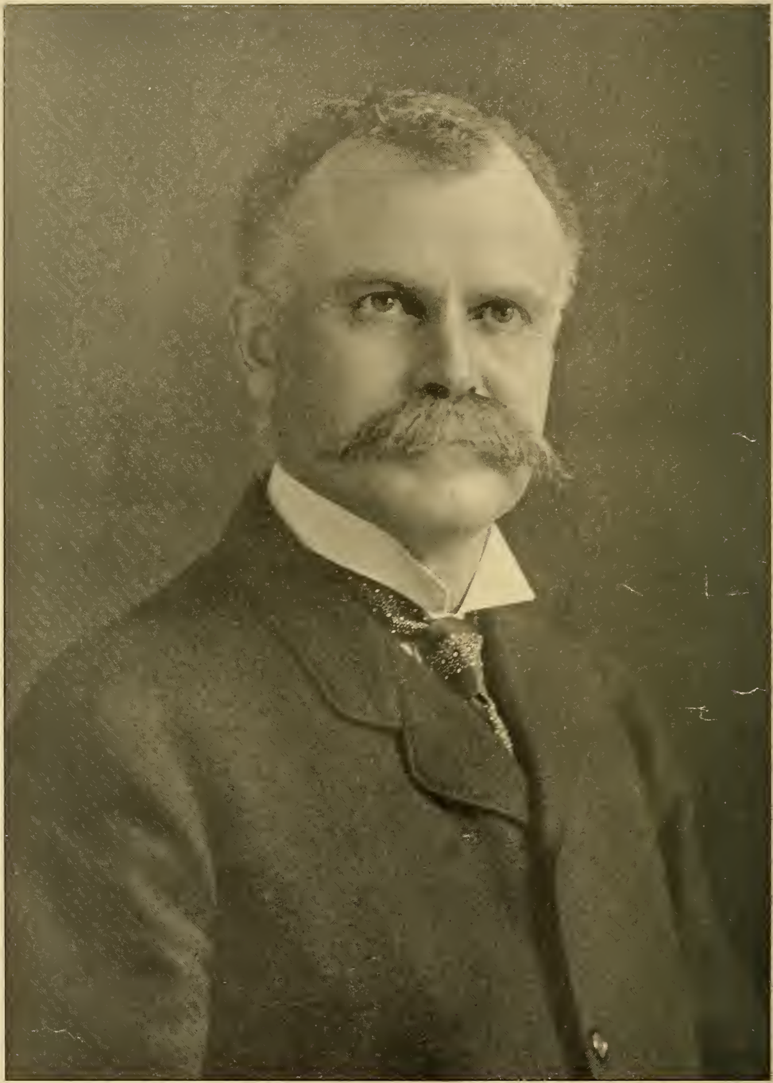


PHOTO BY CHRISTOPHER JOHNSTONE, HARTFORD

LYMAN BUSHNELL BRAINERD

THE NEW PRESIDENT OF THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY

SEE PAGE 263

CASSIER'S MAGAZINE

VOL. XXVII JANUARY, 1905 No. 3

PIONEER WORK IN HIGH-TENSION ELECTRIC POWER TRANSMISSION

THE OPERATIONS OF THE TELLURIDE POWER COMPANY

By P. N. Nunn

In the light of present achievements in high-tension, long-distance electric power transmission, the early work of the Telluride Power Company, fourteen years ago, and further developed in the immediately succeeding years, commands unqualified admiration. It was work of daring enterprise, pioneer work in the face of discouraging comment from almost everywhere, making its successful outcome all the more gratifying to those who undertook it, and interesting to the profession generally. Mr. Nunn's account of it was given for the first time in a paper presented at the recent International Electrical Congress at St. Louis, and its publication here, embellished by many additional illustrations, has been made possible through his kind co-operation.—The Editor.

THE ORIGINAL POWER HOUSE AT AMES, 1890

DURING the winter of 1890, the year preceding the famous Frankfort-Lauffen experiment, apparatus was installed for the first commercial, high-pressure, alternating-current power transmission of the world. From that beginning has grown the Telluride Power Company.

The mining district surrounding Telluride, Colorado, is at the same time one of the most rugged and one of the richest in the Rocky Mountains; but its inaccessibility and the consequent cost of producing power caused the financial failure of many important enterprises in the early days of its history. The statement made in the annual report of the Treasury of the United States, in 1901,* that " for the growth of its mining industry San Miguel County is indebted to the Telluride Power Transmission Company more than to any other agency," is borne out by the fact that at the present time all the important mines and mills of the district are operated by power furnished by this company.

The Gold King mill, situated at an altitude of 12,000 feet, where the cost of fuel for steam power had become prohibitive, was the first to be operated by means of this power. This property had been attached in 1888 to satisfy a con-

---

* Annual reports of the Treasury of the United States, report of the Director of the Mint, page 135.

A VIEW OF TELLURIDE, COLORADO

GOLD KING MILL, IN WHICH THE FIRST SYNCHRONOUS MOTOR WAS USED

tinued deficit in operations. Mr. L. L. Nunn, the attorney retained by the owners, found that this deficit was due largely to the enormous cost of power, and that there would have been a handsome margin if power could have been furnished at not more than $100 per H. P.-year. Down in a deep gorge of the valley, over 2000 feet lower, but less than three miles away, two mountain streams formed at their confluence the South Fork of the San Miguel River, offering cheap and continuous power.

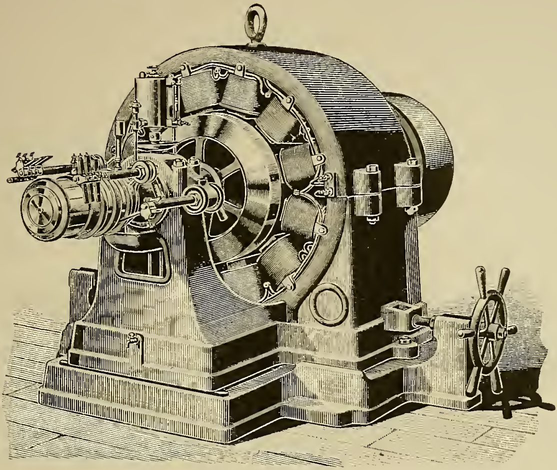
A stay of proceedings was secured, and, as a means of transmitting this power, cable drive, compressed air, and continuous-current electricity were all investigated. The limitations of each were apparent, while the advantages of alternating current and higher pressures became gradually recognised, and a decision was reached to attempt their use. This decision was due less to the immediate saving in copper than to a keen sense of the limitation of continuous, and faith in the final success and ultimate superiority of, alternating current.

During the investigation which followed, while selecting apparatus, little but incredulity or ridicule was encountered. Eastern investors in the enterprise were annoyed by predictions of prominent engineers, and discouraged by their insistence, that the experiment would prove a miserable failure and the expenditure go for naught. It was said that there was no alternating-current motor; that oil insulators must be used, and that the line must be fenced in. However, a generator and a motor for 3000 volts and of 100 horse each were ready for trial in the fall of 1890.

Difficulties caused by ice at 40 degrees below zero, by speed control over unusually high water pressure, by avalanche, by blizzard, by electric storms unknown in low altitudes, and scores of others, now generally forgotten, but then most serious, marked every step of progress. Notwithstanding all of these, unqualified success from the beginning caused gradual and constant growth, until at the present time the Telluride Company and its allied industries have six power stations and nearly a thousand miles of line in Colorado, Utah, and Montana.

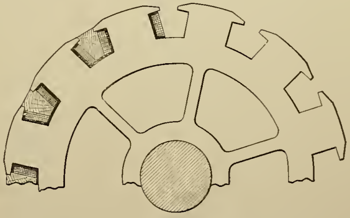
Following its pioneer power trans-

GENERAL VIEW SHOWING AMES WATER POWER AND ITS LOCATION mission, it made practical experiments as early as 1895 with pressures which have never, even yet, been exceeded, and for three years it operated commercially the highest pressure transmission of the world. Thus the record of its work becomes an important chapter in the history of power transmission; but it must readily be seen that the limit of this paper precludes the possibility of describing, even in the briefest terms, all, or even a substantial part, of its pioneer work.



THE EARLIEST ALTERNATING CURRENT GENERATOR FOR POWER SERVICE

The initial installation, purchased through Mr. F. B. H. Paine, comprised a generator installed in a rough cabin upon the site of the present Ames station and belted to a 6-foot Pelton wheel under 320 feet head, and a motor at the mill 2.6 miles distant. The two were identical Westinghouse single-phase alternators of 100 H. P., the largest then made. The generator was separately excited, while the motor was self-exciting. Each carried a twelve-part commutator, and was slightly compounded through current transformers upon opposite spokes of its armature. The latter were ironclad, or "T"-toothed, wound with twelve simple coils in cells of fullerboard and mica. Switchboards consisted of matched and shellaced pine sheathing, and the bases of instruments were dry hardwood. Only voltmeters and ammeters were used, both of the solenoid and gravity balance type, in black walnut cases with window glass fronts. Circuits were closed with jaw switches and opened by arc-light plugs. The line carried two No. 3 bare copper wires, mounted upon short Western Union cross-arms and insulators. The copper cost about $700, or about 1 per cent. of the esti-



SECTION OF "T"-TOOTHED ARMATURE WITH THREE COILS IN PLACE

GENERAL VIEW OF SAVAGE BASIN, SHOWING THE TOM

mated cost for continuous current. The main motor was brought to synchronous speed by a single-phase induction starting motor, which received its current at full line voltage. The current taken was more than full load current of the main motor. This starting motor even required starting by hand, its torque being zero at starting, and so feeble at low speeds that when cold it could only with the greatest difficulty be persuaded to pull up to speed its belt and loose pulley. Nor could it at speed start the main motor without help, and even then it became so hot that its short-circuited secondary frequently burned out.

Another motor of 50 horse-power was soon added. While in other respects similar to the first, this motor was intended to be self-starting, with armature and field in series through a current transformer, and on account of its frightful flashing it was fitted with a special eight-part commutator of non-arcing metal. This feature, however, proving a failure, was soon replaced by a separate starter.

The need of wattmeter or power-factor indicator not having been at that time recognised, motor field charge was adjusted for least main current. This current was accepted as having unity power factor, and, therefore, as the measure of actual power.

BOY, JAPAN AND OTHER PROPERTIES AND CAMP BIRD DIVIDE

Everything was extremely simple, from water-wheels to motors, and, except for lightning, the plant ran smoothly and steadily thirty days and more without a stop. The report made in the East by associates of the enterprise that at Telluride a hundred horse-power were being successfully transmitted nearly three miles over No. 3 copper, with less than 5 per cent. loss, was received with the utmost incredulity.

During the autumn of 1892 a 600-horse generator of the same characteristics was installed, and a 250-horse motor for the mill on Bear Creek, ten miles from the generator. Early in 1894 a 50-horse, and, during the fall, a 75-horse motor were placed in Savage Basin, fourteen miles from the power house. The former was soon replaced by a 100-horse motor, and in 1895 a 100-horse motor was set up at Pandora.

Except as to size, these motors were substantially identical. The 250-horse motor was badly designed, and the pole pieces were of cast iron. Its starting motor was insufficient, and was, therefore, soon replaced by one having split-phase secondary with external resistances. Marble with brass trimmings replaced wooden-base instruments, and such elegance demanded highly polished slat switchboards of paraffined oak. Imposing marble rheostats were

GENERAL VIEW OF SAVAGE BASIN, SHOWING THE TOMBOY, JAPAN AND OTHER PROPERTIES AND CAMP BIRD DIVIDE

mated cost for continuous current. The main motor was brought to synchronous speed by a single-phase induction starting motor, which received its current at full line voltage. The current taken was more than full load current of the main motor. This starting motor even required starting by hand, its torque being zero at starting, and so feeble at low speeds that when cold it could only with the greatest difficulty be persuaded to pull up to speed its belt and loose pulley. Nor could it at speed start the main motor without help, and even then it became so hot that its short-circuited secondary frequently burned out.

Another motor of 50 horse-power was soon added. While in other respects similar to the first, this motor was intended to be self-starting, with armature and field in series through a current transformer, and on account of its frightful flashing it was fitted with a special eight-part commutator of non-arcing metal. This feature, however, proving a failure, was soon replaced by a separate starter.

The need of wattmeter or power-factor indicator not having been at that time recognised, motor field charge was adjusted for least main current. This current was accepted as having unity power factor, and, therefore, as the measure of actual power.

Everything was extremely simple, from water-wheels to motors, and, except for lightning, the plant ran smoothly and steadily thirty days and more without a stop. The report made in the East by associates of the enterprise that at Telluride a hundred horse-power were being successfully transmitted nearly three miles over No. 3 copper, with less than 5 per cent. loss, was received with the utmost incredulity.

During the autumn of 1892 a 600-horse generator of the same characteristics was installed, and a 250-horse motor for the mill on Bear Creek, ten miles from the generator. Early in 1894 a 50-horse, and, during the fall, a 75-horse motor were placed in Savage Basin, fourteen miles from the power house. The former was soon replaced by a 100-horse motor, and in 1895 a 100-horse motor was set up at Pandora.

Except as to size, these motors were substantially identical. The 250-horse motor was badly designed, and the pole pieces were of cast iron. Its starting motor was insufficient, and was, therefore, soon replaced by one having split-phase secondary with external resistances. Marble with brass trimmings replaced wooden-base instruments, and such elegance demanded highly polished slat switchboards of paraffined oak. Imposing marble rheostats were

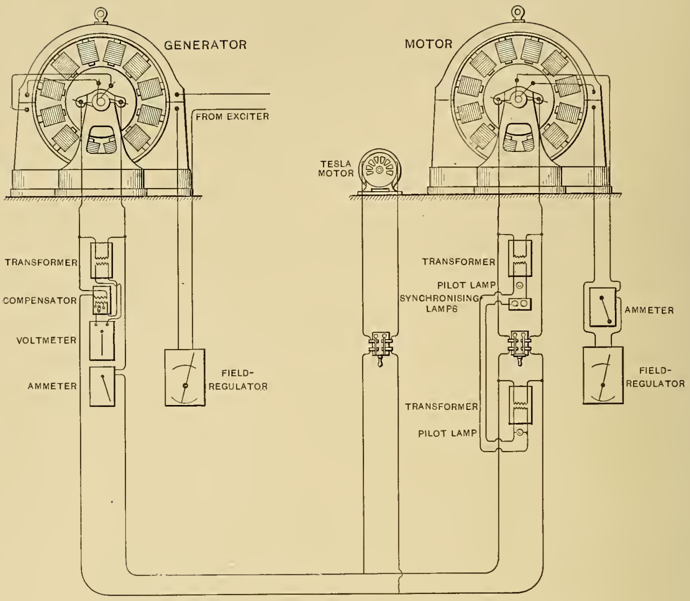


DIAGRAM OF ORIGINAL SYNCHRONOUS MOTOR SYSTEM AT TELLURIDE

mounted at switchboards like keyboards upon grand organs. Fuse blocks, the only protective device, became marble slabs with duplicate aluminium strips. The first synchrophone came with the 75 H. P. equipment.

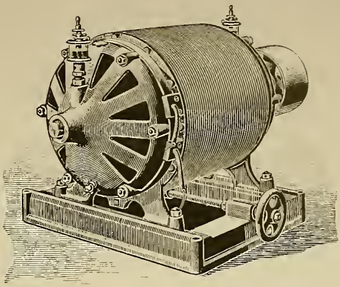
Owing to its altitude and geographic position, the Telluride district is peculiarly subject to atmospheric disturbances. Over a hundred distinct discharges have been counted within a single hour, and lightning caused more discouragement than any other obstacle. A neighbouring continuous-current plant, transmitting a little more than a mile, carried several extra armatures; and even then it was so frequently compelled to close down during the daily storms of the rainy season that the company was eventually bankrupted.

The alternating plant might have suffered a similar fate had it not been for its "T"-toothed armatures and replaceable coils, eight of which were successively burned out and replaced on one motor within a single week. To get a coil into place, and its oak keys driven home, required such bending, clamping and pounding as inevitably resulted in injury to insulation, and only by the greatest care could replaced coils be made to stand a test adequate to the 3000 volts employed.

For protection from lightning several types of manufactured arresters, then various original devices were tried, ending with a simple gap in series with a score or more of fuse blocks in parallel, arranged about a radial commutator switch, turned from point to point as the fuses were blown by successive discharges. From the first, these conditions caused the greatest apprehension as to the commercial success of electric power transmission, until Mr. Alexander J. Wurts, during a stay of several months with the company, gave the protection of the now well-known non-arcing arrester.

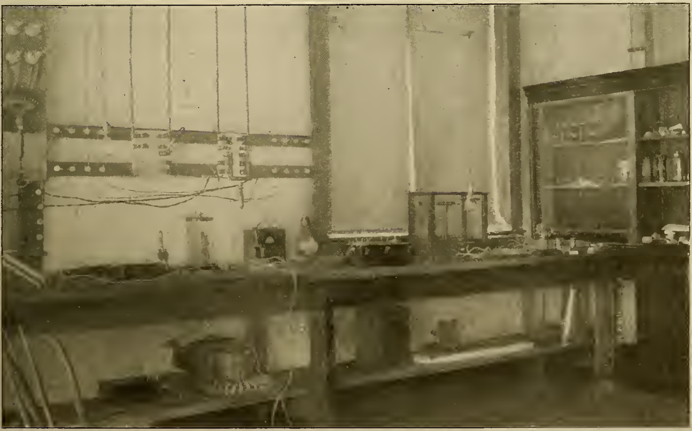
No transformers were used between machines and line, the largest transformers at first being 2 KW, or 40-light. Aside from the effects of lightning, even to-day 3000 volts upon the winding of small, high-speed armatures requires first-class insulation. Frequent grounds were prevented by deep insulating foundations of paraffined wood. To prevent short circuits within the coils, their cells, just before placing, were poured full of shellac, and the entire armature was afterwards baked for several days. By this means the 50-horse motor ran a full year without trouble in a room dripping with moisture.

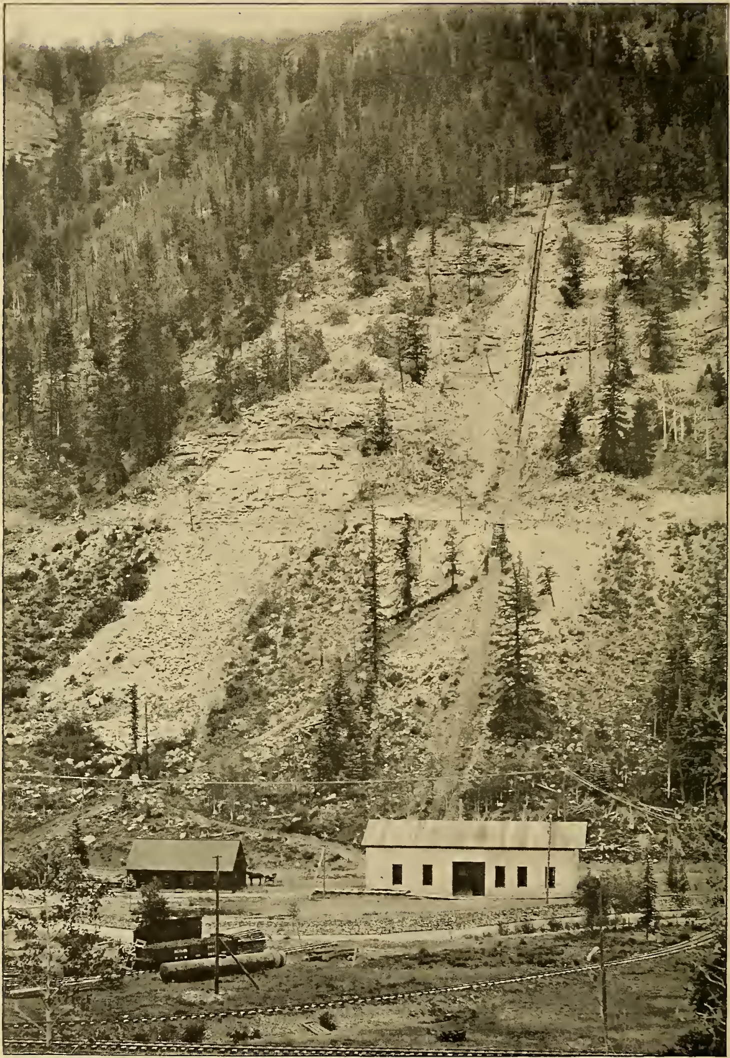
A lighting transformer received in 1891 was rated at 5 KW. Theretofore transformers had been rated in lights, and generators in horse-power. This transformer was immersed in engine oil, and marked an epoch in the company's history. Lightning frequently punctured it, causing its fuses to blow without other apparent injury. It remained in service for years. All others were soon likewise immersed. Four 500-light, dry Stanley transformers, purchased in 1892 for lighting Telluride, were broken down by the thunder storms of the following spring. When repaired, these also were immersed in engine oil, and gave no further trouble during the three years they remained in service.


TESLA STARTING MOTOR

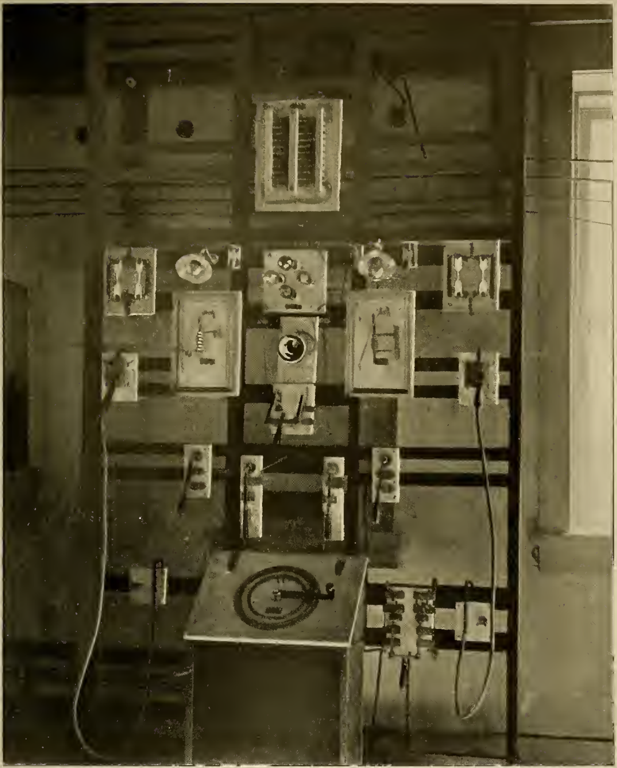
Alternators were paralleled at Telluride in the spring of 1893, and thereafter they were so operated with full load upon the smaller and regulation upon the larger machine.

Manipulation at switchboards or at brushes involved direct handling of 3000 volts,—a rather high switchboard pressure even now. It was a rule that every attendant keep one hand in his pocket


THE EARLY LABORATORY FOR STUDENTS



THE ILIUM POWER HOUSE

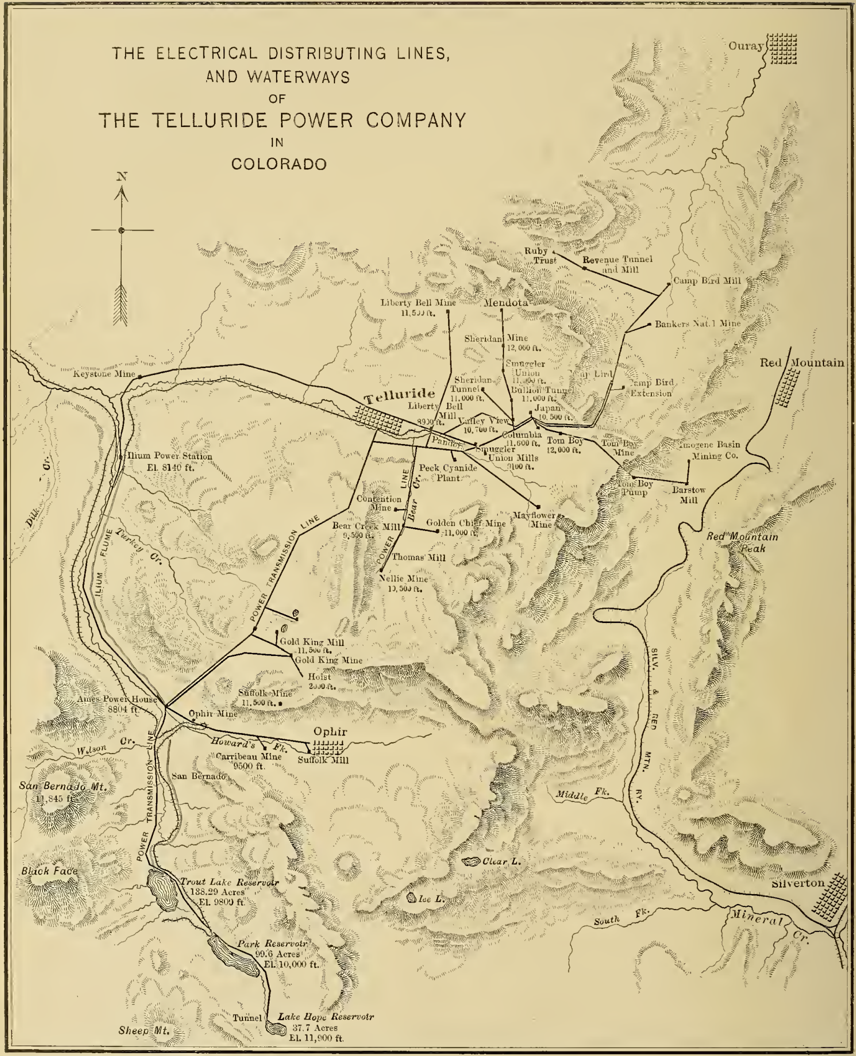


ONE OF THE MOTOR SWITCHBOARDS OF THE TELLURIDE SYNCHRONOUS SYSTEM

while working with the other. It is pleasant to record that during these years no loss of life and but few accidents occurred.

There being no other circuit breakers, it was necessary when a motor dropped out of step to break the circuit with the single arc-light plug. This always drew a heavy, vicious arc, which, on the big motor, frequently held to the full length of the 6-foot cable, and then sometimes required a whiff from the attendant's hat. When not broken promptly, it frequently involved the entire switchboard and shut down the plant.

Duties of this nature required considerable skill and cool heads, and in order to operate the plant continuously, night and day, fifteen or twenty competent attendants were required. To fit young men for these positions, a course was arranged during which they were taught something of machinery, of shop-work in metal and wood, and of wiring, insulating and repairing, while receiving such assistance in daily study as conditions permitted. A technical library, including the electrical papers, and a conveniently fitted testing room were always open. Each student was then given a short laboratory course in graphic treatment of alternating-current


THE ELECTRICAL DISTRIBUTING LINES,
AND WATERWAYS
OF
THE TELLURIDE POWER COMPANY
IN
COLORADO
N
Ouray
Ruby Trust
Revenue Tunnel and Mill
Camp Bird Mill
Liberty Bell Mine 11,500 ft.
Mendota
Bankers Nat.1 Mine
Sheridan Mine 12,000 ft.
Red Mountain
Keystone Mine
Smuggler Union 11,400 ft.
Camp Bird
Sheridan Tunnel 11,000 ft.
Bullion Tunnel 11,000 ft.
Camp Bird Extension
Telluride
Liberty Bell Mill 8900 ft.
Japan 10,500 ft.
Valley View 10,700 ft.
Columbia 11,600 ft.
Tom Boy 12,000 ft.
Tom Boy Mine
Imogene Basin Mining Co.
Pandora
Smuggler Union Mills 9100 ft.
Ilium Power Station El. 8140 ft.
Peck Cyanide Plant
Tom Boy Pump
Barstow Mill
Dilk Cr.
Contention Mine
LINE
Bear Cr.
Mayflower Mine
Bear Creek Mill 9,500 ft.
Golden Chief Mine 11,000 ft.
Red Mountain Peak
ILIUM FLUME
Turkey Cr.
POWER TRANSMISSION LINE
POWER
Thomas' Mill
Nellie Mine 10,500 ft.
Gold King Mill 11,500 ft.
Gold King Mine
SILV. & RED MTN. RY.
Hoist 2000 ft.
Suffolk Mine 11,500 ft.
Ames Power House 8804 ft.
Ophir Mine
Ophir
Wilson Cr.
Howard's Fk.
Suffolk Mill
Carribeau Mine 9500 ft.
San Bernado
San Bernado Mt. 11,845 ft.
POWER TRANSMISSION LINE
Middle Fk.
Clear L.
Black Face
Trout Lake Reservoir 138.29 Acres El. 9800 ft.
Ice L.
Silverton
South Fk.
Mineral Cr.
Park Reservoir 99.6 Acres El. 10,000 ft.
Tunnel
Lake Hope Reservoir 37.7 Acres El. 11,900 ft.
Sheep Mt.

theory. This is said to have been the first systematic effort made by a corporation to train its employees for responsible positions.

Although the plant, as a whole, was an unqualified commercial success, no explanation need here be made as to why it was replaced by the induction system as soon as the latter had been perfected. This marks the limit of the most extensive single-phase, synchronous plant ever operated. With but one or two motors its operation was not difficult, but each motor added to the system brought increased demand for care and skill.

The causes of difficulty were not understood then as now, nor was the effect of power factor fully appreciated. Lack of both wattmeters and power-factor indicators left the adjustment of field charges to the judgment of the operators. The power factor of each motor being dependent not only upon its own adjustment, but upon that of all, the closest attention and co-operation were necessary, in marked contrast with the simplicity of operation of induction motors. Disturbances due to starting motors were especially trying; and the unqualified success attained, notwithstanding defects of apparatus and system, is attributed now, far more than then, to the skill and vigilance of the operators in this new and fascinating field.

The Tesla system, substituted for the synchronous in the year 1896, comprised two 600-KW, 60-cycle, 500-volt, two-phase generators, direct connected to water-wheels under 600 and 900 feet head, respectively, and an equal capacity of raising and reducing transformers and of two-phase, 220-volt induction motors. The twelve 100-KW step-up transformers were connected in pairs, two-phase, three-phase for three phase, 10,000-volt transmission. These transformers were worthless; all broke down within a year, and one or more were always undergoing repairs. Breakdowns occasionally caused sufficient explosion to lift a cover, or splash the oil. The woodwork soon became saturated, and hot metal from the near-by main fuses frequently started fires, endangering the wooden power house. A masonry transformer house in two compartments was, therefore, constructed, and into it the transformers were moved,—this being the first known case of isolation of oil transformers on account of fire risk.

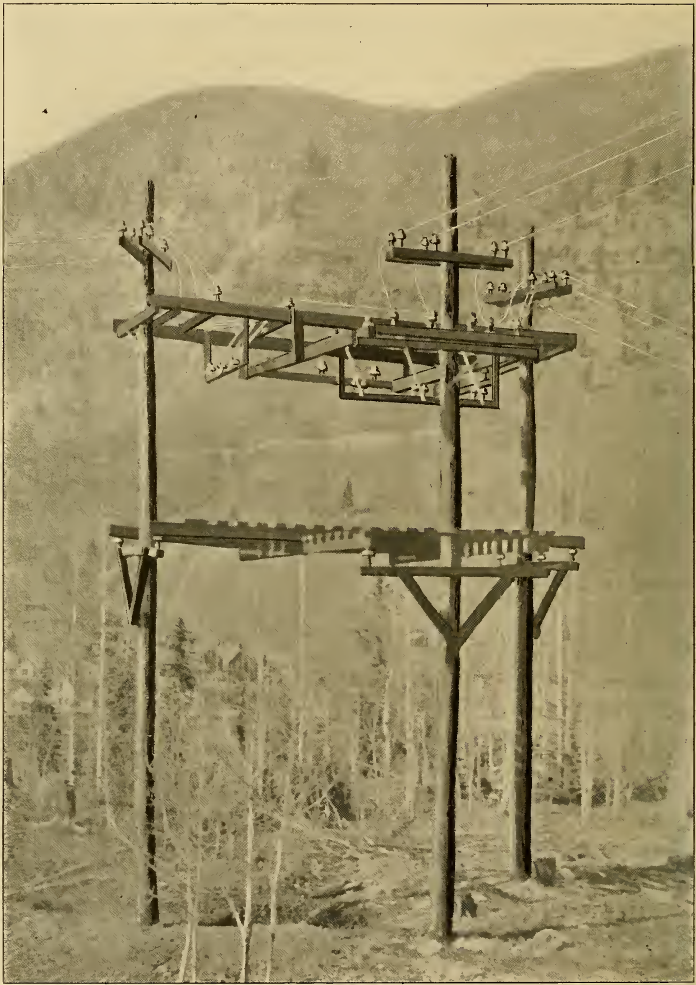
The power house at Ilium, situated six miles below Ames, on the same stream and using the same water, was built in 1900, and contains one 1200-kilowatt, revolving-field, General Electric generator, direct connected to two impulse wheels under 500 feet head. Transmission lines extend both to the Ames station and to points of distribution, providing the insurance of duplicate transmission. Any section of line can be cut out for repair, or either power house shut down, without interrupting the service. Junctions other than generating and distributing points are equipped with open air switches, mounted upon standard line insulators and operated from platforms similarly insulated, and have proven invaluable.

Junction houses at distributing centres provide for a branch line to each customer, which is equipped with switches, fuses, and a set of five record-making instruments,—a voltmeter, two ammeters and two wattmeters. The power company thus secures upon its own property a continuous, accurate, and satisfactory record of each load.

The long spans crossing canyons and "divides" surrounding Savage Basin may be worthy of note. These divides are bare ridges at an altitude of 13,000 feet, inaccessible in winter and swept by frequent snow-slides. Spans up to 1150 feet are used in order to reach safe points for supports. A number of these supports, although simple and inexpensive, have stood for years without repair. The longest span is of No. 1, hard-drawn copper, supported by half-inch plough-steel cable, both being carried by the same insulators. The deflection is approximately 35 feet on a slope of 31 degrees. Another is of ⅜-inch soft iron cable, 1120 feet long, and has been in service five years. A third, 660 feet long, is of hard-drawn

A LONG SPAN AT RED MOUNTAIN DIVIDE

ANOTHER LONG SPAN AT CAMP BIRD DIVIDE



AN OPEN-AIR SWITCHING JUNCTION

copper only, having 25 feet deflection. The strain insulators in all cases are a series of the usual line insulators and pins upon a longitudinal arm hinged to permit adjustment to span motion. They are simple, inexpensive, and entirely successful.

A 10,000-volt underground transmission was put in operation at the Gold King mine in 1896. Power was carried through an unused tunnel, 1300 feet long, upon bare copper conductors 12 inches apart on standard line insulators, to a deep mining hoist equipped for electric power. The tunnel was always dripping with water, but no trouble was experienced during the several years of operation, although slight brush discharge or halo was at times observed.

An interesting installation to which power is furnished is that of the well-known Camp Bird, Limited, near Ouray. Nineteen motors and rotaries, in sizes up to 150 KW, drive crushers, Huntingtons, concentrators, compressors, pumps and hoists, aggregating in all about 1000 KW. Two underground transmissions, each a mile in extent, are in operation. Continuous current at 550 volts from two rotaries and a 650-ampère-hour storage battery operate three deep-mine hoists of 150 H. P., and an installation designed by Mr. C. S. Ruffner, now engineer of the Utah department, makes use of the alternating current transmitted at 10,000 volts through paper-insulated, lead-covered cable, for the purpose of operating two 50 H. P. pumps.

The success of the original plant prompted the manager of the company, Mr. L. L. Nunn, to institute a search for other water powers in the West, finding, as a result, that such powers were very remote from available markets, requiring much longer transmissions than theretofore used. Voltages higher than from 10,000 to 15,000 were not in commercial use, and were regarded as merely problematical; but two important water rights, already acquired in Utah and Montana, would have been worthless at such pressures. Mr. Nunn therefore determined in 1895 to undertake at Telluride an experimental transmission at higher voltages, to be installed and operated as a practical test for power purposes, and to determine, if possible, the problems peculiar to long distances and high pressures.

Two identical 75-KW, oil-insulated transformers were installed in the autumn of 1895, one at the Ames station and the other at the Gold King mill. They were designed for pressures varying from 15,000 to 60,000 volts by convenient steps. A separate pole line was equipped with three circuits of different characteristics upon three types of insulators.

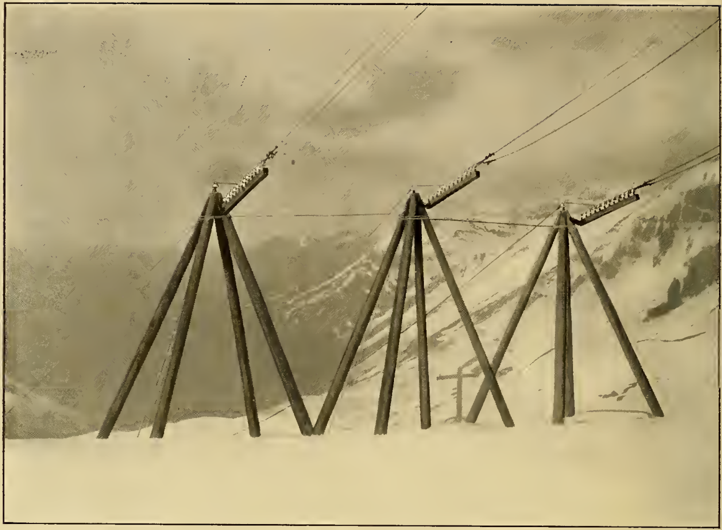
Measurements with many special instruments were made, embracing the different voltages, styles of insulators, conductors and distances between them, and the conditions peculiar to the various phenomena met at every step. Observations upon a wide range of atmospheric conditions were made by means of United States Weather Bureau apparatus at either end of the line. The commercial feasibility of high pressures was demonstrated by the successful operation of the Gold King mill during a great part of the year at pressures from 30,000 to nearly 60,000 volts, as well as by continuous electrification for nearly a month during dry weather of a three-mile telephone circuit, upon telegraph insulators, at pressures rising from 10,000 to 40,000 volts.

The change of the system from single to polyphase terminated actual transmission experiments. The reducing transformer was moved to the station, and another equipment, designed for polyphase tests, was ordered. The remaining time was devoted to open circuit losses, and to the verification of measurements previously made. This work continued until August, 1897, when construction was begun upon the Provo plant

Much of the data obtained from these experiments was incomplete, requiring caution in its use, due largely to the time and study required in solving, step by step, the problems and difficulties met at every stage of the work. However, that much of value was obtained

THE TOWER ON THE SUMMIT OF CAMP BIRD DIVIDE

A SIDE HILL SUPPORT IN EDGE OF SNOW SLIDE



SPECIAL CONSTRUCTION FOR SEPARATION OF CONDUCTORS

is shown by the subsequent successes at Provo. Sufficient had been learned to warrant the commercial adoption for the first time of 40,000 volts, nearly thrice the voltage of any previous plant; to lead to the manufacture of transformers which, after seven years' continuous operation, are still in daily service; to determine the design of the Provo-type insulator, the method of line construction, distance between wires, and the importance of wave form, and to make possible this great advance in long-distance, high-voltage transmission.

This experimental work, as clearly appears from the foregoing facts, was begun, carried on and finally utilised by the Telluride Company in the regular and necessary course of its growing business; yet it must be added that important services were rendered by Mr. V. G. Converse, under whose direction the transformers had been designed and constructed, and who participated throughout the greater part of the work during all the experiments with actual high-pressure transmission, and subsequently by Mr. Ralph D. Mershon in the elaborate instrumentation and laboratory practice, including a notably ingenious method of reading high-tension losses upon low-tension circuits, devised by him and used in substantiating the accuracy of the earlier measurements; also that different types of insulators were contributed by the General Electric and the Westinghouse Companies and by Mr. F. M. Locke on account of their friendly interest in the work.*

The original plant at Provo contained two 750-KW, 60-cycle, 800-volt, three-phase General Electric generators, direct connected at 300 revolutions per minute to twin horizontal turbines under 125 feet head, a six-panel Wagner switchboard, two banks of oil transformers and two outgoing circuits. All contents, thus in duplicate, were assembled in two complete, independent units, designed for operation independently or paralleled at both high and low pressure. Prior to the power-factor indi-

---

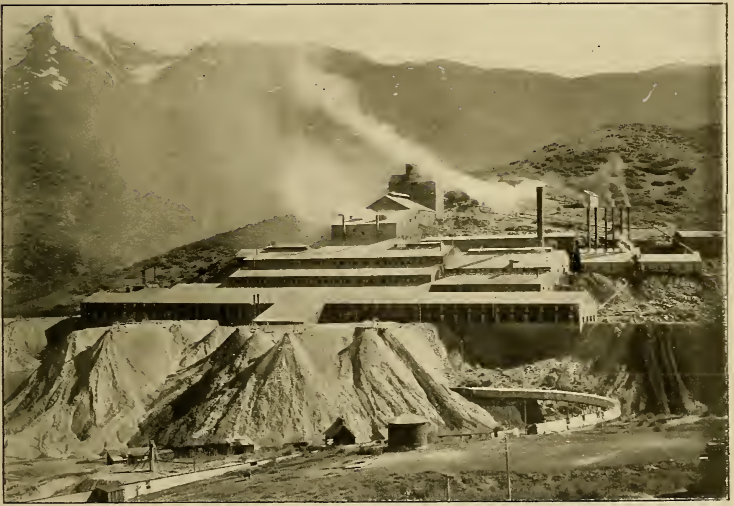
* An interesting account of this work and some of the technical results may be found in Mr. Mershon's report quoted in Mr. Scott's paper before the A. I. E. E. at the Omaha meeting, in July, 1898.

cator, a device which answered a somewhat similar purpose was installed, consisting of a wattmeter on the low-pressure paralleling bus with current coil in one bus and shunt across the other two. This indicated cross-current, and was used in the adjustment of field charges. Transformers were each 250 KW, 800 to 40,000 volts, star connected at both high and low pressure, with neutrals grounded.

Triple-pole air switches and four-foot fuses formerly connected each bank of transformers with its transmission line. One form of air switch, opening six feet, contained no metal except conductors, and was composed entirely of paraffined wood and rawhide, without porcelain, glass or other insulator. Others were sliding frames carrying line insulators.

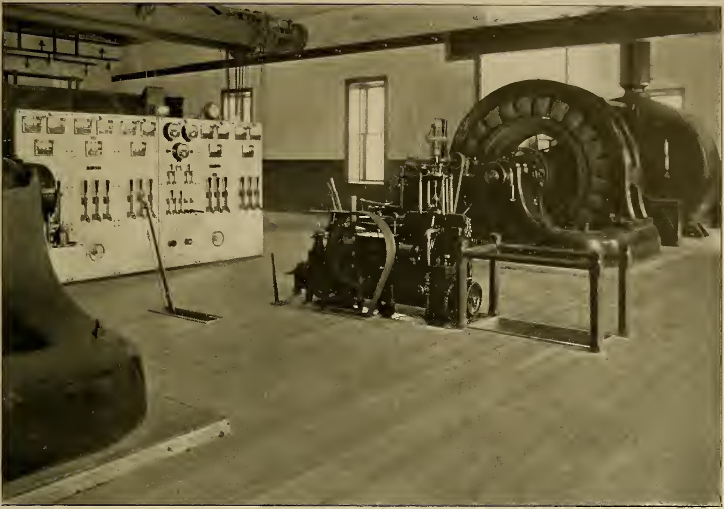
During the first year of operation the transmission comprised a single 32-mile line to one receiving point at Mercur, where the arrangement was similar to that at the power house, save that two reducing transformers were connected two-phase three-phase, grounded neutral, for 220-volt, two-phase induction motors. The Provo-Eureka line, 42 miles long, carries seven-strand aluminium cable equivalent to No. 4 copper. The Eureka-Mercur cross line, 28 miles long, equivalent to No. 5 copper, was added to complete the triangle thus formed and permit cutting out either of the three sides without interrupting service.

The Logan plant was completed in 1901, containing two 1000-KW, revolving-field alternators, direct connected at 400 revolutions to double-discharge twin turbines under 212 feet head. This plant is connected with the Provo system by duplicate lines over 100 miles long, passing the cities of Ogden and Salt Lake. The Provo and Logan plants are thus operated in unison through nearly 200 miles of transmission. Distributing points at Mercur, Eureka, Bingham, Salt Lake and Provo are also junction points of the duplicate lines, equipped with switches in each



THE MERCUR MILL, SUPPLIED WITH POWER FROM THE PROVO, UTAH, STATION, SHOWN ON PAGES 192 AND 193. THE FIRST INDUSTRY OPERATED BY 40,000-VOLT POWER

THE FIRST 40,000-VOLT POWER PLANT, PROVO, UTAH



THE INTERIOR OF THE PROVO POWER HOUSE

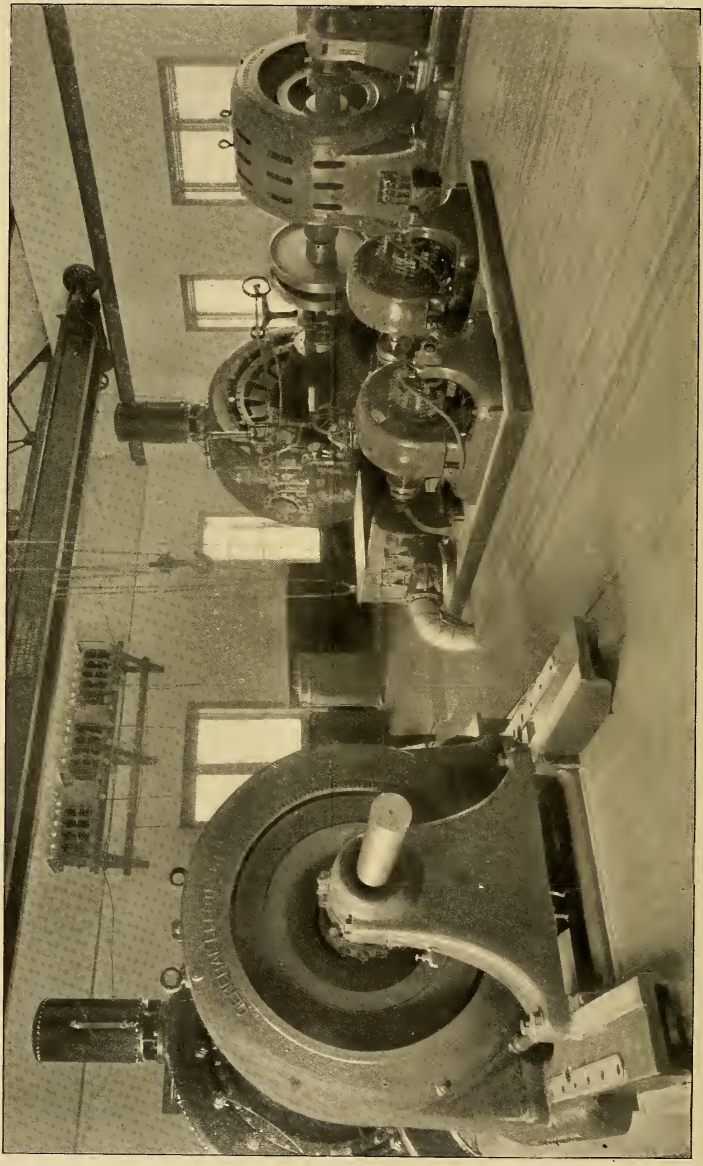
incoming line, as well as in circuit with the transformers, so that in case of threatened trouble the patrolman can without delay have his section cut off for immediate repair without interrupting service.

The three conductors of each transmission form an equilateral triangle, 76 inches between wires, carried by a seven-foot cross-arm and the top of the pole. Extra long pins raise the insulators from 6 to 12 inches above the cross-arms, are of selected locust, kiln-dried and immersed from six to twelve hours in hard paraffine at 150° C. Cross arms are of Oregon fir, kiln-dried and soaked in boiling bitumen. Those upon the first line were attached in the usual manner with metal braces.

The burning of cross arms and poles on account of broken insulators, during prolonged wet weather, occurred most frequently at these braces. When the next lines were built, in 1899, treated wooden braces were substituted, with results so favourable that all metal braces were soon replaced. It was still observed, however, that even light leakage seemed to concentrate around the lag bolts, carbonising the wood and finally loosening the bolts.

For the Logan lines of 1900 and all later lines, therefore, the cross-arms were mortised through the poles and wedged and pinned with hard wood, thus discarding all metal except conductors. This construction was originated by Mr. A. L. Woodhouse, who, upon the close of the high pressure experimental work in Colorado, of which he had charge, became, and still is, superintendent of the Utah department. It has proved amply strong, not expensive, and during the four years' operation of the 400 miles thus constructed very few poles have been burned.

Provo type glass insulators, designed by Mr. V. G. Converse, have been used throughout. Many have broken, but these have usually shown the effects of gunshots or stones. In fact, there has not been a single breakage, except in one lot, improperly annealed, clearly due to either internal or dielectric stresses. It is difficult to see wherein



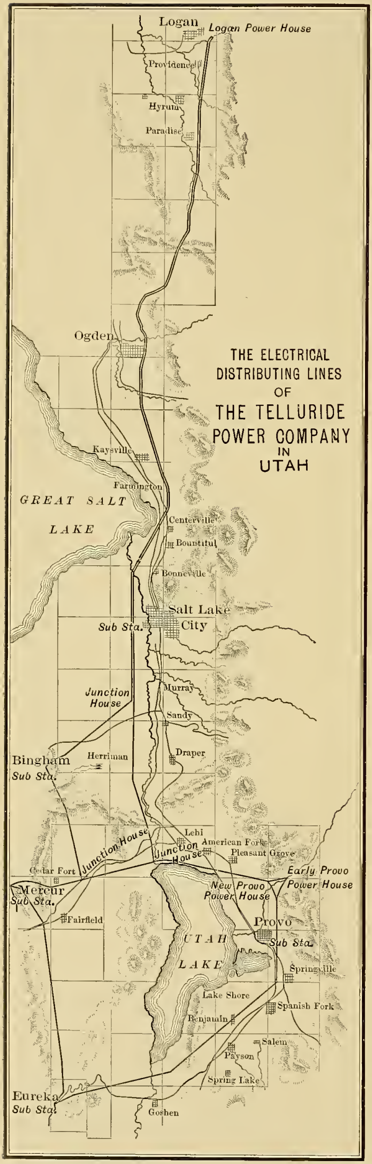
THE INTERIOR OF THE LOGAN POWER HOUSE

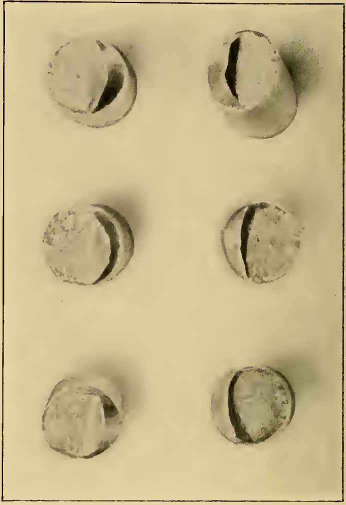
any other insulators could have done better, unless bullet-proof. College laboratory tests to the contrary notwithstanding, leakage losses are inappreciable, except during severest storms, and then not serious where insulators are unbroken.

It is a mistake to suppose that Utah climate is favourable. During the rainy season it is as wet as any, and the alkali dust of the so-called salt storms is as trying as sea-coast spray. At times dense volumes of this impalpable dust from the Great Desert are accompanied by clouds or fog. In this damp, sticky state the dust completely covers to a considerable depth the under as well as the upper surfaces of insulators, as well as poles, cross-arms and pins. Over these surfaces streamers gradually creep until, meeting at the pole, they break into an arc, like that which was photographed by Mr. C. E. Baker, the line patrolman at Mercur, and which has several times been published. A quick turn of the generator rheostat at the critical instant breaks the arc, without interrupting service of induction motors.

The arrangement of power houses and transmissions already described is such that the opening of paralleling switches may resolve the system into a single transmission from 100 to nearly 400 miles in length with a generator at each end, yet side by side. If one generator be reversed, synchronised as a motor with the other and loaded by its water-wheel, any length of transmission may, by manipulation of a paralleling switch, be alternately cut in and out between them. Since switchboards and instruments are connected, measurements

THE LOGAN POWER HOUSE



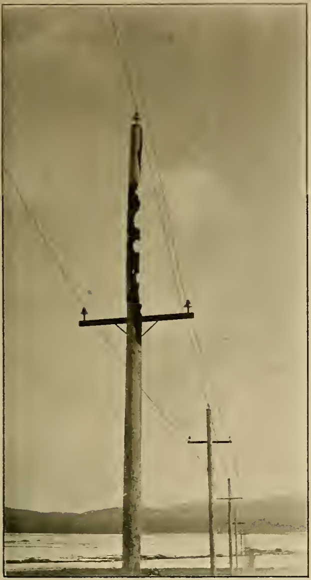


FRACTURE OF ALLOYED SOLID ALUMINIUM CONDUCTORS

made are immediately comparable. In this manner losses and power factor may be measured, and the corrective effect of charging current observed.

Solid aluminium wire, first used in 1898, was slightly alloyed to increase strength, but proved worthless, breaking repeatedly with square, glass-like fractures. It was at once replaced with commercially pure, seven-strand cable, still in use. Similar cables have generally been employed for subsequent lines, while spans have been successfully increased to 180 and 200 feet, with less deflection than usual with copper.

The experience with oil transformers for 10,000 volts at Telluride, and the refusal of manufacturers to give any guarantees whatever for other transformers for higher pressures, led the Telluride Company, when undertaking this 40,000-volt transmission, to manufacture its own. The first equipment was made at the Wagner Company's works under designs and supervision of Mr. Converse. The later ones were



BURNT POLE OF EARLY CONSTRUCTION

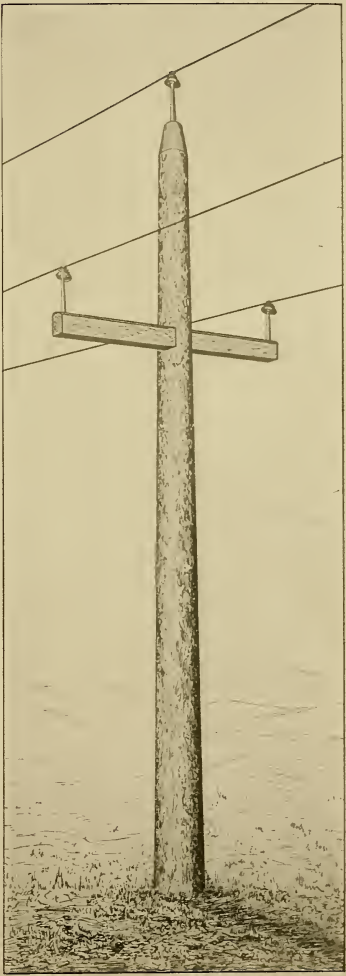
made by the Converse Transformer Company.

When erected, the oil in the tank and the transformer in an oven were slowly raised to, and then maintained during twenty-four hours at, a temperature of 125° C. The transformer was then immersed in the oil, and both continued at the same temperature for a further twenty-four hours.

As bearing upon the question of fire risk due to oil transformers, it may be of interest to note that of the large number of these high-pressure transformers used during the past seven years, chiefly in isolated sub-stations containing much wood and seldom visited, all but four are still in operation; that these four were destroyed by fire of doubtful origin, and that only one transformer has required repair other than change of oil.

The plant at Norris, Montana, designed and constructed in 1901 by Mr. O. B. Suhr, Superintendent (now Resident Engineer of the Ontario Power Company), contains at present two low-speed, 1000-KW units.

A duplicate transmission of 60 miles conveys power to the city of Butte. These lines, as well as both raising and reducing transformers, were designed



PRESENT ALL-WOOD POLE CONSTRUCTION

GENERAL VIEW OF OLMSTED, LOOKING EAST, SHOWING NEW PROVO POWER HOUSE AND INSTITUTE BUILDINGS

A VIEW OF OLMSTED LOOKING TOWARD UTAH LAKE

ARC CAUSED BY A SALT STORM

for the use of 40,000, 60,000, or 80,000 volts. Longer pins are used than in Utah, and conductors form a triangle of 108 inches. While producing the present limited amount of power, and awaiting a suitable insulator, the lower voltage has been used.

In conclusion, it may be said that the Provo plant,—the first transmission at more than 16,000 volts,—while undertaken materially in advance of the art, and not exempt from its share of troubles, has, nevertheless, been fully successful as a financial venture, and not without value in the progress of the science. Long periods of perfect operation, monotonous in their uneventfulness, have proven beyond question the success of high pressures for long distances.

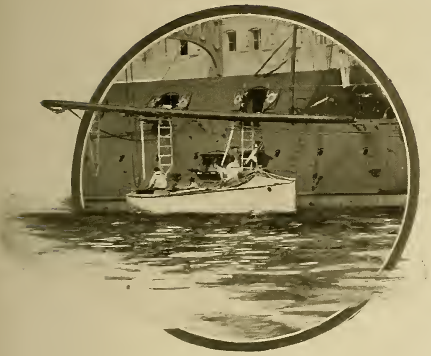
The new and larger power house at Olmsted, at the mouth of Provo Canyon, completed this season, is modern in every detail. It contains three 3600-horse generators, operating under 340 feet head. Air switches and fuses are everywhere giving place to oil switches with time-limit automatics, and constant reconstruction to meet its increasing demands keeps the system, as a whole, abreast of present practice. Thus the Telluride Power Company, while again and again a pioneer in power transmission, must not be associated alone with the experimental methods of early days, but may in the future be found still engaged in progressive, practical, pioneer work.

For the illustrations on pages 175 and 178, and for the upper one on page 179, the writer is indebted to a paper entitled "Long-Distance Transmission for Lighting and Power," read by Charles F. Scott before the American Institute of Electrical Engineers on June 7, 1892.

ENGINEER OFFICERS IN THE BRITISH NAVY

THEIR PAST AND FUTURE

By Archibald S. Hurd



NOTHING reveals in more striking light the conservative policy which distinguished for many years the administration of the British fleet than the treatment of non-combatant officers. It was not until 1843 that paymasters (pursers), surgeons, chaplains and naval instructors were raised from the rank of warrant officers to be commissioned officers, and ten years later, though the chief engineer of a ship lived in the wardroom with the military officers and others, his junior companions had a mess of their own, but were not provided with cabins. They had to sling their hammocks like the seamen, as, in fact, some of the youngest engineers in many ships do to this day. The chief engineer had a cabin, but, as a rule, it was small and stuffy, and had to serve as office as well as cabin; in some ships it was on the engine platform, a kind of black hole.

Those who go down to the sea in ships get accustomed to the worst conditions. A flag officer, who has vivid recollections of this period, has told the writer that no one seemed to think the arrangements for the engineering officers bad. This admiral's memories of these early days of steam in the navy will give some idea of the state of affairs at the time of the Crimea.

" Steam," he says, " was thought of little importance. There were no facilities for the training of engineering officers, who seemed to be regarded by the Admiralty as a necessary, but most inconvenient, evil.

" My early recollection is that most of the engineers of this time,—there were exceptions, of course,—were men who entered from the engineering works ashore, men of the roughest habits and speech, not even representative of the type of foremen in works at that period, for the terms offered by the Admiralty would not tempt the best men from their shore employment.

" They were a class unto themselves, and only the chief was in the wardroom; the others had a mess of their own, just as the warrant officers and midshipmen had. At this time the engineer officer was a rough-cut diamond, who came to sea with all his imperfections thick upon him straight from his life ashore."

Another officer who remembers the engineer officers of these times records that his memory is that they were very low down in the social scale, and their duty was thought less highly of than that of the locomotive driver of to-day; the engines were very simple, for it was not until 1853 that high-pressure steam,—the *Malacca* had steam at 60 pounds,—was used. It was only very slowly that the authorities awoke to the fact that steam was to play a large part in future naval development. They put off the evil day of steam as long as possible, deeming it unnecessary to enter into the question as to how far the power of the steam engine might be made applicable to the general purposes of navigation.

Later on, when screws were pressed on the attention of the Admiralty, they solemnly sat in judgment upon the innovation, and in the period preceding the Crimea declined to entertain the project of fitting the screw to navy vessels. They came to the conclusion that under some circumstances steam was serviceable for use in small ships and tugs, but it was a long time before they could be convinced that it was desirable to use it as the main motive power of ships of the line. Since they thought so little of steam, it follows that they held in no esteem those who were entrusted with the care of these revolutionary agents.

The Admiralty was ruled by " salt horse " sailors, and they could not bring themselves to believe that the old, dearly loved sails were doomed; they did not conceal their feeling that with the advance of the steam engine would come the end of British mastery of the seas. They fought the steam engine with the deep conviction that, in so doing, they were acting in the best interests of the nation. Even as late as the Crimean War a large part of the British squadrons consisted of sailing ships, innocent even of steam for auxiliary purposes.

As the importance of steam was forced to the front, the grievances of the engineer officers began to come to a head. This was due not only to the augmented use of machinery for propelling and other purposes, but to the improved status of the officers who were trained in the Engineering College, which was first established at Portsmouth, in the old Marlborough. Later on a rival was erected at Devonport, and in 1880 a large college was erected at the latter port, at which practically all engineer officers have since been trained.

Students have been drawn from all classes of the community which are able to bear the cost of the training. The parent of each student has to provide an outfit on joining, which costs about £35, and during the course of study the disbursements which have to be made amount to about £60 a year. On the other hand, a certain number of entries into the Engineering College have been reserved for the brightest boys from the dockyard schools, shipwright apprentices, who by their application have shown themselves to merit official encouragement. These students, many of them the sons of parents in the humblest of circumstances, have provided the fleet with some of its most practical and skilled officers. Students who do best at the final examination go to the Royal Naval College at Greenwich.

The mixed system of entry for the commissioned ranks of the navy did not work well. Cadets for the executive line entered on the nomination by the First Lord of the Admiralty, while their colleagues in the engine room joined by open competition. The one line was aristocratic, while the basis of the other was strictly democratic. The engineering profession was free to any boy who could produce satisfactory reports as to character, satisfy the health standard, and pass the necessary examinations.

Moreover, as engineering ashore rose in estimation, a higher standard of student was attracted to the fleet, and there gradually gained in volume complaints that the naval engineers were not well treated by the Admiralty, that they were suffering under grievances, and the competition for entry to the college fell off as a result. In a few years the agitation for reform became known as the " engineering crisis," and year by year when the navy estimates came before the House of Commons debates were raised on the disabilities of this important class. At last the North-East Coast Institution of Engineers and Shipbuilders, under the leadership of Mr. D. B. Morison, boldly championed the case of these officers, and in 1902 their grievances were set out in a memorandum which was signed on behalf of this body and the Institute of Marine Engineers in London and South Wales. This statement was presented by a deputation which Sir Fortescue Flannery had arranged to introduce to the First Lord of the Admiralty. In this memorandum the signatories stated:—

"The above named engineering institutions deem it their duty to record and submit their opinion that the present constitution and organisation of the Engineer Branch of the Royal Navy do not admit of it efficiently fulfilling its important functions.

"The causes of inefficiency may be divided into two classes:—(1) those which create dissatisfaction and deter the enlistment of desirable candidates, and (2) those which relate to the numbers, training and organisation of the engine room complements.

"We are of opinion that the primary cause of the unpopularity, inadequacy, and consequent inefficiency of the Engineering Department is its inclusion in the Civil Branch of the service, whereby the executive authority and status of its officers are rendered incommensurate with their duties and responsibilities.

"We, therefore, recommend that the Engineering Department be embodied in the Executive Branch of the service, and that its officers be endowed with executive rank, accompanied, however, by executive control restricted to their own department.

"The Engineer Branch being a large and important factor in the war efficiency of the Royal Navy, it would appear that it should be adequately represented on the Board of Admiralty.

"In view of the technical nature of the issues involved in courts martially affecting the engineering personnel, such courts should comprise a proportion of engineer officers.

"The existing system under which junior engineer officers are appointed 'in lieu of' senior officers, and are thus called upon to undertake the duties and responsibilities properly attaching to the higher rank, without receiving that rank and the corresponding rate of pay, is obviously unjust, and should be suppressed.

"The proportion of engineer officers of higher rank than 'fleet engineer' is at present discouragingly small. We are also of opinion that some attempt should be made to render the Engineer Branch more attractive by a revision of the scales of pay and pension.

"In view of the rapid evolution which has taken place during recent years in engineering as applied to naval purposes, we are strongly of opinion that the whole question of the education and training of the engineering personnel should be thoroughly investigated.

"The total numbers of the trained personnel of the Engineer Branch at present fall so far short of the requirements of the service that it is impossible to provide ships in commission with engine room complements which are adequate in numbers, skill and experience.

"Some of the causes above referred to have so far discouraged candidates that the number of entries into the Engineer Branch through the normal channel has decreased to a dangerous extent, and the Admiralty have had to resort to expedients to make good the deficiency which have lowered the standard of the candidates, and tended to undermine the efficiency of the Branch.

"The important duties of the 'artificer' ratings in modern warships can only be efficiently performed by thoroughly skilled and experienced mechanics, such as the existing conditions of service have failed to attract in the required numbers; we, therefore, submit that increased inducements should be offered in respect of pay and accommodation."

These views were expanded before the First Lord of the Admiralty, Lord Selborne, and it will be appropriate to quote a few significant speeches made by a few of the deputation in order the better to understand the full meaning of the changes which the Admiralty announced the following Christmas Day.

Sir Fortescue Flannery, in introducing the deputation, said:—

"It is fifty years ago since the Steam Branch of the Navy was established, and the engineer officers of to-day are of an entirely different class from the workmen, who were, in the first instance, entered to take charge of the engines of His Majesty's ships. Not only are they of a different class, but they have increased enormously, both as regards the engineers themselves and the men placed under their immediate charge. That is the case, because the personnel of the engine room at present is about one-third of the entire personnel of the whole fleet. * * *

"I remember before the outbreak of the South African War there were five candidates for every position which could be given in the army,—five men anxious to serve Her Majesty in the position of executive combatant officers. I venture to say that the reason that there is not the same proportion of candidates for vacancies amongst engineer officers is that the engineer officer, although called an officer, is not in reality an officer; he is a civil servant, and is not an executive officer, with all the dignity and position attached to the holding of His Majesty's commission under those circumstances."

Sir John Columb remarked:—

"The Engineering Branch is still regarded as a group of civil units put into warships, and has neither obtained organisation nor an executive part in the ship's complement complete in itself."

Mr. John Corry, president of the Institute of Marine Engineers, added:—

"In times of peace and war the chief engineer is the most important man on board your ship, because all the machinery of that ship is under his charge, and if he is not a man of power and ability, or does not know how to use his power and ability, so as to impress the personnel of his staff, you will not have that efficiency which is absolutely necessary.

"It has been said, and said very truly, that the position of machinery has increased enormously. Everything now on board ship is done by machinery, and it requires a very able man, and a very clear-headed man, to be ready and competent at all times and under all emergencies, and to make the best of circumstances that may arrive. You must have men of first-class ability, and you must give them that position which their training, their knowledge, and their capacity warrants them in expecting."

Such was the case put forward by the spokesmen of the Royal Naval Engineers.

Curiosity was raised to the highest pitch as to the solution which the Admiralty would find for the difficulties of the then existing situation. Rumours were current that they were going to give way, to a great extent, in face of the powerful influences at work on behalf of the naval engineers. On Christmas Day the Admiralty reply was published. It made no concession to naval engineers, but at one blow swept away the whole existing line and substituted in the engine room a system similar to that under which executive officers had been obtained with so much success.

Students by open competition would no longer be entered, there would be no more entries from the mercantile marine or the dockyards schools; but all engineer, marine and executive officers would join at the same age, undergo at first the same training, and would begin and end their careers as companions with the same early memories and associations and the same social advantages. The naval engineer of the then existing line was abolished, that all officers of the fleet might be made into mechanicians.

In announcing to the country the revolutionary decision at which the Board of Admiralty had arrived, Lord Selborne admitted that matters had reached a crisis, and that the Admiralty considered that the solution lay not in the way of small changes to this or that class, but in a radical reform, by which every officer would be given a mechanical training before specialising for his own line, character would be developed in a common school, and *esprit de corps* cultivated not in one branch only, but throughout the fleet by all officers passing through the same course of early training. Under this new scheme it was proposed that:—

"All officers for the Executive and Engineer Branches of the Navy and for the Royal Marines should enter the service as naval cadets under exactly the same conditions between the ages of 12 and 13, and be so trained as to be able to serve in any of the three branches. They would be educated and trained together until passing as sub-lieutenants at the age of 19-20.

"At about the age of 20 these sub-lieutenants would be distributed between the three branches of the service which are essential to the fighting efficiency of the fleet,—the Executive, the Engineer, and the Marine. The result aimed at is, to a certain point, community of knowledge and lifelong community of sentiment. It being held that the only machinery which can produce this result is early companionship and community of instruction, the opportunities will be secured by a policy of:—

" One System of Supply.

" One System of Entry.

" One System of Training.

" It is considered," the First Lord continued, " that entry at the early age of 12 13 is necessary if the cadets are, by the age of 20, to receive that increased professional education which is required to qualify them to become commissioned officers; and it is not considered that it would be compatible with the welfare of the service if they were to become commissioned officers at any materially later age.

"Appointments to naval cadetships will be made by limited competition after nomination. In the nomination of candidates, preference, other things being equal, will be given to those boys whose parents or guardians declare for them that they are prepared to enter any one of the three branches of the service at the termination of their probationary period of service afloat.

" The nominations will be made three times a year, six weeks before the date fixed for the examination of candidates.

" Cadets will remain under instruction at the Royal Naval College for four years before going to sea, and they will all receive similar instruction, which will comprise an extension of the Britannia course, including elementary instruction in physics and marine engineering, with the use of tools and machines in connection therewith. The object of this course will be to give them a good grounding in the subjects necessary to their profession, and at the same time such a general education as will enable them to grasp the theory of their future subjects of study, whichever branch they may eventually join.

"At the end of this period the cadets will go to sea and become midshipmen. Special attention will then be paid to their instruction in mechanics and the other applied sciences and to marine engineering. The instruction of the midshipmen in seamanship will be given, as at present, by an executive officer deputed by the captain; otherwise it will, under the general responsibility of the captain, be supervised by the engineer, gunnery, marine, navigating, and torpedo-lieutenants of their respective ships; they will be examined annually as to their progress in seamanship, navigation and pilotage, gunnery, torpedo work, and engineering, all set papers being, as at present, sent from the Admiralty; and at the end of three years every midshipman who has passed the qualifying standards at the last annual examination and the final examination in seamanship before a board of three captains or commanders (constituted as at present), will become an acting sub-lieutenant, and return to England.

" These acting sub-lieutenants will then go to the college at Greenwich for a three months' course of mathematics and navigation and pilotage, followed by an examination, and afterwards to Portsmouth for a six months' course in gunnery, torpedo and engineering, at the close of which they will be examined, receive their classification 1, 2, 3 in each subject, and on passing out be confirmed in the rank of sub-lieutenant.

" When the young officers, aged 19 to 20, have passed out of the college at Portsmouth as sub-lieutenants, and have gained their classification in the different subjects of the examination, their careers for the first time will begin to diverge, and they will be posted to the Executive or to the Engineer Branch of the Navy, or to the Royal Marines. As far as possible each officer will be allowed to choose which branch he will join, but this must be subject to the proviso that all branches are satisfactorily filled.

"No sub-lieutenant will be compelled to join a branch for which he did not enter as a boy when applying for a nomination, but in giving nominations for competition for entrance to the Britannia, preference will (other things being equal) be given to those boys whose parents or guardians declare for them that they will be ready to enter either of the three branches of the service. The Board of Admiralty will thus have in reserve a means of remedying a surplus or deficiency in either of the three branches, and of insuring that every branch receives a due proportion of the most capable officers.

"The sub-lieutenants of the Engineer Branch will go to the college at Keyham for a professional course, the exact duration of which will be determined with great care. At the expiration of this course a proportion, to be equally carefully determined, will be selected to go to Greenwich for a further course, while the remainder go to sea. They will then, if found qualified, all be promoted to be lieutenants under the same conditions as the executives."

Up to the age of 19 or 20 years the future naval officer, to whatever special line he is to be detailed, Executive, Engineering or Marine, will pass through the same course, and then at 19 or 20 his training becomes specialised. If he should choose executive duties, he will devote himself to navigation, gunnery or torpedoes; if he should prefer or be selected for engineering, then his studies will become special to this profession; and if he is to be a sea soldier, he will spend part of his time at the Naval College and part at the headquarters of his corps.

The British naval scheme has been much misunderstood, and it has been repeatedly claimed that it is merely the same as has been applied to the naval service of the United States. This is a complete misapprehension. In Great Britain a good deal has been made of this resemblance; but it remained for Mr. Moody, the Secretary of the United States Navy, to point out the vital differences, which render the study of the two methods of training and entry so very interesting.

On the two sides of the Atlantic are being tested two schemes which embody practically in more or less complete forms the views of the different schools of thought, and the authorities of other navies, before taking a plunge themselves, are looking on to see the success or non-success of the rival plans.

As Mr. Moody has pointed out in his report:—"In comparing the two systems it is obvious that both proceed upon the theory that the best results can be secured by early companionship and unity of preparatory instruction, and there has been provided accordingly, for line and engineering officers alike, in each navy, one source of supply and uniformity in entry, study, and general training.

"The vital point of difference between the two systems is found in the fact that in the British navy a junior officer upon reaching the age of 20, or thereabouts, is assigned to one of the three branches of the service, and, thereafter, pursues accordingly a specialised course of study and training in the duties of the line, engineering, or the marine corps, while in the American navy no provision is made for the maintenance of a separate corps of naval engineers.

"Minor points of difference between the British and American systems are the following:—

"1. In the British service nominations of candidates for naval cadetships are made by the First Lord of the Admiralty, with the exception of a limited number placed at the disposal of certain officials; while all appointments to the United States Naval Academy are made on the nomination of Senators, members of Congress, or the President.

"2. In the British service cadets enter between the ages of 12 and 13. Midshipmen enter Annapolis between 16 and 20.

"3. Cadets entering under the British regulations pay £75 per annum, a limited number, however, being accepted upon payment of £40 only. In addition, British cadets are charged with certain incidental expenses. On the contrary, midshipmen at Annapolis receive pay at the rate of $600 per annum, with certain allowances."

In a supplementary statement issued by the First Lord of the British Admiralty, the declaration is made that future Boards of Admiralty may provide for a complete interchangeability of line and engineering duties; but that at present the division of duties shall remain definite, without interchangeability.

The British Admiralty has given assurance to those electing engineering duty that the rank of engineer officers will be assimilated to that of executive officers, it being provided that the engineer officers will wear the same uniform and bear the same titles of rank, *e. g.*, "sub-lieutenant (E)," "lieutenant (E)," "commander (E)," "captain (E)," and "rear-admiral (E)".

The Admiralty also declares that the Engineer Branch will receive additional pay, and although it is proposed to make the divisions into the various branches definite and final, every endeavour will be made to provide those who enter the Engineer Branch with opportunities equal to those of the Executive Branch, including the same opportunity of rising to flag rank.

In no other navy in the world have the authorities had the temerity to face the problem with the boldness evinced first by the Washington Department and then by the British Board of Admiralty. Those in control of foreign fleets recognise that the time for some change has come, and they are watching the results in America and in England in the hope that they may see the right solution.

The day of the triumph of electric, hydraulic and steam engines has dawned, and every naval officer of the British Navy must be a mechanician. There is no room in the new fleets coming into being for "salt horse" lieutenants. In a floating fortress, in which everything is done by machinery, the old sailorman type is out of place. There is no niche for him.

It may be that in time we shall have engineer officers flying their flags in command of British fleets. The prospect would have been considered burlesque by the executive officers of a few years ago, but it is now a prospect which is recognised as not only within the realms of possibility, but as a probable outcome of the apotheosis of the steam and hydraulic engines and the electric dynamo at sea.

Lord Selborne has definitely stated that he has purposely left the door open so that his successor, with full knowledge of the results of the reforms lately introduced, may act as he thinks fit. For the present, the young officer who chooses or is selected for the engineering line has his career fixed for life. If, however, a captain finds that a Nelson has by mistake got into the engine room, it will be within his power at any time to recommend that he should be shifted to the Executive Branch.

The scheme is still in its infancy. It may be criticised on many points, but now that the British authorities have taken the final step and founded a new establishment for the young cadets at Osborne, as a feeder for the Britannia College, there will be no turning back. This has been most clearly stated, and, consequently, for the time opposition has died down.

Opponents, however, are merely waiting their opportunity. The first flaw will be seized as a weapon for attack. It is realised that a change was necessary so as to bring deck officers into sympathy with and knowledge of the machinery of the ship; but the revolution lies not so much in this quarter as in the sweeping away of the democratic line of engineers and substituting for them officers of the same social status, ideals and aspirations as their comrades on the quarterdeck. The existing line is to be retained only until the new line is ready to take its place.

This is the most noteworthy change in the manning of the British navy that has ever been carried out, and it remains to be seen how far the engine room attracts cadets entered on this system, and also how far it is possible for them to become efficient, practical engineers under the new scheme.

BIG MACHINE TOOLS

By Joseph Horner

THE problem of the big machine tool becomes more complicated than of old, because dimensions have increased so greatly. The points of similarity between the tool of medium size and the mammoth one are dwarfed beside their differences. Mass requires solutions of a different kind from those which are applicable to the ordinary machines. It affects both main designs and details, methods of operation, and questions of manufacture, transit, and fixing, so that a big tool is not merely a common article magnified, but is in most respects a new design, which has to be treated on independent lines. The experience gained in one is only partly helpful in the other. It is the old division between light and heavy repeated,—groups which are judiciously kept distinct in all departments and in all the shops which constitute a factory.

There is another aspect of the big tool, namely, the rivalry between it and the portable type. The relations between the two broad systems are being intensified, for never before have so many portable tools been in service. The question of bringing the tools to the work, or carrying the work to the tools, is one of the interesting problems of the time, of which it would be unwise to forecast the issue.

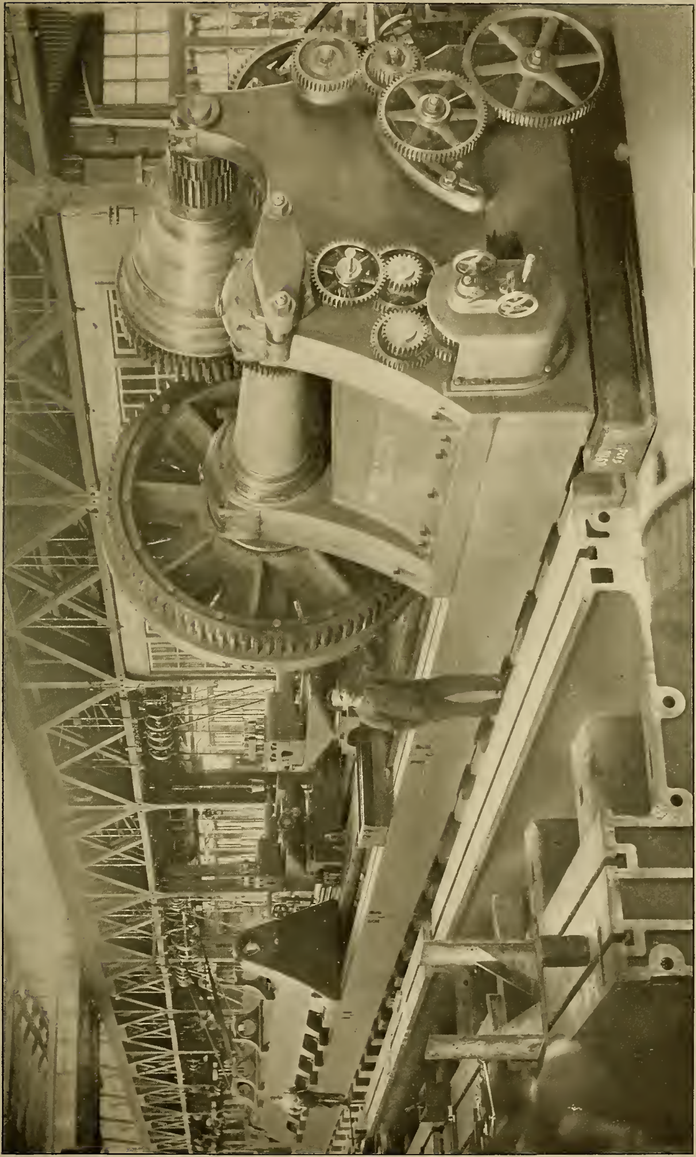
There are many jobs which practically admit of no choice of method, but there are large numbers in which the question of portable *versus* big tools is yet an open one. There is no chance for portable tools, for example, in turning big diameters, or long shafts, such as those for propellers, or cranks, or for planing long beds or tables. The true sphere for the portable tool is in the drilling of holes, cutting keyways and slots, planing and shaping comparatively small faces on large masses, and generally for attachment to massive mechanisms in course of erection.

The alternative to these is generally expensive hand work, due to the impossibility of taking such large pieces to any machines, or the absence of the latter, of sufficient capacity to cope with the work. But the portable machine tool is a useful alternative for much work, saving, as it does, the necessity for providing large and very costly fixed machines,—a question apart from that of transportation of work in the shops.

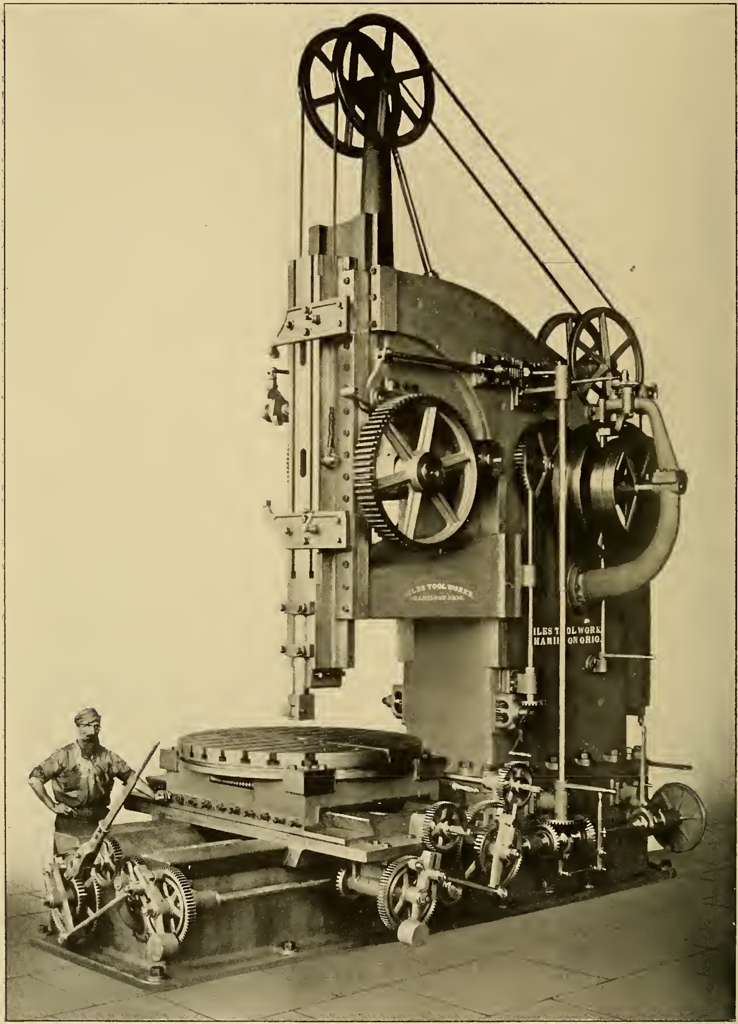
Looking into the details of design of big machine tools, we note that the following points arise:—First, there is the obvious problem of mass. There is no great harm in "lumping the metal" into machines if small and of medium dimensions, because it often means a difference of only a few hundredweights of metal of comparatively trifling cost. Such small possible savings should not be allowed to weigh against the advantages which mass and rigidity confer.

But in the big machines the question is one often of several tons weight, and then designs must be carefully worked out with judicious regard to economy, obtained by comparatively thin metal, stiffened liberally, and rendered rigid by ample bracketing, and a tapering of metal in some cases on the cantilever principle, towards overhanging or unsupported parts.

In other words, suitable outlines, rather than mere mass, represent the problem to be worked out. The general outlines are often made approxi-

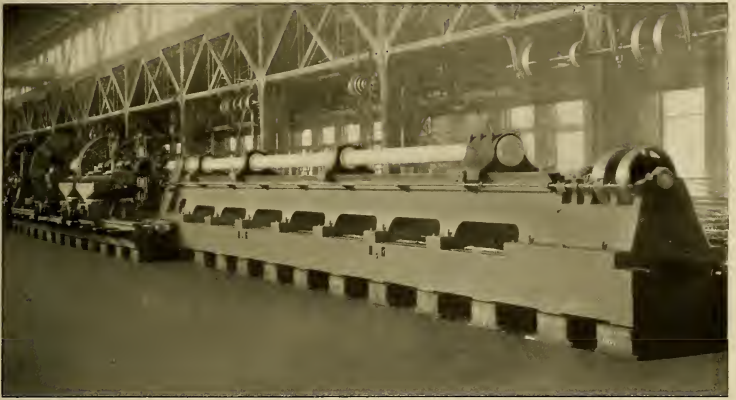


A GUN LATHE, 154 FEET LONG BETWEEN CENTERS, FOR BORING AND TURNING GUNS WEIGHING 165 TONS WHEN COMPLETED. BUILT BY THE NILES-BEMENT-POND CO., NEW YORK



A 54-INCH SLOTTING MACHINE BUILT BY THE NILES-BEMENT-POND CO., NEW YORK mately parabolic, or cambered, or semi-parabolic. Snugness of design is also studied in many ways, as in keeping tool boxes as closely as possible to their slides, in bringing beds and screws close to the areas of severest stress; and where this is not practicable, then it becomes necessary to receive the strains on slides of ample width and length in order to prevent jerky movements and lost motion.

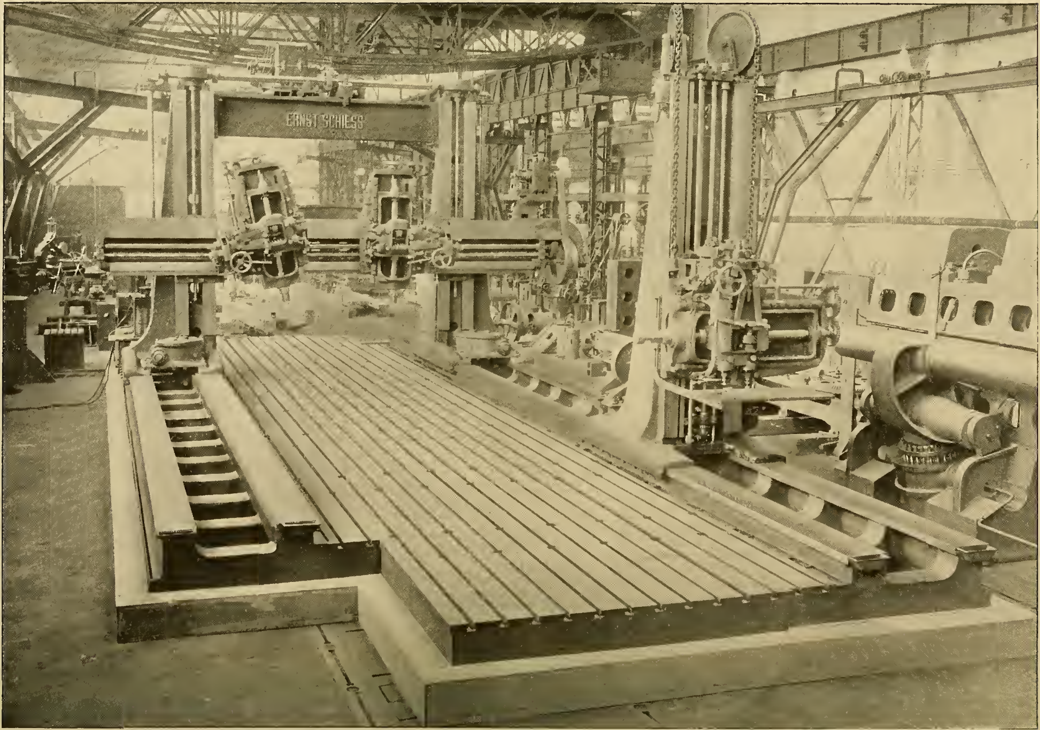
Mass, again, involves casting in pieces, because single castings of abnormal dimensions are difficult to make, to handle, to tool, to fit up, and to transport when finished. There is no virtue in casting big work whole, though such jobs are something to be proud of. A properly built-up casting is just as rigid and useful as one that is cast entire, and it is generally more likely to be sound throughout. A big wasted casting is a proportionately heavier loss than a sectional one. A fracture, too, either during erection or while in use, is of less moment if the frame of a machine is in sections, which can be readily replaced without great expense or delay, while a break in a big casting is a serious thing.


ANOTHER VIEW OF THE 16-INCH GUN LATHE SHOWN OPPOSITE

The problem is wholly different from that of casting numerous parts together, as is frequently done in the case of small machines, engines, and cranes. It is difficult to make massive castings, because they require special tackle in the foundry, powerful cranes, big core-drying stoves, cupolas, or receivers of large capacity, and large doors for exit. It is equally difficult to handle them in the machine shop, some of the reasons for which are similar to those just noted in the foundry, while another is that the machine tools are too small to deal with castings of abnormal dimensions except by the adoption of makeshift methods.

The fastening of the sections of a framework together is an important matter, rigidity, and immunity from shifting, relatively, being essential. The contact surfaces must be broad, provided in many cases with shoulders or tongues to prevent lateral movement, and held together with closely-fitting turned bolts. Large keys also are often fitted in the joints, to assist in holding, and to draw the joints up to their proper bedding.

Akin to the principle of bolting-up of castings in sections is that of making the floor plate and the bed plate or the machine base distinct from each other. The idea is embodied in the big break lathes with movable gaps, but it is much



A TRIPLE VERTICAL AND HORIZONTAL BORING, DRILLING, AND MILLING MACHINE, ELECTRICALLY DRIVEN. EXTREME LENGTH OF BED, 60 FEET; DISTANCE BETWEEN STANDARDS, 13½ FEET. THE HEADS TRAVEL INSTEAD OF THE BED. BUILT BY ERNST SCHIESS, DUESSELDORF, GERMANY extended in the wall planers, floor boring machines, and what are termed floor machines generally. In these, a big plate with tee grooves forms the foundation on which, in some cases, the actual machine is moved about for adjustment, and fixed to suit work bolted to the plate.

In other cases the machine is fixed, and the work is adjusted and bolted down. This is a very accommodating method of working, and if the plate is of sufficient area, and several machine heads are provided, a number of separate castings can be tooled in various ways when there are no castings of the largest sizes waiting to be done. In this way the utility of the machine is increased, and it need never stand idle. An extreme illustration of providing a separate heavy base is that of casting the anvil of a steam hammer in position, which has been done in some cases.

When machines grow to unwieldy dimensions, the cast iron girder or beam often gives place to the built-up plated member. Though cast iron is more rigid than rolled steel, yet the latter can, by judicious arrangement of the material, be made equal to withstanding all vibratory strains imposed upon it. Moreover, though large castings are not easily made soundly, plated steel is usually homogeneous throughout; and, further, as long castings must generally be bolted-up in sections for convenience of manufacture and of transit, there is no objection to the parallel case of riveting, since long riveted work can also be made in sections. The reliability of plated work is mainly a question of the care exercised in workmanship, *e. g.*, planed joints, drilled or reamered holes, and close-fitting rivets.

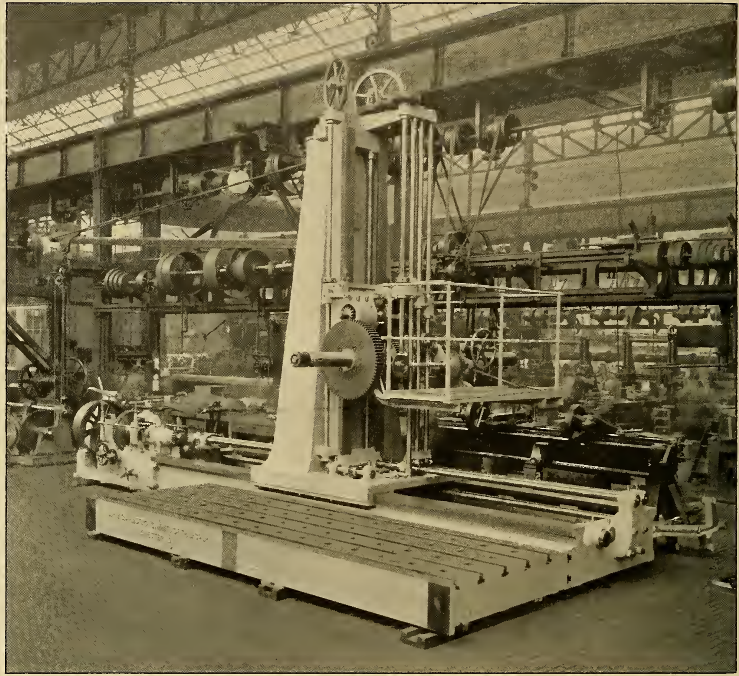
The low elasticity of cast iron is not calculated to withstand sudden and severe strains without risk of cracking, so that from this point of view the greater elasticity of a plated framing should be advantageous. The ideal strength would be that which is amply rigid under all ordinary stresses, but sufficiently elastic to withstand severe and abnormal ones due to accidental occurrences.

The limitations of plated work are these:—All sliding bearing surfaces must be of cast iron or gun-metal; hence, if mild steel is used for main framings, the sliding portions must be of cast metal attached thereto. This is hardly good practice, and in such cases cast frames are employed. But for stretchers and main framings plating is eminently suitable.

Another aspect of the subject is this:—Since in heavy machines everything must be on a massive scale, two problems are involved that offer no difficulties in the case of ordinary dimensions, namely, counterbalancing and power operation. Thus, on a small planer or vertical lathe, the cross-slide is raised and lowered by hand-operated gears. On a small boring machine the head can be elevated and lowered by hand. But as mass increases, these operations demand the application of power, from belt or motor, which must move the parts at a fairly rapid pace, in order to save time. Exceptionally fine adjustment is not necessary, because the final small movements are given by the lesser slides, which are moved by hand. Thus, on a planing machine, the cross-rail would be elevated by power; but the tool box slides,—hand moved,—provide a few inches of adjustment for setting in the cut.

Frequently nowadays separate motors are provided on the largest machines for effecting these auxiliary motions of slides, a function apart from the actual driving of the machine. An intermediate stage is reached when gears are introduced, in order to ease the labour of operating screws and slides by hand, cases in which no gearing is necessary on small machines. Thus geared movements become essential on the poppets of big lathes which have to be racked bodily along the bed, and the spindles of which have to be thrust and withdrawn by the help of gears.

Counterbalancing is very essential to lessen the strain on the gears and screws, and to prevent jerky movements, as well as to diminish wear and friction between the slides. In the big machines the tool slides have to be balanced sepa-



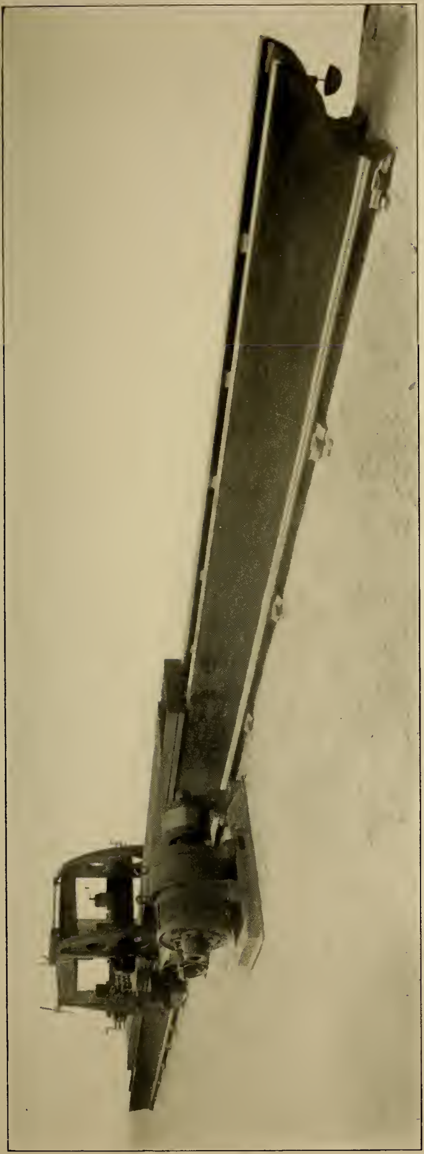
HORIZONTAL DRILLING AND MILLING MACHINE BUILT BY AND IN THE SHOPS OF SIR W. G. ARMSTRONG, WHITWORTH & CO., LTD., MANCHESTER. TRAVEL OF UPRIGHT, 12 FEET. MAXIMUM HEIGHT OF SPINDLE, 10 FEET.

rately from the main cross slides, and this often necessitates a somewhat complicated arrangement of chains and pulleys.

Support has to be afforded to long and heavy screws by tumbler brackets, to prevent sagging at stages intermediate with the bearings. No lead screw of 3 or 4 inches in diameter on a long lathe can possibly be self-supporting, and the need of making the brackets to fall over and return after the passage of the slide rest is obvious.

Another case of support afforded to long shafts is seen in some big bending rolls. The usual practice has been to increase the diameter of these rolls in proportion to length, thus making them rigid in themselves. But it has still been found difficult to maintain the same thickness in the rolled plates over the central areas as at the edges, since a very slight amount of spring suffices to make ⅛ inch of difference. The improved device consists in taking the spring of the rolls against a cambered girder; the latter is provided with friction rollers which receive the pressure of the top rolls of the machine. The latter are then kept down to reasonable dimensions, and are, in fact, small by comparison with those which have to be made stiff enough in themselves. This is one result of the use of steel boiler plates 1¼ to 1½ inches thick demanded by the present pressures.

The bearing problem does not weigh very heavily on the big machine designer,

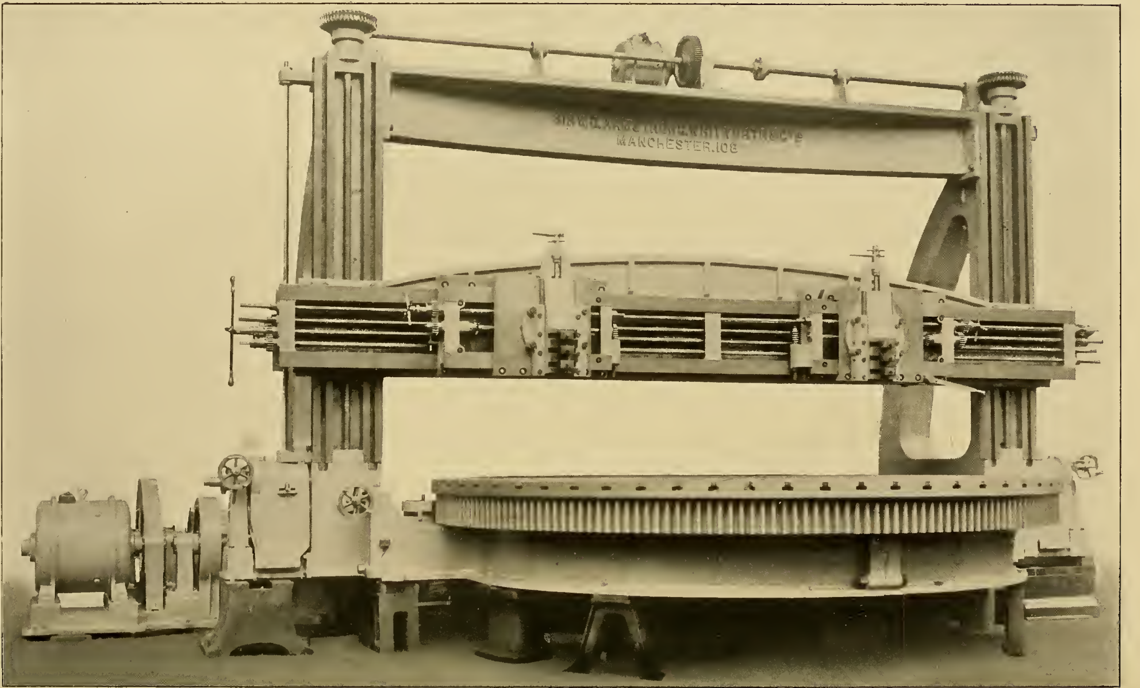


A PLANER WITH 77-FOOT BED CAPABLE OF TOOLING 40 FEET IN LENGTH. BUILT BY MESSRS. C. REDMAN & SONS, HALIFAX, ENGLAND

because speeds are comparatively low, although at the same time rigidity and freedom from chatter must be guarded against. Bearings of gun-metal or of cast iron are suitable for nearly all big machine shafts and spindles. The ball bearings of the smaller lathe spindles and drilling spindles are, therefore, not wanted in the larger shafts and spindles of the big tools. In the vertical lathes, however, a special problem arises,—that of the bearings for the vertical spindle. In the earlier types this had a neck with the section of the Schiele curve, which is an ideal form. In later machines an approximation to this is employed, flat, coned surfaces being used, as being more easily machined. A large surface support is given on the back of the face-plate when doing heavy turning. For boring and turning of small diameters at high speeds the spindle is lifted clear of this face, and it runs on the spindle alone.

The attendant of the big machine is dwarfed beside it. Two results follow, one being that he must be accommodated with a seat or a platform, which, in some cases, must travel along with the work or the tool-slide. The other is that all or most of the operating handles must be brought to one location, close within his reach, if long perambulations about the machine are to be avoided.

A necessary equipment of some big machines is a crane for handling work of a repetitive character, and so prevent holding up the shop travellers which are wanted for the general service. Generally these are hand cranes,



A 20-FOOT DIAMETER HORIZONTAL LATHE, WITH A MOTOR-DRIVEN TABLE AND A SEPARATE MOTOR ON THE CROSS GIRDER FOR RAISING THE CROSS RAIL. BUILT BY SIR W. G. ARMSTRONG, WHITWORTH & CO., LTD., MANCHESTER but we may expect to see light electric cranes and hoists attached to the big tools

The tendency of design in the smaller machine tools is to restrict the range of their operations, in order to render them suitable for producing specialties. But the tendency in big tools is in the other direction, namely, to increase their range of utility. The reason is that a large machine with a very restricted scope of operations would seldom be employed profitably all the time, and the capital outlay on it is too great to permit this. Hence, we have extension boring and turning mills; combined planing, drilling, milling, and tapping machines; heavy break lathes capable of doing work between centres, turning face work, and screw-cutting; duplex boring mills with adjustable centres, capable of being operated simultaneously or independently. The capacity for work is also increased by multiplying tool boxes, as in big planers, which have boxes on uprights and cross rail, all capable of simultaneous operation when necessary.

This multiplication of operations results in saving much transference of work to other machines, which is a very important consideration when mass is concerned. A big boring mill frequently has an extension arm fitted to the cross-slide, reaching out over the table, to do boring that could not be performed by the ordinary tool holders. An addition of another kind has been made by one builder in the shape of a rear tool column attached to the base behind the table, and having a horizontal tool bar for turning.

Another example is seen in the heavy turret lathes in which turret and cross-slide operate numerous tools, some of which are little complicated machine tools in themselves, instances occurring in the more elaborate box tools fitted with slides, springs, and various automatic movements for bar and casting work.

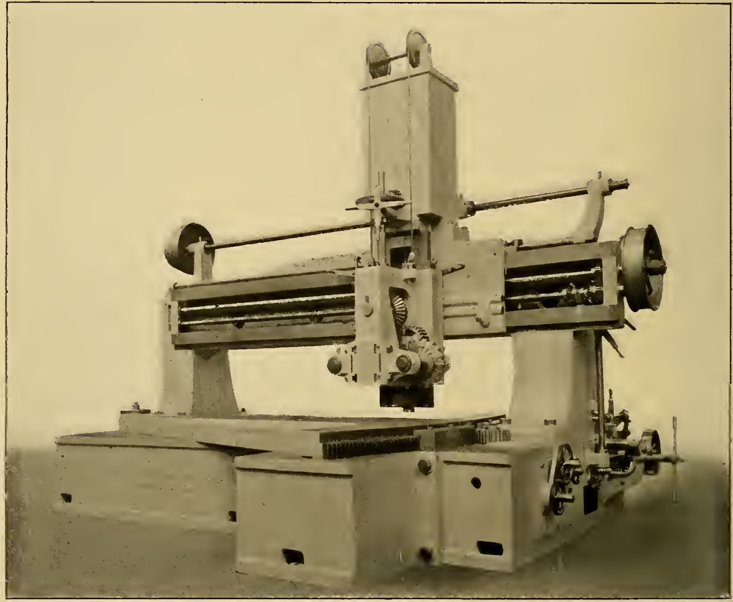
Another variation in old practice brought about by the increasing size of machines consequent on growing massiveness of work is the travel of tools over the fixed work. This is adopted on planers and milling machines. It is then possible to maintain rigidity only by bases of large area to the columns, and slides of great length and width, combined with excellence of fitting, and means for taking up wear immediately it becomes apparent. Metal must then be massed about the bases, and lightened in the upper parts of the standards.

The question of driving big machine tools is simplified by the electric motor. Long ago the growth of large machines used by boilermakers for steel work occasioned the introduction of the independent drive, effected by means of a steam engine attached directly to each machine. But that does not meet the case of the big tools of the machine shop, in which two or more movements are involved, each absorbing different degrees of power, and to each of which a separate motor can be fitted, with the subsidiary advantage that there is no trouble about the direction of drive of belting.

Machines driven electrically can be set in the positions which are most convenient for the shop arrangements and the handling of work, instead of being controlled by the position of the line shaft. In some of the heavy boilermakers' rolls two sets of steam engines are fitted, the main ones for driving, the smaller ones for elevating the girder to give the plate thickness to be rolled. In this way the idea of fitting several motors to a machine has, therefore, been anticipated.

The difficulties of belt-driving increase with the power absorbed by machines. Long drives are difficult to obtain in shops, and short ones do not admit of the sag which is desirable in an ideal drive. A short, wide, thick belt is difficult to keep in working order, and the bearings adjacent are greatly stressed. Link belts are, therefore, often substituted with advantage in such cases. Rope drives are not common on machine tools, though used freely in one notable works in Belfast. The electric drive has come opportunely here, though the high motor speed involves more reduction gear than it does on the smaller, quick-running machines. But a good worm gear again solves this difficulty.

The increase in dimensions of machines has thus been conducive to an extension of electric driving, and in a similar way to that of overhead travellers. The necessity for power movements of the parts of mechanism, each part requiring different amounts of power, affords just the opportunity for individual motors selected for the special duty required. The three movements of overhead travellers, each taking a motor of a different power, have their analogies in planing machines, in the table travel (or the travel of housings), and in the elevation of the cross-slide. In the plate rolls it is found in the driving of the rolls and the adjustment of the top rolls; in planer-millers, in the table travel and the cutter spindle driving, with also the cross-slide elevation sometimes. When an independent standard and tool box is fitted, the case is analogous to that of the auxiliary hoist in a crane, and a separate motor is frequently attached.



LARGE AUTOMATIC GEAR CUTTER FOR INTERNAL OR EXTERNAL GEARS USED IN GUN TURNTABLES. MAXIMUM RADIUS 12 FEET. CUTS UP TO 4 INCHES PITCH. THE CUTTER IS 16 INCHES IN DIAMETER. BUILT BY SIR W. G. ARMSTRONG, WHITWORTH & CO., LTD., MANCHESTER

The erection of the big machines has to be done under conditions different from those which are met with when machines of medium and small dimensions are in question. The differences are due both to mass and to area. The foundations have to be broad and deep, and carefully levelled, and the difficulty of getting long beds and base-plates absolutely level can be surmounted only by employing very true parallel straight-edges and spirit levels.

The levels of large erections may be obtained or checked with the theodolite. The difficulties of erection are increased by the bolting of members in lengths, and by the fact that the entire lengths of the longer entire beds and slides cannot be tooled at one setting, two or more fixings for machinery being necessary, at each of which error is liable to occur. Mutual corrections of large areas are also much more labouriously done than are those of smaller dimensions.

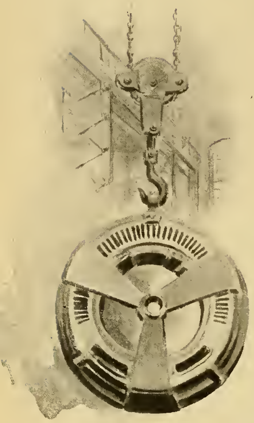
The erection of heavy machines is a slow job in the absence of powerful overhead cranes. Pulley blocks are always available, and these have to be used if ample crane power is absent, as it frequently is, and then the movements are very slow. Pieces of awkward shapes, of large areas, or which are inconvenient to sling so as to balance, present other difficulties, because they are too massive for the workman to steady with the hands. In such cases extra sling chains may have to be attached to outlying portions of the job to balance the mass. Or, when the piece has been slung and located somewhat approximately to its position, an extra rope or chain may be rigged up to pull the outstanding portions up true to their seating, a frequent instance being that of castings fitting on vertical faces.

Another problem, apart from that of manufacture, is that of transport, introduced by the question of mass. When big machines are built by firms for their own use, this problem may be mostly neglected; but not when sectional parts have to be conveyed over railways and under tunnels and arches, or have to be shipped abroad. The question of crane power available at wharves and sidings will have to be ascertained, and weight kept down to the limits which can be handled with safety at all points of the route. Thus the designer of heavy tools must take note of the entire movements for the parts from the place of manufacture to their ultimate destination, if he would avoid an awkward contretemps at some stage, or stages, of its journey.

These are the leading problems and aspects of the big machine tools of recent years. It is hard to say when the limit of size will be reached. As long as the dimensions of ships are increased, and the diameters of electric generators, the size of guns, etc., the growth must go on. Plates, forgings and castings, and the demands for higher speeds, feeds, and duties, the growth of the high-speed steels, and lastly the need for bigger machine tools to manufacture new machines, are all favouring the growth of more massive structures, with the problems to which they give rise.

THE TRAINING OF THE ELECTRICAL ENGINEER

By Dr. Louis Bell



IN the past few years there has been an almost continual controversy between educators, both here and abroad, concerning the professional training to be given to those who propose entering upon the career of the electrical engineer. In existing schools engaged in this important work there is small agreement as to principles and still less as to practice, while each can point to graduates who have distinguished themselves, as living evidence of correct educational doctrines.

One group of excellent institutions lays great stress on exhaustive laboratory courses, dealing with the minutiæ of electrical measurements of every sort; another pins its faith to long-continued shop practice in the designing and construction of electrical apparatus and the study of concrete commercial forms of electrical machinery; a third devotes the major part of its energy to the mathematical side of the subject, using shop and laboratory chiefly for purposes of illustration; and in some places there is a strong sentiment in favour of interpolating a considerable amount of actual commercial work in the course of theoretical and laboratory study.

This diversity of opinion might, at first thought, be taken as an intimation that out of the various methods some must be irremediably bad and lead to highly unsatisfactory results; but even were technical education an exact science, which it is not, a little reflection would suggest that a diversified product requires a somewhat wide range of processes, alike, perhaps, in general principles, but varying greatly in details.

The chief difficulty in laying judicious plans for training electrical engineers lies in the fundamental difficulty of saying exactly what one means by an electrical engineer. In popular apprehension he may represent almost any phase of technical expertness between a boss bell-hanger and the guiding genius of a great industrial organisation. Both extremes are necessary in the world's work, together with all the degrees which lie between. It is quite impossible to formulate a course of instruction equally well adapted for turning out as a finished product the bell-hanger and the guiding genius and practically very difficult to adjust a curriculum to suit even a much narrower range of requirements. Even an attempt to forecast the probable demand for different classes of technical graduates is somewhat futile, for this demand varies almost from year to year.

One thing, however, can be set down as certain, that the demand for guiding geniuses is very small, even though it more than equals the supply. The day has gone by in which the cub engineer was hardly out of sight of the maternal lair before he became the proud originator of a "system" exploited by silver-tongued agents and heralded by the blare of reportorial trumpets. Getting ahead is hard, gruelling work now in any one of the score of crowded branches of the electrical profession.

The student who starts in electrical engineering to-day must make up his mind to a long, steady pull to gain a vantage ground, and an unceasing fight to maintain it. He may as well rid himself of illusions at the outset and settle down to win his way by hard work. The first thing is to get as thorough a general training as time and means permit. There is a considerable temptation both for institutions and individuals to enter upon a policy of specialisation in certain branches of applied electricity. For the average institution or man it is likely to be a policy of disaster, since it necessarily narrows the available market for the product.

This is a general principle to be borne in mind. The bane of modern industrial life is the tendency which makes, let us say, a machinist an operator on a "No. 6 *A* Cyclone automatic screw machine," instead of an intelligent and resourceful craftsman. Once out of a job in his narrow field, he has nothing else to which he can turn his hand for a livelihood.

In similar fashion an engineering student who has, for example, specialised in machine design, finds, at graduation, his particular qualifications at a discount, save in a comparatively small group of manufacturing establishments. Of course, in some instances he has a line of work already mapped out, and is really in training for a place reserved for him; but such luck is very exceptional. And furthermore, in institutions which tend somewhat to specialisation the lines chosen for particular development are rarely those which will give the graduate the broadest opportunity for success. The common tendency is to train men for factory engineering rather than for the broader field of outside work. If one wants a man for the draughting room or the testing department of an electrical works, he can easily be found among technical graduates. But men capable of grappling intelligently with the problems of the constructing engineer, and, above all, men able rapidly to master the multifarious technical details of operating a plant, are by no means easy to find.

Yet for every man required in the design and testing of electrical machinery a score are needed to install and operate his output, and the earning capacity of the installing and operating force, man for man, is quite as great as that of the construction force. One naturally raises the objection that installation and operation are subjects impracticable to teach in a technical school, and require practical experience.

But, in the first place, there is much of these things which can be taught, and in the second place, the same objection holds with respect to designing and testing machinery. There is a certain manufacturing technique which has to be acquired by experience, and, after all, the function of education is to put the student in the way of easily and quickly acquiring these special qualifications rather than to give him a deck load of petty details, which have at best a limited usefulness.

A technical graduate has to learn many things before he settles down to his bearings in practical engineering, and the very best thing that can be done for him is to give him the power of quickly grasping his environment, whether that chances to be in the factory or the field.

The principle here involved is a commonplace of the higher education in general. The practical difficulty of the situation lies not in recognition of the necessities of the case, but in meeting them. Alertness and facility of acquisition are qualities partly inherent in the individual mind, but susceptible of high cultivation in many ways. A well-trained lawyer or a first-class journalist has them in a very high degree, but each has gained them by a difficult schooling. Their desirability, unfortunately, tells us nothing as to the best method of inculcating them during the education of an engineer.

Two other qualities, however, the successful engineer must have preeminently,—initiative and resourcefulness,—and these have a more definite connection with the character and scope of his training. The former demands a strong and certain grasp of fundamental principles and methods, while the latter requires, in addition, a wide acquaintance with phenomena. The one connotes the power of applying promptly and accurately theoretical principles; the other, the possession of data to which these can be quickly applied. Given these, the student can safely be left to work out his own salvation in a new environment.

The weak point in ordinary technical education is that the correlation between these two lines of procedure is too often very imperfect or altogether lost. There are, indeed, many points at which the connection can very easily be missed. As a rule, electrical theory, as theory, is better taught than electrical practice; it is, indeed, far easier to teach. Given a certain degree of mathematical facility, and electrical theory, up to the point required in ordinary engineering operations, can be acquired by the student with surprising rapidity. But the power of intelligently applying it is painfully rare.

It is most astonishing to note how a student can run the gauntlet of quizzes and examinations, with electrical theory apparently at his finger-tips, and yet fail dismally when confronted by the concrete embodiment of the very equations which he has deftly been juggling. The fault in this case lies at the door of the instructor, who has misjudged the real scope of his work. Sometimes he may have slipped easily over the applications from lack of personal familiarity with their practical bearings; perhaps more often he has risen so far beyond sublunary things that the mere existence of an application robs the theorem of its interest. There is a certain mathematical attitude that suggests the prestidigitator pulling a rabbit from the ear of the rustic on the front row, and then proudly expatiating on its importance as a beautiful example of bilateral symmetry.

The necessary thing in inculcating engineering theory is to drive home and clinch every principle, never reaching for another until the one in hand is firmly in place. And this can never be done unless the instructor knows accurately what the practical applications of his theory mean.

Anything less than the degree of thoroughness here implied does the student almost as much harm as good, and tends to set up an artificial barrier between theory and practice that is the cause of as much bickering as a " spite fence."

The practical side of engineering involves many more real difficulties in teaching than does the theory. It requires a large general plant, a large instructing force, and a big grasp of engineering details. On its proper administration depends the grasp of the student on phenomena and his power of applying general principles to concrete cases. The field to be covered is large and somewhat indefinite, so that a proper balance of material is difficult to preserve. It is here that the claims of shop and of testing laboratory come into active conflict, and in the fracas other things equally necessary are too often cast into outer darkness.

Various technical schools differ more sharply in the distribution of practical applications than in any other features of instruction. There are many things more important to the engineering student than the ability to operate machine tools adroitly, or facility in carrying an efficiency test three decimal places beyond the point justified by his instruments. Nevertheless, the usefulness of acquaintance with shop methods is not lightly to be underestimated, particularly when operative engineering is concerned. And likewise it is a good thing for a student to do one piece of work, or a few pieces, with the last degree of refinement, for the sake of learning what real precision implies. But *au large* these things bear about the same relation to electrical engineering that the manual of arms bears to military science, —they have a value as training, but are important on the real battlefield mainly as occasional aids to discipline. The vital thing is technical strategy, which is not to be learned through mechanical dexterity or by cut-and-dried tests.

Granted all this, and still the problem of technical education is troublesome. The first difficulty to be faced practically is lack of time. Modern education is a perpetual and hopeless struggle to put a quart into a pint bottle. A young man comes up to the engineering school at, say, eighteen years of age, and begins the task of completing a technical education in four much abbreviated years thereafter. He has been graduated from a high school with a smattering of many things, knowing few or none of them with the thoroughness that really puts them at his command. Very little that he has learned, save his mathematics, is of any real help to him in his engineering studies, and, as a rule, his instruction in algebra,—the key to all the higher mathematics,—has been both impractical and insufficient. His alleged courses in science have been nearly or quite a waste of time, and the result is that his first year of work is undertaken at a disadvantage.

This inefficiency in preparation is greatly to be regretted, but is not easy to remedy. The writer strongly disbelieves in early specialisation; but it certainly would facilitate technical education if the student intending to enter a technical institution could be given some special attention in the last two years of his preparation, not at all in the way of technical studies, however. More thorough, not more advanced, mathematical work, and especially more English and general culture studies, to take the place of the classics or of infantile science, would give the student a better start than at present. In fact, it is altogether probable that a classical high school, if sound in its mathematics, serves the purpose quite as well as the so-called English high schools, the value of these earlier studies being mainly disciplinary.

The real truth is that our present division of secondary and collegiate education is artificial and by no means well suited to secure the greatest good for the greatest number. The more training, the better, on general principles; but it is a fact that under existing conditions a great many promising youngsters cannot afford the technical training that is now available, and pass into the ranks from the high school. Perhaps few among them would develop into accomplished engineers; but many of them, if given the chance, would be most valuable in the technical arts, in the factory and out of it. At present very little is being done toward training the non-commissioned officers of the technical army. A subsidiary technical school, taking students, say, from sixteen to twenty years of age, and preparing them to enter the technical arts or to go on into advanced engineering studies, would have a great practical value. In this would legitimately belong the training in shop work and methods for which it is so difficult now to find a proper place, and for the English studies which are now inadequately jammed into the interstices of the freshman work of the average technical institution.

But taking the freshman as he is, the very unpleasant necessity arises of giving him not the best possible training for the engineering professions, but the best compromise that can be squeezed into three or four thousand hours in the class room or laboratory. From this amount must be subtracted time for certain general culture studies that have no direct bearing on professional work, but yet cannot be omitted from any course intended to turn out decently educated young men.

Opinions and practices differ in the importance assigned to these non-technical subjects, but perhaps it is usually too small rather than too great. Professor Gradgrind does not represent a species yet extinct; but facts are really useful about in proportion to one's power of co-ordinating them, which, in turn, depends not on the acquisition of more facts, but on stopping to think about the stock already on hand, and the mind is the fresher for this when it periodically gets out of its wonted channel and takes a new start.

And then arises the ever-pressing question of shop instruction in the mechanic arts, in the amount and scope of which institutions differ more than in any other one particular. It may range from a brief course in the use of wood and metal-working tools to shop work under almost commercial conditions, and in amount a very substantial fraction of the total time devoted to technical training. Its value depends almost entirely upon the field to which the student later devotes himself.

The original conception of the electrical engineer was that of a fellow who designed and built dynamos, motors, arc lamps, and so forth; in short, a manufacturer of electrical apparatus, either as principal or accessory. The personage thus defined was a mechanical engineer with a smattering of electricity, and the more draughting and shop work he had, the easier would be his entrance of the factory.

The growth of the electrical art has radically altered the facts in the case, although the popular conception is little changed. The electrical engineer of the present day may require a knowledge of civil or hydraulic engineering, of chemistry or of general physics far more than he needs to make a pattern or to calculate the deflection of a beam. Handling men may be of vastly more importance to him than handling machines.

To meet these varying requirements, either the engineer's instruction must be varied to suit the case, or one must work, as it were, by general average. In a course of the length now in vogue the former alternative is practically out of the question from mere lack of time, so that the principle of the greatest good to the greatest number should prevail. This undoubtedly tends at present to the reduction of shop work in a general course below the amount which would be really advantageous to the student contingent later devoted to manufacturing.

Shop practice from the commercial standpoint cannot be well taught outside of a shop which is, in a measure at least, doing real commercial work, and this cannot be crowded into a four years' course beginning at the ordinary point without crowding out other things that must not be omitted. A recognition of this condition has led to the inauguration of some very useful schools in which shop practice is made a predominant feature, and also to the suggested interpolation of one or more periods of actual commercial work during the course of a technical education. The latter procedure too often leads to the loss of the student before his education is completed.

The school based upon shop work can certainly do admirable work in training the non-commissioned officer before referred to, and there is a steady demand for foremen and assistants that should take good care of the product; but no more than a certain amount can be crowded into four years of instruction, and if shop work goes in, something else has to go out, so that a course of this kind comes no nearer to training an engineer in the general sense than the broader course does to training a specialist in machine tool building. Here, again, one comes upon the disadvantage of the arbitrary way in which the current education is divided.

If the student could come up from a higher secondary school with English studies, draughting and shop practice well in hand, his professional course could be laid out to far greater advantage than at present. However, no institution could well make a requirement of this sort on account of the existing system of secondary education, so that perhaps the best compromise is the common one of directing shop practice to the inculcation of mechanical principles rather than the acquisition of manual adroitness or manufacturing methods, however valuable these may in themselves be to a certain limited number of students.

As regards the balance of various branches of pure and applied science in a course primarily devoted to electrical engineering, the case is not so bad, for a certain amount of elective work can be made effective in meeting the varied requirements of various men, so far as they can be ascertained. This much is certain, that the field of electrical engineering is steadily broadening, and that the training of maximum usefulness ten years ago does not now retain its supremacy. To meet these changed conditions, the educational line of action must be very essentially modified. Two general courses of improvement are open. In the first place, a certain amount of flexibility can be gained by an elective system, pushed rather farther than is now usual in engineering studies, allowing the student, for example, to work over toward electro chemistry, which is just now a region of rapidly increasing importance, or toward telephony, or toward some other of the larger divisions of the subject.

It is perfectly true that by so doing he would have to be content with somewhat less of some other subjects, but what of it? The fundamental purpose of professional training is professional work, not the demonstration of pedagogic theories, and some allowance must be made for the capabilities and necessities of individual men. Of course, elective systems can be, and sometimes are, overdone; but this probability does not detract from their real value. One can catch cold in a draught, but that is no valid reason for living with the doors screwed up and the windows battened down, nor does the logic of the situation compel those who believe in ventilation to abandon houses and live in tents.

In the second place, one may frankly admit that an adequate technical training cannot be gained in four years of study, starting from the usual point, and may add provision for two or more years of post-graduate study. Very likely such a course might prove to be more than most men could afford at present, and perhaps only a relatively small body of men are in a position to greatly profit by it. To a certain and certainly increasing number, however, post graduate study is useful and important, and it is a good sign of the times to see the extent to which post-graduate work is already being introduced in various institutions.

But one thing must here be remembered,—that the existence of a post-graduate course does not excuse mismanagement of the undergraduate course, which ought to be planned for the greatest good of the greatest number, irrespective of the existence of further opportunity for study, since it is not fair to the undergraduate to lay out his work for the benefit of a relatively small body of post-graduates. One of the salient faults of American education is failure to recognise the plain duty of the school toward the student who has not indefinite time at his disposal. It took a long time to develop an English high school system for those who did not have opportunity to attend college, and even now the great body of public school children who never reach the high school is neglected in working out fine drawn educational theories for the benefit of the more fortunate minority.

This is not a plea for so-called practical branches as against culture studies and the fundamental theory that lies at the root of all practice; it is merely a demand for so close a welding together of theory and practice that if you tap the course at any point you will find them interlaced like the steel and iron of a Damascus gun-barrel. Probably the very best results within the limitations of time imposed can be obtained by a combination of a certain amount of undergraduate elective work with an opportunity for post-graduate study, never forgetting that it is quite out of the question by any system of instruction to graduate a regiment of colonels.

To pass from the general to the particular, engineering education, like engineering itself, is necessarily a series of compromises. Its two great branches, —mathematical theory and laboratory practice,—have a strong tendency to diverge, and some freedom of action in each must be sacrificed in order to keep them together. Laboratory work itself has a two-fold purpose,—the acquisition of familiarity with methods and apparatus and the gaining of initiative in attacking new problems. If the former fails to run parallel with the development of theory, and if theory does not bear squarely upon methods and apparatus, each has missed its proper aim.

Experiments merely confirmatory of mathematical theory, of which so much use has been made in some misguided elementary science teaching, are worse than useless in an engineering course, since they distract attention from the real problem, *i. e.*, the applicability of the theory in concrete cases. As an example, take the law of inverse squares which turns up so often in physical science. That a flux proceeding uniformly from a point in a homogeneous medium obeys this law needs no experimental proof, the mathematical one being far more rigid than any experiment can possibly be; but the limits of applicability of the law form a proper subject of laboratory inquiry and further mathematical investigation as well. The law of the deflections of a tangent galvanometer follows rigorously from the usual assumptions and needs no further demonstration, while the validity of these assumptions in an instrument set up in a laboratory full of electrical currents and iron steam pipes is the really important question at issue.

The engineering student in his laboratory work ought never to be turned aside from the real problems of practical engineering and allowed to drift along through a course of routine experiments in which his thinking is, for the most part, done for him, for thinking is what he needs in his business. Methods and manipulation can be just as well taught in useful experiments as in useless ones, and to far greater advantage.

Practical engineering deals with the applications of theory under limiting conditions arbitrarily imposed by the data of the problem in hand, and generally quite independent of the fundamental equations. For example, it is not a difficult task to predetermine the characteristics of a dynamo, or to lay out a distributing system for equipotential distribution within expressed limits; but to design the one so as to call for less labour and material than the similar machine of a rival company, or the other with a limit of cost which must not be exceeded, calls for qualities which cannot be developed by the ordinary routine of the lecture room and laboratory. The engineering habit of mind can, however, be cultivated by hard work on problems which involve arbitrary limitations of various sorts, and these are of immense value in gaining initiative.

It is greatly to be regretted that more stress is not laid on this sort of thing in the ordinary institution. It is sometimes almost limited to a perfunctory "thesis" at the end of the course, while the real necessity is for minor thesis work all the time. Such practice, too, is invaluable from the standpoint of theoretical instruction, for the theory which is kept fresh in the memory is that which keeps turning up in daily tasks. In this particular a well-planned engineering course can really be made richer than actual professional practice, which is apt to settle down into rather well-defined lines and to stay there for long periods.

The scope of electrical theory as generally taught in technical schools is ample for its purpose if the student is sufficiently well grounded to appreciate it. This he rarely is, for he seldom has been sufficiently drilled in algebra to make his calculus easy, and if there are any two subjects generally taught without proper reference to practical applications these two are calculus and differential equations. It is one thing to make an integration with a certain amount of deftness, and quite another to apply the calculus to a disintegrated mass of data and bring out a coherent result. It must not be understood that calculus and differential equations are the daily food of an engineer in his professional work. Far from it; it may be only once in many months that they appear upon his menu, but when they do, there is apt to be no other sustenance in sight.

For the purposes of technical education, mathematics should be taught as applied science, the usual gap between theory and practice being continually bridged by the application of methods and formulæ to concrete cases. With a basis thus properly formed, electrical theory presents no serious difficulties to the average student, and its application becomes more than the perfunctory thing which it now too often is. No man really appreciates a formula until he grasps the physical relations of its parts. It is this which makes the constant interrelation between theoretical and laboratory instruction of such fundamental importance.

Lack of this, as has already been intimated, is the gravest fault that can exist in a technical course. No man can become independent and resourceful if he has to fritter away his time puzzling out relations that should have been interconnected from the beginning. Engineering is a living, growing subject. Even the best men can hardly keep pace with it, and the young engineer needs an athlete's training in the fundamental exercises that give speed and endurance. Beyond this, thoroughness and initiative are the watchwords of the profession.

ENGINEERING MATHEMATICS

By E. Sherman Gould, M. Am. Soc. C. E.

THE subject of this paper was suggested by a perusal of the article entitled "Mathematics in Engineering," by Mr. Thorburn Reid, in the September, 1904, number of this magazine, and occasion is taken by the present writer to enlarge upon a theme which appears to him to be of the utmost importance in directing the education of the engineer.

It is a common saying that engineering is partly a science and partly an art, the scientific part comprising all that can be reduced to figures and put into a book, and the art covering all that vast field controlled by genius, skill and experience which has no formulas, and where the personal equation is supreme.

This definition is largely true:—All engineering projects pass through three stages on their way from inception to accomplishment,—first, the design, or project; second, placing the design on paper in the form of working drawings; and third, the execution of the work as shown by the drawings, on the ground, thus giving the design bodily form and being.

In the first of these stages science can hardly be said to enter, that is to say, not in the form generally known as "mathematics." It is pre-eminently the field of genius and experience. In the third stage some mathematics enters, as far as laying out the work is concerned; but it is the special province of art, of the artificer, of the skilled constructor who is master of good workmanship in the putting together of structural materials. Mathematics is wholly excluded in this work, beyond the use of the foot-rule, measuring tape, straight-edge, level and plumb-line. It is in the intermediate stage, in the preparation of the working drawings, the fixing of dimensions and proportions, that science and mathematics come into full play and reign supreme.

To illustrate:—In 1858 the French Government decided to undertake works for regulating the flow of the river Furens in order to protect the city of St. Etienne from the inundations to which it was occasionally exposed. A long study of existing conditions resulted in the project of an immense reservoir capable of receiving and storing the flood waters of freshets, and incidentally aiding the water supply of the town. This reservoir was to be created by building a masonry dam, about 170 feet high, across the valley, the dam forming one wall of the reservoir and the sides and end of the valley the others. The height determined upon was that necessary to give the reservoir the capacity to fulfill the object for which it was built. All this formed the first stage of the project,—the study of conditions and the determining of the thing to be done. It called for the exercise of engineering talent and skill of the highest order, to grasp the requirements on the one hand, and to adapt the means of fulfilling them on the other. But there was no mathematics in it.

The task then passed to its second stage, namely, the preparing the working drawings for this great dam, at the time and for long afterwards of unprecedented dimensions. One dimension only, the height, was fixed; but how thick should it be, and what the shape of its cross-section?

The first essential was stability; the second, economy. Stability could be secured by erecting a masonry bulkhead of such huge thickness as to manifestly defy displacement, regardless of expenditure of time and money. But the point was to secure sufficient, but not extravagant, strength with the least volume of material, by the adoption of a section of equal resistance, so that the structure should possess uniform strength in all its parts, not being redundantly strong in one place and only just strong enough in another.

It was recognised that the securing of these conditions depended not only on the amount of material used, but on the form in which it was placed, because it was well known that a certain mass of material possesses a greater or less degree of resistance to destruction according to whether it is disposed in one form or another.

To ascertain this proper cross-section, that is to say, to select from among all possible shapes which the cross-section could assume, the one best fulfilling the requirements, two steps were necessary; first, to correctly analyse the nature, direction, and intensity of the forces, both exterior and interior, acting upon the structure and tending to destroy it, and then to deduce a cross-section or profile such that its resisting forces at any point could be equated to the destructive forces at the same point, the calculation to include a predetermined factor of safety, or uniform excess of strength.

This problem was successfully worked out by a rigid application of mathematical analysis. A solution could have been reached in no other way, and the result was the establishment of a standard cross-section, bounded on its interior and exterior sides by easy and graceful curves, which at once commended the design to the practised eye as being adapted to the ascertained conditions. Not only did analysis evolve this appropriate form, but it made evident the fact that such was the only form which could fulfill the requirements. It was a problem admitting of only one solution, and that solution was unerringly and triumphantly reached. This was the work done in the scientific or mathematical stage.

The third stage was now arrived at. The method of executing the work was entered into. This involved devising a plan for the diversion of the river while the foundations were being put in, the order and routine in which work should be carried on, and the faithful and skilful manner in which it was executed, both as regards materials and workmanship. All this was art, pure and simple, and could safely be intrusted to artists alone, and not to scientists.

Of these three stages, it is idle to inquire which was the most important. Each step was necessary to achieve the result as a whole, and the work could not have been carried on without the concurrence of all. But the title and scope of the present paper compel us to concentrate our attention upon the intermediate, or mathematical, stage of the work.

The calculations and investigations involved in the operations just described were voluminous and intricate. It requires considerable mathematical ability to follow them. If it should be necessary to repeat these calculations every time a high masonry dam were built, then evidently the work must be confined to a favoured few who were masters of mathematical analysis. And just here the methods pursued by the two classes that Mr. Reid aptly terms the precisians and the practicians come strongly in contrast.

On carefully scrutinising the calculations of the precisians, the practicians became aware that they were not so very precise after all. Important data were lacking, and had to be supplied by more or less plausible assumptions. If these assumptions were admitted, exact results followed; but it seemed a question if an elaborate superstructure was not being reared upon an uncertain foundation. It also became evident that the exact theoretical profile could not be followed out in practice, as it would conflict with certain principles of good construction.

Moreover, it was soon perceived that, although the theoretical profile was bounded by sweeping curves, a very simple figure, a right-angled triangle in fact, could be laid off within it that would account for by far the larger part of the total area, the remainder forming merely a border or fringe to the main figure. A familiar example of this process is to be found in text-books on physical geography, where the general shape of states, countries and continents is shown to be formed around certain plain figures, bounded by straight lines.

It was seen that, no matter with what scrupulous and minute detail the calculations of any particular case were worked out, the result invariably led to a skeleton composed of a right-angled triangle, of which the base was from one third to three-quarters the height, according to the factor of safety adopted. The outer and interior curved faces were merely the covering and filling-out of this skeleton. It was but a short step to combine all those considerations of theory and practice and evolve a typical profile satisfying them, and susceptible of simple modifications to adapt it to any particular case. In a word, the precisians aimed at a mathematical result; the practicians, realising that such a result was as impossible as it was unnecessary, were satisfied by a safe working approximation.

The writer thinks that this instance of the Furens dam is an admirable example of the part that mathematics plays in the genesis of the engineering formula. Analysis of the most refined and searching character was absolutely necessary in the first instance. In order to carry on this analysis, data were indispensable. If they did not exist in a positive form, they must be introduced in an assumed or tentative one, and their truth tested by the outcome of the calculation.

When mathematics had done its utmost, the art of the builder came in to decide if the rules of good construction permitted of the execution of the plan, and finally art and science both combined to embody the results of calculation in a simple general process admitting of easy application without repetition of the tedious and intricate work upon which it was founded.

It will be interesting to examine more closely the way in which the calculations of a special case can be transformed into a general formula. It is astonishing how many such formulas may be derived by merely treating the problem algebraically instead of arithmetically, that is, by using symbols instead of numerals. When we solve any problem algebraically, we obtain not only an answer to that particular problem, but also a general formula by which all other problems of a similar nature may be solved. And not only so, but we get a formula in which, by the cancelling of common factors, all data, except those which are essential, are eliminated.

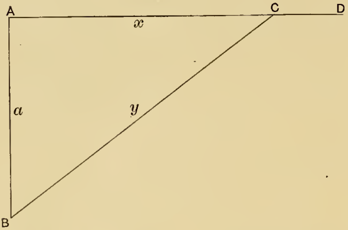
An excellent illustration of this may be found in a very familiar example of maxima and minima given in almost every treatise on the differential calculus which is shown in the figure, and enunciated as follows:—

A boatman at B, in the diagram on the next page, 3 miles out at sea from the nearest point A on the shore, wishes to reach the point D on the beach, 5 miles from A, in the shortest possible time. He can row at the rate of 4 miles an hour, and can walk at the rate of 5 miles an hour. At what point C should he land?

Using the figures representing the distances and rates, a simple differential calculation gives $A\ C = 4$ miles.

This, however, is a special solution

for a special case. If the rates and distances were changed, the entire calculation would have to be gone through with, using the new data. Now, if we can imagine the above example, as stated, to be a practical one of frequent recurrence, it would be very desirable to have a general formula by which all such questions could be solved without each time repeating the entire work.



This is easily arrived at, if we use symbols instead of numerals.

Thus, let $A\,C = x$; $B\,C = y$; and $A\,B = a$. Let the rowing rate be represented by R, and the walking rate by R'. Then it is readily shown that the general formula is:—

$$x = \frac{a\,R}{\sqrt{R'^2 - R^2}} \quad . \quad . \qquad (1)$$

Replacing the symbols by the numbers given in the example, we find $x = 4$.

This formula not only enables us to solve very readily all problems of its class, but it also shows that the total distance $A\,D$ does not enter into the calculation at all, provided it is greater than x, which, indeed, is a condition of the problem. It may be remarked that if $A\,D$ is not greater than x, or if the walking rate is not greater than the rowing rate, no advantage is gained by the boatman in not pulling directly to the point D.

But the formula shows us more than this. If we write it thus,—

$$\frac{x}{a} = \frac{R}{\sqrt{R'^2 - R^2}} \quad . \quad . \qquad (2)$$

we see that not only does not the distance $A\,D$ enter the question, but the distance $A\,B = a$ does not either. It is only necessary to know the ratio between x and a. Those familiar with trigonometry will see that equation (2) may be written thus:—

$$\textit{Tangent}\ A\,B\,C = \frac{R}{\sqrt{R'^2 - R^2}} \quad . \qquad (3)$$

Replacing symbols in (3) by the data of our example, we find:—

$$\textit{Tan.}\ A\,B\,C = 1.333.$$

This is the natural tangent of the angle 53° 08′. Therefore, to reach a point D, the farthest possible from A, in the shortest time, and with the given rates, which is what the question resolves itself into, a deviation of 53° 08′ from the line $A\,B$ is required. Indeed, if the question were a practical one, this would be the most useful information, because the distances $A\,B$ and $A\,D$ could not be estimated as accurately as the rates could be.

But this angle can be obtained even more simply. By a slightly different process we find:—

$$\frac{x}{y} = \frac{R}{R'} \quad . \quad . \quad . \quad . \quad . \quad . \qquad (4)$$

That is to say:—

$$\textit{Sine}\ A\,B\,C = \frac{R}{R'} \quad . \quad . \quad . \quad . \quad . \quad . \qquad (5)$$

Combining (3) and (5) we have:—

$$\textit{Cos.}\ A\,B\,C = \frac{\sqrt{R'^2 - R^2}}{R'} \quad . \quad . \qquad (6)$$

Incidentally, we have also:—

$$y = \frac{a\,R'}{\sqrt{R^2 - R^2}} \quad . \quad . \qquad (7)$$

Thus, by treating the question algebraically, instead of arithmetically, we can derive a series of formulas covering the problem in all its aspects. For instance:—In Rice and Johnson's abridged calculus this problem occurs:—"A steamer, whose speed is 8 knots per hour and course due north, sights another steamer, directly ahead, whose speed is 10 knots, and whose course is due west. What must be the course of the first steamer to cross the track of the second at the least possible distance from her?"

The experienced calculator would recognise this problem as belonging to the same family as the one just investigated, and would obtain a solution by a single stroke of the pen. Thus, calling the desired course y,

$$y = \frac{8}{10} = \text{Natural sine } 53^\circ\ 08'$$

Course = N. 53° 08′ W. Answer.

A marked point of difference between the mathematics of the precisian and of the practician is that the former aims at an exact result as the outcome of exact methods, while the latter seeks short cuts to safe working approximations, and cares not how he reaches them. He would as lief guess them as obtain them by the calculus of variations, or vectorial analysis. Mr. Reid gives examples of this having been done; but we must carefully note that a random guess is not meant, but an intelligent one.

An illustration:—An hydraulic calculation, made with the view to ascertain the piezometric pressure at a certain point of a given pipe line, worked out in this form:—

$$33\,x = 804 - 8\,\sqrt{x^2 - 4\,x}.$$

The solution presents no difficulty. The number 804 can be transferred to the other side, the equation squared, and by any of the familiar methods of solving adfected quadratics, the value of x can be obtained as closely as we care to carry out the decimals. But the reader will find, if he cares to try it, that there is a good deal of tedious figuring before he gets the two roots, $x = 20.02$ and $x = 31.50$, and as both roots are positive, it is necessary to try which is the correct one in the given case. By means of the slide rule, supplemented by a table of squares and square roots, a correct answer is obtained rapidly and easily by the method of successive approximations, particularly as it is unnecessary in the class of practical problems to which this case belongs to do more than get an approximate value for x.

In this particular case, however, it is a proof of how easily the mind becomes a slave to routine, that a still simpler method was, so to speak, staring the calculator in the face without attracting his attention. It should have been evident at once that, since only a close approximation was needed, it could introduce but a small error to add the figure 4 to the quantity under the radical sign. Thus, without sensible error we might write:—

$$33\,x = 804 - 8\,\sqrt{x^2 - 4\,x + 4}$$

This completes the square, and readily reduces the equation to:—

$$33\,x = 804 - 8\,x + 16.$$

Whence:—

$$x = 20.$$

When one is confronted with a tedious arithmetical operation, it is well worth while to cast about for self-evident short cuts, which can often be detected by mere inspection, as in the above case.

Many hydraulic formulas are found to be susceptible of important simplifications. For instance, the French engineer Darcy established certain formulas for the flow of water through cast-iron pipes by mathematical deductions based upon actual experiment. He obtained in this way the following formula for the velocity of flow in long pipe lines, that is, lines of not less than 1000 diameters in length:—

$$V = \sqrt{\frac{D \times H}{L \times C}} \quad . \quad . \quad (8)$$

In this formula:—

V = velocity of flow in feet per second.

D = diameter of pipe in feet.

H = pressure head or difference of level in feet between the points of supply and discharge, frequently called the "fall."

L = length of pipe in feet.

C = an experimental coefficient.

Since the discharge Q of the pipe in cubic feet per second is equal to its velocity multiplied by the area A of the pipe in square feet, we have:—

$$Q = A\sqrt{\frac{D \times H}{L \times C}} \quad . \quad (9)$$

The area of the pipe is the square of its diameter multiplied by 0.785. Expressing A in these terms, and passing it under the radical sign, we have:—

$$Q = \sqrt{\frac{0.616\ D^5\ H}{L \times C}} \quad . \quad (10)$$

The coefficient C varies with the diameter and the condition of the interior surface of the pipe. For rough cast-iron pipes, that is, for pipes which have become somewhat incrusted or tuberculated from long service, and for diameters of from 10 inches to 48 inches (5-6 feet and 4 feet, respectively) the range of values for C is from 0.00066 to 0.00062. Now these figures do not greatly differ, and as they depend upon the greater or less degree of roughness of the pipe, which cannot be mathematically fixed and is subject to considerable variations, we sacrifice but little accuracy,—probably none at all,—by calling the coefficient for this range of diameters 0.000616. Formula (10) then becomes:—

$$Q = \sqrt{\frac{1000\, D^5\, H}{L}} \quad . \quad (11)$$

The factor $\frac{H}{L}$ in the above is the head or fall per foot. It may be reduced to the fall per 1000 by being multiplied by 1000. Designating the fall per 1000 by h, and substituting it for $1000 \frac{H}{L}$ in (11), we have:—

$$Q = \sqrt{D^5\, h} \quad . \quad . \quad . \quad (12)$$

Or, as is sometimes more convenient:

$$Q = D^2 \sqrt{D\, h} \quad . \quad . \quad (13)$$

Formula (5) may be generalised thus:—

$$\frac{Q^2}{h\, D^5} = 1 \quad . \quad . \quad . \quad . \quad (14)$$

As an example in the use of (13), we may ask, What is the discharge through a long, rough cast iron pipe line, 2 feet in diameter, with a fall of 5 feet per 1000? Substituting data in (13), we have:—

$$Q = 4 \sqrt{2 \times 5}$$

$Q = 12.66$ cubic feet per second.

These formulas will give safe results for even very rough pipes. A new and clean pipe line will give a larger delivery

Two very striking instances of the immense value of simple and readily applied laws and formulas which they give, even when only approximations, are furnished by the use, in steam engineering, of Boyle's law for the expansion of gases under pressure and Carnot's criterion of the efficiency of a heat engine. In this application they are far from being accurate, but they are so simple that they are readily grasped by practical men, and work so entirely in the right direction that it is not too much to say that, in the whole range of thermodynamics, they have played the most important part in the development of the steam engine.

In this sketch the writer has endeavoured to establish two facts,—first, that mathematics lies at the bottom of all scientific engineering, that it is an indispensable part of the accomplished engineer's equipment; and second, that the mathematics of the engineer is a different thing from that of the astronomer or the professor. In certain branches, bridge engineering, for instance, the difference is less marked, although it is still there; but in most cases the product which the engineer receives from the professor requires to be worked over by him before he can use it handily in his business.

It would take too long to express the writer's views as to what amount and kind of mathematics, pure and applied, should be taught in engineering schools, or what method of instruction should be employed. He will simply state that, in his opinion, the courses at present professed should be largely pruned and directed into engineering channels, and that applied mechanics, also greatly reduced, should as early as possible in the course be combined with the mathematics, so as to furnish examples of practical utility.

THE MAKING OF THE BRITISH MERCANTILE MARINE

By Brysson Cunningham, B. E., Assoc. M. Inst. C. E.

IN a preceding article,* the writer ventured to deal with the very important subject of the world's oversea trade, and to indicate, in diagrammatic and statistical form, some of the more striking instances of activity and enterprise displayed during the past century by Great Britain in her commercial operations upon the high seas. One sphere of engineering industry, closely allied to navigation, is in no less degree remarkable for the evidence which it affords in confirmation of this energy in maritime affairs. Shipbuilding must almost of necessity be a staple industry of an insular country with commercial instincts and worldwide interests. Reliance by the inhabitants of such a country upon alien transport as the principal, if not the only, means of communication with other nations, would be a suicidal policy, and a visible indication of national decline and impending ruin.

Hence, before making any inquiry whatever into the matter, it is not unreasonable to anticipate the existence in Great Britain of numerous shipbuilding centres, combined with considerable development in the science and practice of naval construction. Nor is the expectation belied. The official returns issued by the British Board of Trade afford conclusive evidence upon the point, even if the fact be not patent from personal observation. Moreover, these returns furnish reliable indications, for a number of years past, of the degree of activity prevailing in shipbuilding operations carried on in various countries, whereby an effective comparison may be instituted and certain useful and instructive deductions made. The object of the present article is to collate and present this information in an interesting form.

It would, of course, be idle to attempt anything in the nature of a lengthy examination of shipbuilding statistics, even if returns for an indefinite series of years were forthcoming, which, indeed, is not the case. It is not necessary to retrace one's steps very far into bygone history before arriving at a period in which conditions were radically different from those obtaining at the present day. Records anterior to this date may have an antiquarian interest, but they are not of much practical value. The era of the wooden merchantman in all the glory of widespread canvas is gone beyond recall; it has disappeared as completely as the three-decker, the gallion and the trireme. We will, therefore, not pursue our investigations beyond the limit of half a century; in fact, it is desirable to confine it to the period subsequent to the advent of the *Great Eastern.*

The year 1860 marked an epoch in the history of British shipbuilding. It was a time of much controversy and dispute. The old order of things was passing away. After centuries of sail power, steam was becoming definitely and universally recognised as in every way superior for purposes of navigation. Iron was, moreover, rapidly supplanting timber in the hulls of vessels, and screw propellers were usurping the functions of paddles. Yet the old system died

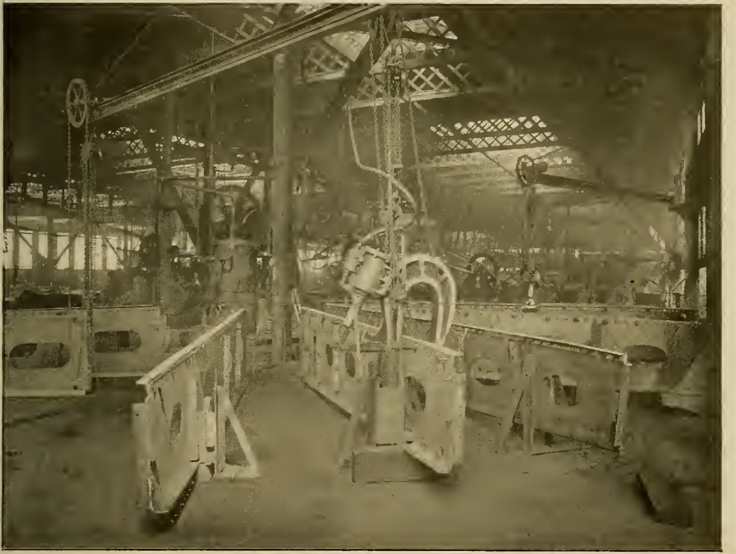
---

* CASSIER'S MAGAZINE, November, 1904.

THE TRIPLE-SCREW TURBINE STEAMSHIP "VICTORIAN," THE FIRST OF THE TWO TURBINE-DRIVEN SHIPS ORDERED BY THE ALLAN LINE, AND THE PIONEER TURBINE VESSEL FOR THE ATLANTIC TRADE. LENGTH, 540 FEET. BEAM. 60 FEET. DISPLACEMENT, 12,000 TONS. THE "VICTORIAN" WAS LAUNCHED LAST SEPTEMBER AT THE YARD OF MESSRS. WORKMAN, CLARK & CO., LTD., OF BELFAST hard. As much as two-thirds of the tonnage added to the British register at this date was wood-built, and the finest vessel of the day was a paddle steamer. Wood, in fact, continued to be more largely used than iron for nearly another decade. Despite, however, the most persistent and zealous opposition of conservative ideas, revolutionary changes were inevitable, and they came. The greatest scope in design afforded by the employment of metal and the restrictions removed from the determination of practicable and serviceable dimensions left no doubt as to the ultimate issue of the conflict.

In 1860 sailing ships accounted for 90 per cent. of the total tonnage of the British merchant marine; to-day they claim less than 10 per cent. and the ratio is daily decreasing. Paddle steamers have disappeared from other than river and coastwise traffic. Wood is no longer looked upon as a suitable material for ships' hulls. Even iron steamers have had their day, and have given place to steel vessels; scarcely any of the former are now constructed.

Let us look at some instances of shipbuilding enterprise forty years ago. Exclusive of the *Great Eastern*, which must always be considered an abnormal case, the finest steamers of the day were the *Persia* and the *Scotia*, both belonging to the Cunard Company, the former built in 1859, and the latter in 1862. There was not very much difference between them, either in type or size. Both were iron, paddle-wheel steamers, the first of 3300 gross tons, and the second of 3870 tons. The dimensions of the *Scotia* were, 379 feet length by 47.8 feet beam by 32 feet moulded depth; and of the *Persia*, 376 feet by 45.3 feet by 31.5 feet. Their engines developed horse-powers of 4900 and 4000, respectively. The average speed of the former vessel was 14.4 knots, and of the latter, 13.8 knots.



THE PNEUMATIC RIVETING SHED IN THE YARD OF MESSRS. HARLAND & WOLFF, BELFAST

How far these vessels were in advance

A STERN VIEW OF THE "VICTORIAN" BEFORE LAUNCHING. THE CENTRAL PROPELLER IS DRIVEN BY A HIGH-PRESSURE TURBINE; THE TWO OTHERS BY LOW-PRESSURE TURBINES of the bulk of their contemporaries may be gauged from the fact that the average gross tonnage of steamers exceeding 100 tons each was at that time 340 tons. At present the tonnage of the maximum vessel is not quite 24,000, and the average tonnage 2400, yielding a ratio approximately of 1 to 10, which is noteworthy as being the same in both cases.

The events of the ensuing period can be only very briefly summarised. In 1870 iron finally supplanted wood in the estimation of ship owners. Mild steel was introduced about seven years later, but owing to want of confidence and the somewhat higher cost at first involved, it did not immediately find favour. As late as the year 1885 twice as much merchant tonnage was in iron as in steel. For the past twelve years, however, steel has been pre-eminent, and now it enjoys a practically complete monopoly.

The actual extent and use of the three materials, and the relative number of sailing and steam vessels constructed at the present time, is indicated in Table I., compiled from Lloyd's Register, and showing the number of vessels of 100 tons and upwards added to the merchant navies of the United Kingdom, France, and Germany, respectively, during the year.

TABLE I

	Wood or Composite		Iron		Steel		Total		
	Sail	Steam	Sail	Steam	Sail	Steam	Sail	Steam	Grand T'tl
United Kingdom	3	0	0	4	11	453	14	457	471
France	21	1	0	0	0	30	21	31	52
Germany	0	0	0	0	6	74	6	74	80
	24	1	0	4	17	557	41	562	603

The growth and accretion of other constructional features is interestingly shown on page 238, which illustrates the changes in type of the various vessels of the Cunard fleet launched since 1840. Thus it will be noticed that the *Campania* and *Lucania* (1893) were the first vessels of that fleet to be fitted with twin screws, and that triple screws are being adopted for the *Carmania*, which is now building, while quadruple screws are projected for the new 25-knotters. These last and the *Carmania* are also to be turbine steamers. The change in size and profile from the *Persia* and *Scotia* to the latest designs is very noticeable.

An interesting comparison is also to be found in the dimensions of the finest boats on three prominent services at the dates named, as shown in Table II.

TABLE II

Service	Vessel	Date	Length, ft.	Breadth, ft.	Depth, ft.	Gross Tons	Speed Knots
Atlantic	Persia	1860	376	45.3	31.5	3,300	13.8
Atlantic	Baltic	1903	708.3	75.5	49.0	23,870	17
P. and O.	Ceylon	1860	306	41	28	2,000	12.5
P. and O.	Macedonia	1904	530.4	60.4	25.5	10,510	18
Cape	Roman	1863	270	32.4	23.6	1,280	11
Cape	Kenilworth Castle	1904	570.2	64.7	38.7	12,975	71 ½

Turning attention now to the aggregate growth of shipbuilding, there is much material for observation and reflection to be garnered from the diagram on page 242, which has been prepared from the Board of Trade returns for the period 1860-1903.

No more striking object lesson could be devised to demonstrate the very remarkable strides made by Great Britain, and latterly also by the United States, in this important industry.

We find that forty-three years ago the British output was somewhere about 200,000 tons per annum; in 1901 it reached the enormous total of almost a million tons. Although the United States had the same starting point, the maximum of that country in 1901 was but 50 per cent. of the British record, and last year it fell short of the same standard by 322,000 tons. The records for France and Germany are comparatively insignificant. They do not attain

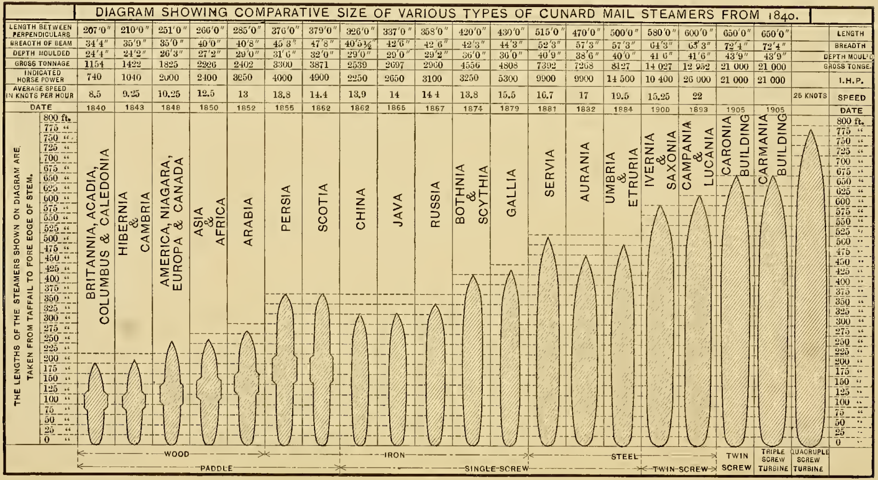


DIAGRAM SHOWING COMPARATIVE SIZE OF VARIOUS TYPES OF CUNARD MAIL STEAMERS FROM 1840.

	BRITANNIA, ACADIA, COLUMBUS & CALEDONIA	HIBERNIA & CAMBRIA	AMERICA, NIAGARA, EUROPA & CANADA	ASIA & AFRICA	ARABIA	PERSIA	SCOTIA	CHINA	JAVA	RUSSIA	BOTHNIA & SCYTHIA	GALLIA	SERVIA	AURANIA	UMBRIA & ETRURIA	IVERNIA & SAXONIA	CAMPANIA & LUCANIA	CARONIA BUILDING	CARMANIA BUILDING		
LENGTH BETWEEN PERPENDICULARS	207'0"	210'0"	251'0"	266'0"	285'0"	376'0"	379'0"	326'0"	337'0"	358'0"	420'0"	430'0"	515'0"	470'0"	500'0"	580'0"	600'0"	650'0"	650'0"		LENGTH
BREADTH OF BEAM	34'4"	35'9"	35'0"	40'0"	40'8"	45'3"	47'8"	40'5½"	42'6"	42'6"	42'3"	44'3"	52'3"	57'3"	57'3"	64'3"	65'3"	72'4"	72'4"		BREADTH
DEPTH MOULDED	24'4"	24'2"	26'3"	27'2"	29'0"	31'6"	32'0"	29'0"	29'0"	29'2"	36'0"	36'0"	40'9"	38'6"	40'0"	41'6"	41'6"	43'9"	43'9"		DEPTH MOUL'D
GROSS TONNAGE	1154	1422	1825	2226	2402	3300	3871	2539	2697	2960	4556	4808	7392	7268	8127	14 027	12 952	21 000	21 000		GROSS TONGE.
INDICATED HORSE POWER	740	1040	2000	2400	3250	4000	4900	2250	2650	3100	3250	5300	9900	9900	14 500	10 400	26 000	21 000	21 000		I.H.P.
AVERAGE SPEED IN KNOTS PER HOUR	8.5	9.25	10.25	12.5	13	13.8	14.4	13.9	14	14.4	13.8	15.5	16.7	17	19.5	15.25	22			25 KNOTS	SPEED
DATE	1840	1843	1848	1850	1852	1855	1862	1862	1866	1867	1874	1879	1881	1882	1884	1900	1893	1905	1905		DATE

THE TWENTY-FIVE KNOT EXPRESS TURBINE STEAMERS WILL BE THE LARGEST AND FASTEST STEAMSHIPS IN THE WORLD to the figures of Great Britain and the United States forty years ago. There is, however, a noticeable upward tendency in the later returns which augurs considerable expansion in the future.

Examining the diagram opposite, we cannot fail to be struck by the fact that there are certain well-marked epochs of energy and depression in the annals of shipbuilding, and that these fluctuations are more or less characteristic of the history of all four countries, simultaneously, though their coincidence is most evident and striking in the case of the two more prominent countries, viz., Great Britain and the United States.

The periods of depression occur in the years 1867, 1876-9, 1886, 1893-4, 1897-8, and at the present time. It is by no means an unexpected discovery to find that these periods synchronise with periods of depression in trade generally. The year 1866 was the date of the Overend-Gurney collapse, and there were a number of heavy commercial failures in 1875. In 1877 came the Russo-Turkish war, and in 1878 the stoppage of the City of Glasgow Bank. The year 1886 was another period of depression, and in 1893-4 a number of Australian and American banks stopped payment. In 1897-8 occurred the well-known disputes in the British engineering and coal trades, and, finally, the present indifferent condition of business is such common knowledge as to scarcely call for remark.

The peaks of prosperity were reached in or about the years 1864, 1874, 1882-3, 1889-91, 1896-7, and 1901-2. Somewhat curious it is to note the gradually diminishing interval between them. In the first instance the intercolation is 10 years, then 8½ years, 7½ years and 6½ years down to 5 years. Based on this experience, apparently the next culminating point will be somewhere about 1905-6.

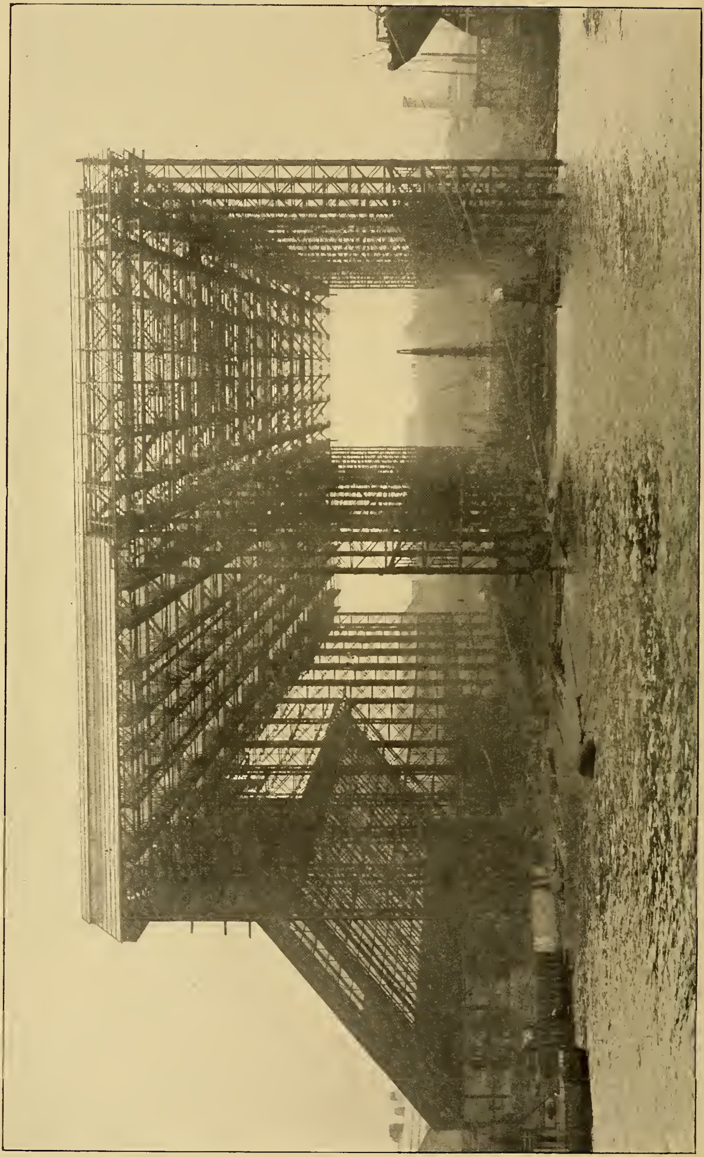
The prosperous years have produced some startling results, well deserving of notice. For example, the output of the United Kingdom for the year 1874 (603,867 tons) was greater than the tonnage of the combined merchant navies of Sweden, Denmark and Belgium at that time existing. In 1883 Great Britain achieved a record which held good for the ensuing fifteen years. The tonnage constructed in 1883 (892,216 tons,—more than three times the output of the United States) was nearly equal to the contemporary tonnage in the whole merchant navy of France, nearly double that of Russia, three times that of Holland, four times that of Austria, and almost twelve times that of Belgium.

The year 1901 saw another British record established, in which the contemporary output of the United States was not only doubled, but the whole registered oversea trading tonnage of that country was outdistanced by 100,000 tons. The British output (983,133 tons) exceeded the combined merchant navies of Spain and Belgium and nearly equalled that of Italy. Such have been the extraordinary results achieved by the energy and enterprise of British shipowners and shipbuilders in the past.

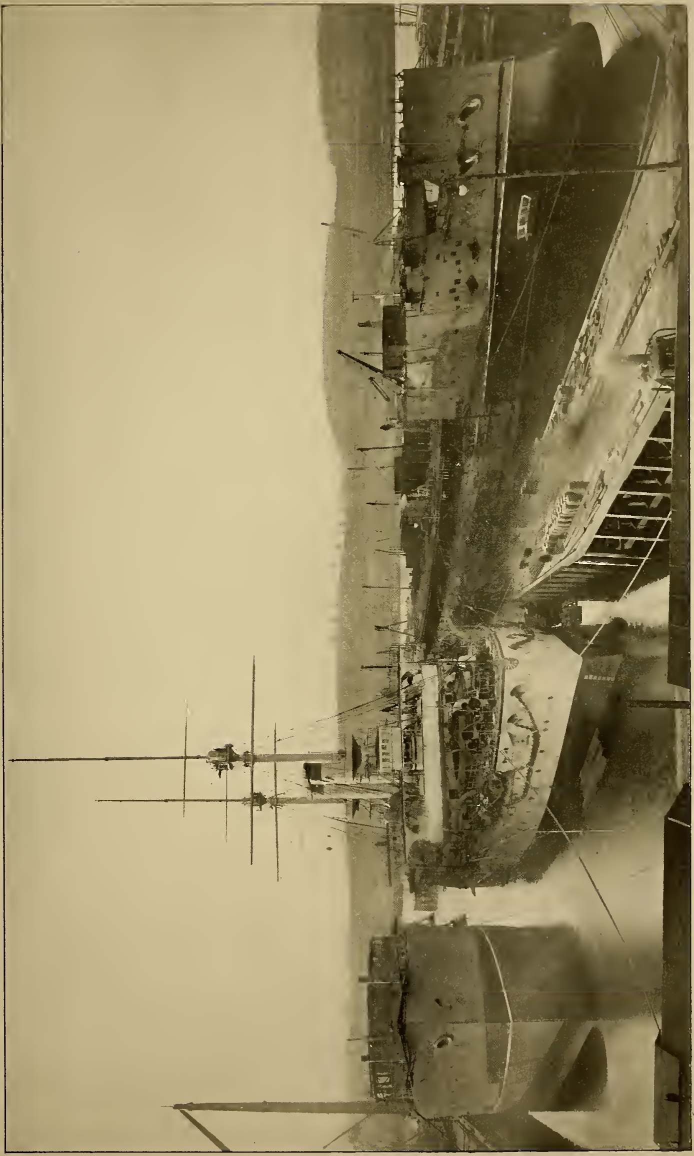
In the figures of 1903 there is a falling off of nearly 25 per cent. from the standard of 1901. The diminution is reported to be mainly in the class of ordinary, moderately-sized "tramp" steamers. The great cargo-carriers have, temporarily at any rate, suspended this class of vessel, and apparently it is the opinion of shipowners that the larger type is more remunerative, even though such vessels may not always be run at their full carrying capacity.

There is no doubt that a considerable reduction in establishment charges can be effected, and one large ship may discharge the functions of a couple or more vessels of smaller calibre but greater aggregate tonnage, without a corresponding increase in working expenses. However that may be, the leviathan cargo-boat first evolved in the Atlantic trade has been introduced into other services in various parts of the world, and there are now not less than eighty-five vessels of over 10,000 tons each in existence on the merchant register.

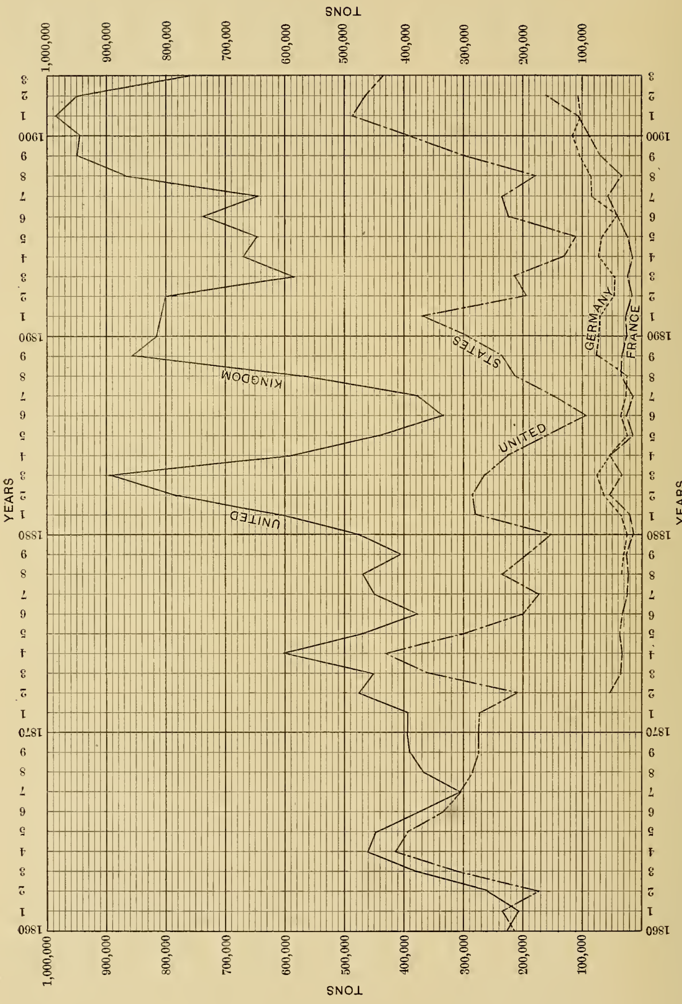
A comparison of the records of Great Britain and the United States is not uninteresting. In 1860 the two countries started under identical conditions; their



A VIEW IN THE YARDS OF MESSRS. SWAN, HUNTER AND WIGHAM RICHARDSON, LTD., AT NEWCASTLE-ON-TYNE, SHOWING NEW BUILDING SHEDS IN PROGRESS



THE FITTING-OUT BASIN OF MESSRS. JOHN BROWN & CO., LTD., AT CLYDEBANK, GLASGOW



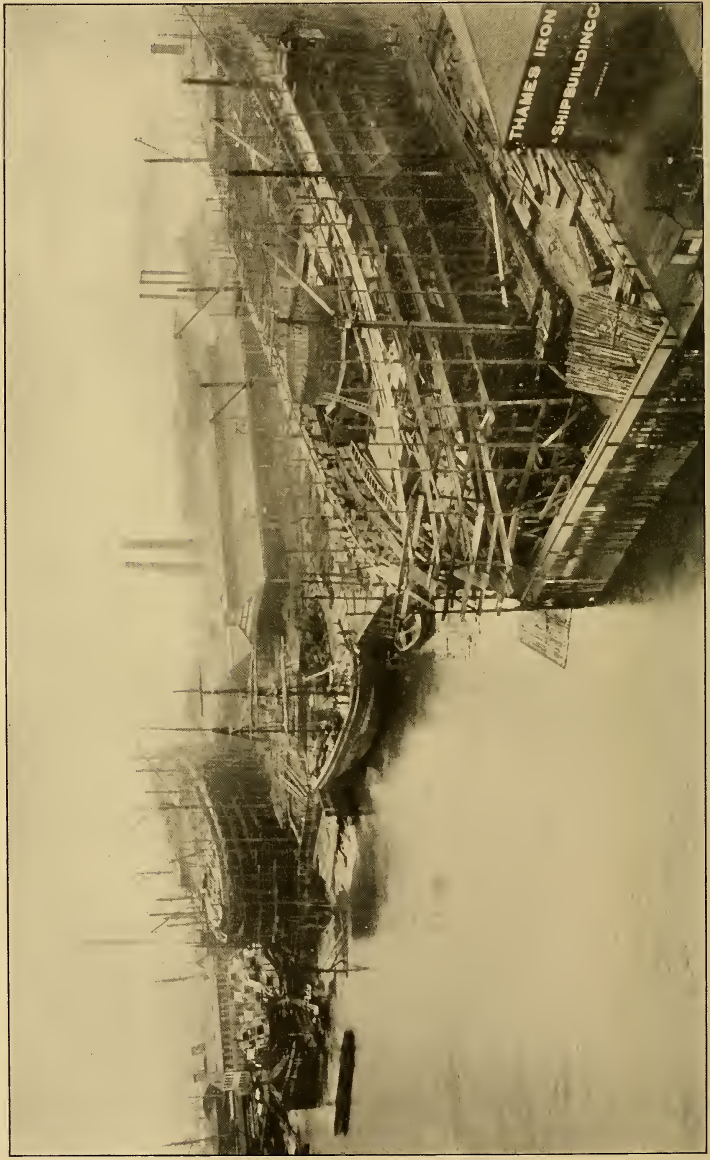
TONNAGE OF MERCANTILE SHIPS BUILT IN THE PRINCIPAL MARITIME COUNTRIES OF THE WORLD FROM 1860 TO 1903 outputs were approximately the same, and they possessed equal facilities for development. During the next six years the United Kingdom obtained a slight lead, which was lost in 1867, when the situation was relatively unchanged. From 1867 upwards, however, British shipbuilding has progressed at a much greater rate than American.

Striking a rough average, the annual British output has been increased in forty-three years by 700,000 tons, while the annual American output during the same period has been augmented by only 300,000; that is to say, the British rate of increase has been more than double that of the United States. This is the more remarkable because American exports have increased during the same time at a much higher rate than British exports. The carrying trade of the Atlantic has, in fact, passed into British hands, and with it the shipbuilding trade.

This indifference to their maritime interests on the part of Americans is, to some extent, intelligible, if we bear in mind the enormous tracts of country within their home jurisdiction, and the almost limitless spheres of enterprise which they have at hand in other directions than that of navigation. They are, to a very considerable degree, a self-contained and self-supporting people, inhabiting a country capable of furnishing the products of the most diverse zones and the most varying climes, so that the inducement to seek and exploit the resources of other lands is not so strong as in the case of Great Britain, which is practically dependent on extraneous sources for food supplies and the very necessaries of life.

THE SMITH'S SHOP AT HARLAND & WOLFF'S YARD, BELFAST. THE STEAM HAMMERS HERE SHOWN ARE FROM THE WORKS OF MESSRS. DAVIS & PRIMROSE, LTD., LEITH

The question now suggests itself:—Can the British supremacy be maintained? How far do present conditions favour the rivalry of foreign competitors? It is, perhaps, difficult to give a decided



THE YARD OF THE THAMES IRON WORKS SHIPBUILDING & ENGINEERING CO., LTD., CANNING TOWN. ON THE EXTREME RIGHT IS SHOWN THE JAPANESE BATTLESHIP "SHIKISHIMA" IN EARLY STAGES

A VIEW OF THE YARD OF MESSRS. WILLIAM DENNY & BROTHERS, AT DUMBARTON. TAKEN FROM THE TOP OF DUMBARTON CASTLE.

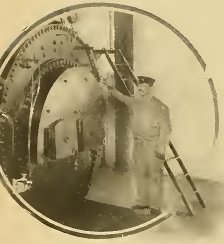
THE CLYDEBANK SHIPYARD OF MESSRS. JOHN BROWN & CO., LTD., NEAR GLASGOW, WHERE ONE OF THE LARGE CUNARD TURBINE STEAMSHIPS IS NOW BUILDING answer to the inquiry, but there are several grounds for believing that no serious change in the relative positions of the principal competing countries is likely to occur for some time. There have been lately, no doubt, searchings of heart in transatlantic circles, and several suggestions have been put forward with a view to promoting and encouraging shipbuilding on the American seaboard.

Subsidies have been mentioned and state recognition, to say nothing of an appeal to the national sentiment. But the last-named is not a very powerful argument with a hard-headed people accustomed to weigh business matters in dollars. The other inducements are artificial and of doubtful ultimate advantage. State subventions come, in the end, from the pocket of the individual, and he is not greatly disposed to foster weak industries at his personal expense, unless, of course, he can be convinced of some tangible advantage to be gained thereby. As a general rule, indigenous trades grow spontaneously and need no forcing-house; they are certainly hardier products, and they flourish the more under such conditions.

As assets on the British side, there are the considerations that shipbuilding is an hereditary instinct, and an industry vitally essential to the national welfare; that generations of training and experience have rendered the British shipwright an adept and the naval architect an expert in its practice; and that the country is favourably endowed with natural resources for the work. Finally, in regard to the large number of orders undertaken on foreign commission, there are the decided advantages of prestige and an unquestioned reputation for good workmanship and sound design. These count for a great deal in an age of fierce and keen competition.

CIRCULATION OF WATER IN STEAM BOILERS

By Egbert P. Watson



THE efficiency of a steam boiler depends very greatly upon the activity of circulation of the water within it; all its other qualities,—strength, durability, ease of access for repair, are secondary. Combustion may be perfect and the proportions of grate and heating surface correct, so far as experience can suggest; but if there be little or no circulation of the water from the hottest to the coldest parts, and the reverse, the boiler will be sluggish, slow to generate and quick to lose steam whenever a sudden demand is made upon it—in a word, inert. It will not fulfill the purpose for which it was intended. Defective circulation is very common in many types of boilers, and accounts for most of the troubles experienced from lack of steam where there should be plenty.

There are three kinds of circulation in steam boilers,—natural, artificial, and forced. The first is the most desirable, for it is that induced by the design. Artificial circulation is produced mechanically by baffle plates or their equivalent, causing the water to arbitrarily traverse certain channels when it would otherwise flow in the lines of least resistance. In the case of forced circulation the water is pumped or injected directly upon hot metal, which turns it into steam within an inappreciable time as compared with the usual methods.

Since the efficiency of a boiler depends upon its ability to turn water into steam as fast as possible with the least expenditure of fuel, one that will do this, all other things being equal, is the most desirable. Generators with forced circulation are called "flash boilers," and there are numbers of them in use for low powers, launches, automobiles, etc.; they occupy but little space, can carry very high pressures, and are inexpensive to maintain, being usually coils of pipe, which can be renewed cheaply when destroyed by conditions peculiar to them. These are that the heating surfaces, being at a high temperature and for some portion of the time not covered by water, absorb oxygen from it and rust out with more or less rapidity.

Since the feed enters the coils in a thin film or stream, it follows that it is vapourised quickly, depending mainly upon the condition of the hot surfaces. If they are smooth, the water is not in as intimate contact with them as if they were comparatively rough, or slightly scaled, for in the latter case the steam film existing between the water and the hot surface is broken up, letting the water come into absolute contact with coils. Of the truth of this the writer has satisfied himself several times by experiment, always with the same result,—an appreciable difference of time existing between the vapourisation, or flashing into steam, with smooth and with rough surfaces.

The writer is not aware of any data which give the relative efficiencies of vapourisation of flash and ordinary boilers; but in the former it is obviously the steam consumption of the engines driven by them, and as this in small engines is usually very high, the evaporation must be complete and rapid; and that it is, for flash boilers have very small heating surfaces compared with those which have a large body of water to maintain in constant ebullition. The action of a flash boiler could be improved in some cases by a different method of introducing the feed. If this enters at the top and is supposed to distribute itself over the heating surfaces by dripping down upon them, it is apparent that the top coils, which are the coldest, or farthest from the furnace certainly, are attacked first, while the hottest coils, or those directly over the furnace, tend to decompose the already formed steam into its constituent gases, and not merely to superheat it, which might be done where there is no body of water present to absorb the extra heat

Manifestly, if the feed entered at the top coil, as stated, the action would not be so thorough or uniform as if it were introduced at several places in the form of minute jets, or spray.

Flash boilers, however, are not popular or widely employed, though one type, the Serpollet, a French invention, has been in extended service in road vans and racing automobiles for many years, and would seem to be satisfactory for that reason if no other. Its heating surface consists of tubes very thick for their diameter (1⅛ inches), the wall thickness measuring 5-16 inch, with water passages only 1-16 inch through the tubes. The first impression would be that this opening is quite inadequate, from the danger to clogging from dirt in the feed-water, and also from pieces of scale being dislodged from the interior of the tubes themselves; but this apprehension has been shown to be groundless by experience with the generator. The unusual tube thickness affords a reservoir or magazine to contain the heat a long time, and being of *U*-section, the tubes are able to withstand enormous pressures; no less than 1000 pounds working pressure are said to have been carried on one during an automobile race.

As regards natural circulation, the vertical tubular boiler has none. A column of water of greater or less height is traversed by tubes emerging from a fire-box beneath them. Above the crown sheet the water is heated equally in all parts, except near the shell, where radiation makes it considerably cooler. The lower portions of the boiler, or the water legs, being underneath the fire, receive little or no heat, so that various temperatures may be found in the same boiler at the same time. The ebullition is directly upward and onward, no interchange between the upper and lower regions being possible. Still further to aggravate the difficulties of a vertical boiler, the feed-water is always introduced at the bottom, possibly for reasons of convenience. Thus, not only is the coldest water put into the coldest part of the boiler, but any mud deposited there during the night, or at other times when the boiler is idle, is dislodged and distributed through the boiler again.

Attempts have been made to remedy the want of circulation in vertical boilers by attaching tubes on the outside of the shell, entering into the steam space above the water, and terminating below in the water space. These tubes are intended to act as siphons; but, in practice, as the legs are of the same length, they are valueless, the water simply remaining in them motionless, and cooling rapidly by reason of the isolation of the tubes from the heated zones of the boiler proper. Another arrangement in vertical boilers consists in dividing the tubes into sections by a diaphragm, the intention being to make part of the heat ascend through the centre and pass by a down-draught through exterior tubes, and to emerge into a combustion chamber at the bottom, whence it goes to the chimney. Both of these devices are only makeshifts to remedy a poor design. A vertical fire surface is the least efficient of all; the gases from the furnace do not impinge upon it, but merely envelop it with more or less loss of heat from lack of complete contact with it.

Experiments were made a few years ago to determine the circulating efficiency of an inclined tube in a water-tube boiler by applying direct heat to certain parts of the tube. It was found that the tendency was to drive the water upward; but as this fact had been established prior to the experiment, no new practical knowledge was gained. Whether the water would have risen had the boiler been heated uniformly all over, as it is in practice, was not investigated.

A form of vertical, or slightly inclined, water-tube boiler was patented by the writer a few years ago. It is not now in the market, so that its principle can be described here without impropriety. Its circulation was established naturally by the action of the water itself, without any outside aids or appliances. The boiler consisted of a stack of tubes disposed in a circle, with a submerged fire-box in the centre. The tubes were also submerged at the upper ends, so that they were never exposed to fire on that portion. A water chamber was at the bottom and a water and steam dome on top; between the first row of tubes externally and their main body was a diaphragm. When the boiler was fired the tubes nearest the furnace were rapidly heated, causing the water in them to rise and flow over the upper tube sheet toward the outside of the boiler. When the water in these tubes rose, a corresponding quantity of liquid flowed down the outside row of tubes to replace it; this action went on continuously without cessation or forcing of any kind. That the movement was as mentioned, was demonstrated by removing the dome and watching the actual flow of the water. It was also proven by placing the hand on the bottom of the water chamber, when the hot water could be felt coming down the outer tubes almost as soon as the fire was started. Generation of steam was exceedingly rapid, but the evaporation averaged only eight to nine pounds of water per pound of coal. With our present knowledge of steam boilers it appears impossible to exceed these figures. In laboratory experiments we may obtain ten and eleven pounds of water evaporated per pound of coal, or about two-fifths of what we should have, according to the possibilities of carbon burned under the best conditions; but the routine of practice is very far from being in the nature of a chemical experiment, by which a pound of pure carbon undergoes perfect combustion. In place of pure carbon we have in practice only "the run of the mine," as it is called, or good commercial coal.

It seems proper in discussing circulation in a steam boiler to refer to certain elementary facts about the liquid with which we have to deal. These will account for some things which seem puzzling. One of these facts is that all liquids are very poor conductors of heat. Water in direct contact with a highly heated plate or tube absorbs heat with greater or less rapidity; tubes containing either fire or water, or hot plates, convey the heat generated in the furnace directly to those portions of the water in contact with them. Where the water spaces are contracted, the heat is immediately absorbed and steam is formed; but if this heat is to be transferred to bodies of water overlying the heated surfaces to any great depth, vapourisation is exceedingly slow. This is easily seen when we compare the time it requires to get up steam in a water-tube boiler and in a fire-tube boiler of the same relative proportions. Water is one of the poorest conductors of heat, and some portions of boilers of certain types remain merely hand warm when there are 100 pounds of steam up. Engineers of coastwise vessels have informed the writer that their boilers would not be uniformly heated until they had been many hours out of port. In such cases an improvement has been made by attaching pumps to the bottom, or coldest part, of the boiler, and thence transferring the water to the hotter zones above.

It seems anomalous that different temperatures should exist at the same time in the tubes of a horizontal tubular boiler; nevertheless, this occurs in some instances. Isherwood discovered this by placing certain metals whose fusing points were known in the tubes of boilers in action; he found that in the upper rows of tubes the temperature was higher than in the lower ones nearest the incandescent fuel. His exact words (Engineering Precedents, Vol. II., page 173) are:—

"With the horizontal fire tubes there was selected one over one of the middle furnaces and in the middle vertical row, the centre tube, from the top, and also from the bottom; in the mouths of these three tubes were placed (on separate tripods of slender iron wire about 1¼ inches high) small pieces of lead and tin, the purpose being to ascertain not only the absolute temperature of the emerging gases, but whether the heat was equally diffused among the tubes vertically. The result was strongly marked. In the lowest tube the tin was not melted; in the central tube, half way between the top and bottom, the tin was melted, but not the lead, while in the upper the lead was melted. Consequently, in the lower tubes the temperature of the emerging gases was less than 440 degrees F.; in the middle tubes it was more than 440 degrees, but less than 600 F.; while in the upper tubes it was over 600 F. * * * We have seen that the temperature of the heated gases emerging from the tubes of a horizontal fire-tube boiler varies enormously in the different rows of tubes, probably 300 degrees F. in the extreme top and bottom rows."

Isherwood's deductions, omitting his elaborate analysis as too long to be here given, are as follows:—

"The result is that from the lower row to the upper one the tubes have a continuously decreasing evaporative efficiency, owing to their absorbing a less and less amount of heat as they ascend, and, as a consequence, delivering their heated gases into the chimney at a continuously increasing temperature."

It may be inferred from the conditions just named that the circulation is also impaired by the unequal temperatures existing in different parts of the same generator. This is in direct contradiction to the often reiterated assertion that the temperature of a boiler varies directly with the steam pressure carried, which view was held for a long time by the present writer, until better information caused him to abandon it. It seems probable that violent repulsion of the water in some highly heated parts of the boiler causes an interference with an even supply of it to other parts remote from the fire; not only this, but the dispersion of the water from certain parts may cause false currents to be set up which divert the liquid from its natural flow into places where it may or may not be more efficient.

To a certain extent all these views must be accepted with some reserve. No one has ever been inside of a boiler under steam; therefore no one can say exactly what occurs under that condition. We can only infer from the inspection of a boiler long used as to what has happened during its term of service. Examination of this sort shows that the sediment or scale left by evaporation of the water is by no means evenly deposited all through the boiler; some parts will be covered thickly with it, while in others there is little or none. The writer has opened a very large number of boilers of all types and has been struck by this fact. It may be presumed that the circulation was so rapid in some places that the deposition of scale was prevented thereby, or that, as scale usually accumulates where the water is quiet, or at least quiescent, the circulation in other places was very sluggish to allow the deposit of sediment. Again, it has been found that in some parts the scale is softer than in others; portions of the incrustation are friable and easily disintegrated, while other portions cannot be cut with a steel tool. This seems to demonstrate the truth of what was mentioned in a previous paragraph, viz., that some parts of the heating surface are hotter than others.

Not the least evil which poor circulation of the water in a steam boiler entails is that of unequal expansion. Undoubtedly this is an important factor in shortening a boiler's life; certainly it necessitates frequent repair and renewal. The statement was made a few years ago that a Scotch marine boiler was very much longer on the top sheet than on the bottom when under steam, owing to the differences in temperature. When it is borne in mind that the plates of such boilers are over an inch thick, it can be appreciated that the strain induced by such expansion must be enormous.

THE MECHANICAL DRAUGHT PROBLEM

By Howard S. Knowlton

THROUGHOUT the entire field of engineering it is difficult to find a more interesting subject of study than the modern power station. Radical changes in design have marked the construction of successive installations from the earliest days of the electrical industry, and the best way to appreciate these evolutionary modifications in practice is a simple comparison of the plant of to-day with that of a few years ago. Three important features of design have become generally impressed upon engineers,—reliability, economy and flexibility of operation. It is now unusual to hear of a total shut-down of a great plant, and on every hand the problem of increasing operating efficiency is coming to the front; but in point of flexibility there is often much to be desired, even in the latest installations.

A study of various modern plants in different parts of the country brings one inevitably to the conclusion that the problem of mechanical draught is not receiving the attention that it deserves from power station designers and operators. Doubtless there are plenty of installations which are better off with the plain, old fashioned chimney; but there certainly would seem to be others that are missing opportunities to save money and enjoy the greater operating flexibility of mechanical methods of promoting combustion. The suspicion arises that in many recent designs the question has been entirely unconsidered. This may be due to simple apathy, or it may be caused by the designer's failure to appreciate the relative advantages and drawbacks of mechanical draught and chimneys. It would seem worth while, therefore, to point out some of the considerations which bear upon the problem of choosing between the two methods.

The advantages of natural draught as obtained through the agency of a chimney are generally well known. The chimney costs a good deal at first, but once it is built, the only direct expenses that it entails are those of interest, insurance, taxes, depreciation, and repairs. With the exception of repairs, these items are fixed charges.

The operating expenses are small, directly considered. Allowing 5 per cent. interest, 2 per cent. for insurance, taxes, and repairs, and, from long experience with chimneys, 1½ per cent. depreciation, the total annual charges thus amount to 8½ per cent. of the investment. The chimney makes no noise about its work; it discharges the products of combustion at a height ordinarily sufficient to eliminate all annoyance to neighbouring establishments; it has no moving parts to get out of order; occupies little real estate; requires no attendance, oil, waste, or other supplies, and is a simple, reliable piece of apparatus. Nothing short of an earthquake, cyclone or explosion will demolish a properly constructed chimney, and it is as permanent an adjunct to a power plant as the walls of the station building. Its operation is positive, although variable.

Mechanical draught, on the other hand, also has many notable advantages. It is extremely flexible, enabling the rate of combustion to be greatly increased during periods of heavy load and correspondingly decreased when the output is small. This feature makes it especially adaptable to electric railway plants suffering from heavy peak loads during the morning and evening hours, while at other times of the day and night a large reserve capacity in boilers is obliged to stand idle with fixed charges going on and with no compensating work to liquidate them.

The first cost is small in comparison with the capital invested in an equivalent chimney. Generally speaking, the cost of installing mechanical draught varies from about 20 to 40 per cent. of the expense of building a stack capable of doing the same work. The cost depends partly upon local conditions and partly upon the type of draught apparatus selected. Allowing 100 per cent. as the cost of the equivalent stack, a prominent authority on mechanical draught states that an induced draught plant with duplex fans is represented in first cost by 42 per cent., a single-fan induced draught plant by 26.7 per cent., and a one-fan forced draught plant by 18.7 per cent. Allowing interest at 5 per cent., depreciation and repairs at 4.5 per cent., and insurance and taxes at 1.5 per cent., the total fixed charges amount to about 11 per cent.

The cost of operation is, of course, the principal item of expense in a mechanical draught system. In one railway plant, equipped with 1600 horsepower in boilers operated by a two-fan induced draught system, the annual cost of operation of the mechanical draught apparatus was $682, including repairs. Six boilers were supplied with artificial draught, the steam pressure was 125 pounds, and the cost of coal for the fan engine of 5 horse-power was about 2 per cent. of the total fuel bill. The first cost of the draught apparatus was $2950, or $1.84 per horse-power of boilers served. Thus, the total cost of operation was 23.1 per cent. of the investment. The company allowed 4 per cent. depreciation, so that with interest at 5 per cent. and insurance and taxes at 1 per cent., the fixed charges were $295, and the total annual expense of the mechanical draught system was $977. The remainder of the plant was served by a chimney. Incidentally, the total rating of the plant was 3000 KW; the first cost $90.60 per KW; the annual output at the direct-current switchboard 431,600 KW-hours, the coal consumption being 2.9 pounds per KW-hour and the water consumption 28.07 pounds per unit of output. The cost of installing the mechanical draught apparatus was thus about 2 per cent. of the total plant investment.

Although in the case here cited an annual expense of almost $1000 seems a good deal to put into the operation of a mechanical draught plant, there are numerous other advantages to be considered. The fixed charges on equivalent chimney capacity would scarcely be less than 75 per cent. of the foregoing. Without the fan system the annual loss of money caused by the heat wasted in escaping chimney gases would be notably increased.

As every chimney depends for its operation upon the maintenance of a temperature difference between the external air and the products of combustion, it is evident that this loss can never be eliminated except by the substitution of artificial for natural methods of obtaining draught. Mechanical draught utilises a very large percentage of the heat which would otherwise be thrown away up the chimney. Without varying the draught it is next to impossible to maintain a constant steam pressure.

Both the intensity of the draught and the volume of the air supply can be adjusted and controlled, either manually or automatically, better by the fan system than by the ordinary damper regulator, useful as the latter device is. Although the loss of heat units by smoke seldom is above one per cent. of the total calorific power of the fuel, the increasing strictness of municipal ordinances in regard to the smoke nuisance constitutes a strong argument for the adoption of the superior methods of combustion represented by the various automatic stoker and draught systems. Mechanical draught will not, in itself, prevent smoke; but, in company with skilled firing or automatic stoking machinery, it is extremely effective. It provides a rapid, strong draught at the exact time when it is most useful.

From 5 to 10 per cent. of the heating value of fuel may easily be lost in the formation of carbon monoxide if the combustion is incomplete. This loss is done away with when the air supply for the furnaces is derived from a properly operated fan, and a large number of flue gas analyses show no trace of carbon monoxide when mechanical draught is employed. To secure good combustion it is highly essential that the air supply be forced in sufficient quantity into all the spaces between the fuel. Here it is that the flexibility of artificial draught enters with a nicety of control and a range of action capable of producing efficient combustion in the furnaces, adjusted in intensity to the load requirements.

Low grade fuels can be burned only by steady and intense draught. Thus it is difficult with a chimney to obtain sufficient blast to burn the smallest sizes of anthracite coal, which require a strong and concentrated draught. The lower efficiency of poorer grades of fuel may readily be offset by the decrease in their cost, provided the fuel is burned under proper conditions; and these conditions can scarcely fail to be supplied by mechanical draught. It has been stated that a simple change in grate bars is all that is required to adapt a boiler to burn practically clear yard screenings by means of forced or induced draught. In general, better results may be expected with automatic stokers when they are used with mechanical draught, on account of the positive and, perchance, automatically controlled air supply.

With the chimney damper wide open, an increase in draught and resulting additional output of the plant can be secured only by adding to the chimney's height. The admission of a little more steam to the cylinder of the fan engine solves the problem with mechanical draught. A further advantage lies in the fan's independence of outside weather and temperature conditions. Additional economy in fan-engine operation may be secured by utilising the exhaust steam for heating purposes.

Mechanical draught finds a special field of usefulness in connection with power plants which are operated wholly by waterfalls during part of the year, and which are reinforced by steam engines in the dry seasons. In most cases it is much cheaper to install a fan system for the allowable purpose of forcing the boiler output for a comparatively short time than it is to invest in additional boilers. As a substitute for the chimney in case of accident, artificial draught may be quickly and easily applied.

In solving the draught problem it is wise to provide every possible precaution to obtain continuous service. This is far more important than an increase in operating efficiency. A flexible arrangement is a combination of chimney and mechanical draught, each of which will serve as a supplement and relay in case of trouble or even in regular operation. Probably the greatest simplicity is secured by driving fans for mechanical draught by steam engines. It would seem that the possible greater economy of an electric motor-drive would be somewhat offset by the increased complication of the regulating and controlling mechanism. Published information in regard to motor-driven draught fans, their economy, and cost of operation in comparison with the single-fan engines largely in use to-day would be welcome to designers.

Enough has been said to indicate the importance of thoroughly going over the draught question before deciding off-hand to use either the chimney or its rival. If more space has been given in these comments to the advantages of mechanical draught over chimneys, it is only because the good points of the artificial method are as yet unrecognised in many places. Experience is not wanting with either method, and there would seem to be no excuse for not analysing both sides of the draught problem in deciding which combination to use.

Current Topics

WHILE the telephone was brought to Japan in the earliest days of telephone engineering,—about 1877,—its practical use was confined to auxiliary police service, and it was not until 1883 that the idea of starting telephone exchanges occurred to the authorities. A company was promoted for carrying on the business, and a petition was forwarded to the government asking for a license to start an exchange and carry on telephone service in Tokyo. That was in 1884. The question whether it should be carried out as a government undertaking or entrusted to private capital remained unsettled until 1889, when it was decided, after deliberation, to undertake the work as a state monopoly. As told by Saitoro Oi, in a paper read before the International Electrical Congress at St. Louis, an executive office was opened in Tokyo, and letters and circulars were sent out to business men, to the nobility, to government officials, to manufacturers, and, in fact, to any person in the city of more or less prominence. The opening of telephone exchanges was advertised in the popular papers, and subscriptions were invited from the general public. In addition, a switchboard and telephones were installed in the building of the Tokyo Chamber of Commerce, and in the Rice and the Stock Exchanges, and people of various occupations were invited to try the instruments in order to be convinced of the practical utility of the tele-

AN AUTOMATIC TELEPHONE CALL BOX IN A STREET OF TOKYO, JAPAN phone. Popular lectures also were delivered to give the public an idea of the commercial and social uses of the telephone. In fact, no pains were spared to secure a satisfactory result in the new enterprise, but notwithstanding such efforts only about 70 contracts were obtained in Tokyo and 20 in Yokohama when the construction of the lines was commenced. The service was started in Tokyo and Yokohama in December of 1890, the number of subscribers at that time being about 200 in Tokyo and 40 in Yokohama. However, the actual opening of the exchanges and establishment of communication between the subscribers spoke far more eloquently to the public than any letters, newspapers or lectures, and before long the facilities were far behind the demand. At the present time forty-six telephone exchanges are in operation, with 36,700 sub-stations. The seven largest exchanges, worked with multiple switchboards, are in the towns of Tokyo, Osaka, Kioto, Yokohama, Kobe, Nagoya, and Nagasaki, serving over 28,000 subscribers in a population of 3,920,000. The automatic telephone has come into use since 1899. In the just mentioned towns 117 automatic call offices are in use.

Insurance on vessels plying the Gulf of St. Lawrence and the river of that name is not particularly sought after by marine underwriters, owing to the well-known difficulties of navigation that beset those waters, which difficulties are somewhat augmented by a scarcity of lighthouses and light-ships between the port of Quebec and the Straits of Belle Isle,—a distance of about 731 miles. In the endeavour to better the conditions that prevail on this Atlantic route, arrangements are being made for the installation of thirty submarine signal bells in the St. Lawrence River and off the coasts of New Brunswick and Nova Scotia. These bells are submerged in the water to a depth of about 25 feet below the bottom of a light-ship, or from a buoy in proximity to a lighthouse. A large hammer, operated by compessed air from the lighthouse or light-ship, is caused to strike the bell at regular intervals during foggy weather. It is well known that water is a good conductor of sound vibrations, and in the system referred to the sound vibrations set up in the water by the bell are caused to operate a telephone transmitter that may be placed in the hold of any passing ship. In one of the arrangements used for this work a cup-shaped cylinder filled with water is bolted to the inside of the hold of the ship, about 20 feet below the water-line, a rubber flange on the edge of the cylinder next the hold making the cylinder watertight. A diaphragm at the upper end of the cylinder carries a microphonic transmitter, fitted with the usual battery and primary and secondary wires of an induction coil. The secondary wire is led to the captain's room or pilot house of the vessel, where a telephone receiver is connected in the circuit. When the sound vibrations from the bell reach the hold of the ship, they are imparted to the transmitter and may be heard as a sound in the telephone receiver. In practice, a cylinder and transmitter are placed on each side of the ship, so that by listening to the sounds alternately from opposite sides of the ship the direction from which the sounds are coming may be ascertained, since they will be louder in the transmitter circuit which is toward the bell. Knowing the code signals allotted to every lighthouse and light-ship, the mariner is thus warned of his approach to a dangerous coast, rock or shoal. If the fog-horn is blown concurrently with the striking of the submarine bell, it will be possible, by the aid of triangulation, to ascertain the distance and the direction of the lighthouse. It is said that a distance of from four to eight miles has been covered by this system of signaling under water.

It may be remarked that as long ago as 1877 experiments were described by M. Paul Laurencin, by which signals were transmitted under water by the strokes of a bell suspended from the stern of a ship, a long trumpet being submerged in the water on another vessel. By placing the ear to the small end of the trumpet signals were heard up to a distance of nearly one mile. It still remains to beseen whether any apparatus of this nature will be found of regular practical utility, —not so much that such systems may not possess inherent merit, but that in times of fog and storm the officers in charge are more likely to depend on frequent heaving of the lead than a more or less uncertain reading of signals.

In the meantime, it is interesting to note that wireless telegraphy is now doing good service on the St. Lawrence route in reporting incoming and outgoing vessels, there being at least four Marconi stations between the Straits of Belle Isle and Quebec,—namely, at Belle Isle, Point Amour, Heath Point, and Fame Point, distant from Quebec, respectively, 731 miles, 671 miles, 437 miles, and 322 miles. Commercial and social telegrams are accepted at any of the Canadian Pacific Telegraph offices in Canada, and are sent, prepaid, to the steamships equipped with Marconi wireless apparatus at a minimum rate of $2 for ten words and 12 cents for each additional word, in addition to the ordinary land charges. A somewhat curious feature of wireless telegraph operation noticed by some operators is that it is much easier to "hold" a station than it is to "pick" it up. On the chain of stations just mentioned one of the steamships of the Allan Line, the *Tunisian*, on one occasion got into communication with Heath Point station at 40 miles, and held the communication for 140 miles.

Smoke prevention ideas in new and attractive shape have been presented by R. S. Hale in a pamphlet recently issued by the Mutual Boiler Insurance Company, of Boston, for whom he is consulting engineer. One of the things to which Mr. Hale gives prominence is the fact that it is the actual quantity or weight of soot discharged into the air that causes trouble, while it is always the appearance of the chimney top that causes complaint. For instance, consider a furnace that gave dense black smoke for ten minutes each morning and each afternoon, or, say, twenty minutes in each twenty-four hours, or 1/72 of the time. If we compared such a chimney with one that gave only 1/10 as much smoke at any particular moment, but gave steadily some light smoke, the latter would cause much less verbal complaint to the smoke inspectors, but would really be giving about six times as much soot. We may also compare a battery of boilers, each with its own chimney, as against the same boilers delivering into a common chimney. If a single one of these boilers smoked very badly and the others not at all, then with individual chimneys there would be much complaint, while with a single large chimney for the battery the top would show only a light smoke, which would cause but slight complaint, although the amount of soot would be the same.

Another point that should be carefully considered, but that is not always thought of, is the question of central power stations. The electric light and power companies are in large cities almost universally spoken of as the worst offenders against the smoke laws, but a brief consideration will show that we could afford to let them send forth almost any amount of smoke rather than put any serious burden on them. The choice whether a small factory or an office building shall put in its own plant to make its own light and power, or, on the other hand, buy electricity from the central station, is a close one; but the central station runs on two pounds of coal per horse-power, while the isolated plant seldom gets under six pounds per horse-power. Hence, for the same amount of soot given forth into the atmosphere, the central station should be allowed to make three times as much

A SELF-PROPELLED STEAM FIRE ENGINE, BUILT BY MESSRS. MERRYWEATHER & SONS, LTD., LONDON

smoke. Still another point is that the amount of soot is not proportional to the colour of the smoke. A small chimney attached to a boiler that is using but a small excess of air may show a dense black smoke. Change this over to a large chimney and let a large amount of air into the flue at the base of the chimney. Then the colour of the smoke at the top will be much lighter, though the amount of soot may be the same as before. Supposing, for instance, that around a smoky chimney of 2 feet diameter we should build a shield 6 feet in diameter and 15 feet high, open top and bottom. If the original chimney extended just above the roof, then this shield would look merely like a much larger chimney. The smoke from the small chimney inside would be so diluted with air by the time it could be seen by the neighbours that no complaint would be made, although the amount of soot would be the same as before. While such a shield has never yet been built, Mr. Hale has no doubt that much of the difference between some chimneys that cause complaint and others that do not is merely the difference in dilution by air leakage into the chimney, and is not due to any difference in amount of soot discharged.

ONE of the absurdities of twentieth century engineering is the horse drawn steam fire engine in large city service. Self-propulsion for such engines has been talked of for the past twenty years, but the sum total of all that has been accomplished during that time towards dispensing with animal traction has amounted to relatively little,—a fact particularly noticeable in America, the generally accredited home of advanced ideas. Indeed, it appears to have been left to conservative British engineers to blaze the way, so to speak, in this field, and the result is that steam motor fire engines; petrol, or what in America would be called gasoline, motor fire engines; and even electrically-operated fire pump equipments, are currently advertised specialties of British make which ought to be worthy object lessons to American municipalities and fire engine builders. At least half a dozen British towns, if not more, have motor-driven fire engines, either steam or petrol, while Cape Town, in South Africa, and Valparaiso, in Chili, and even Mauritius, are equipped with petrol motor hose-carts and tenders, if not pumps. The petrol motor fire engine at present has probably the most immediately promising opportunities; but it is not at all unlikely that in the near future also there will be electric taps along city streets, exactly as there are now fire hydrants, from which electric fire pumps will be able to take current, the propelling power from the outfit being derived from electric storage batteries, which, in turn, may be recharged from the same taps. But whatever the power system, animal traction for fire engines should not be permitted to survive much longer; it should have disappeared with the horse car on city streets.

ONE of the lessons of the recent naval conflicts in the Far East between Russia and Japan, though it is one that has been well learned before, was that of the importance of having a well-trained and sufficient personnel to handle modern ships of war. In that respect Russia was badly deficient. Germany, one of the most vigorous of the younger naval-powers, has, for years, taken active measures towards providing trained men for her navy as well as for her merchant marine, and it may not be uninteresting, therefore, to note briefly what these have been. Schools of navigation were established by the Prussian Government as far back as the beginning of the nineteenth century. One of the earliest of these was the one at Danzig, opened in 1817, with the declared object of turning out competent sailors, pilots and captains. During the decade following, a number of similar schools were founded in other German cities, and preparatory schools were also organised in connection with all the regular schools of navigation. The popularity and value of these institutions are well shown by their wide distribution throughout Prussia. In 1902 schools of this kind were located at twelve cities, each of which has a preparatory school connected with it. The total attendance at the preparatory schools was 828 in 1901, and during the same year 472 pupils were enrolled at the regular schools. The character of the instruction given is eminently practical. Prussian schools for the instruction of pilots, sailors and other deck hands employed in inland navigation are also found at a large number of

AN ELECTRICALLY PROPELLED AND MOTOR-DRIVEN FIRE-PUMP, ALSO OF MERRYWEATHER MAKE places. These schools are well attended. Part of all expenditures which are not covered by tuition fees are met by the State and the rest is met by the cities, chambers of commerce, sailors' unions, and other interested organisations. During recent years the German Government has been paying much attention to the promotion of schools for navigation, shipbuilding, and naval engineering, for these institutions are powerful factors in the attainment of her ideals of commercial supremacy and naval power. In recognition of the growing need for education in this line, plans have been made for new schools, and courses adapted to the needs of naval engineers, shipbuilders and navigators are being given at a number of the technical high schools of the country.

IN view of the widespread attention recently given to statistics of railway accidents on American lines, it is interesting to note that Mr. Victor Hugo, chief inspector for the Hartford Steam Boiler Inspection & Insurance Company, has made a brief analysis of those accidents for the first half of the year just past, for the purpose of showing the importance of the element of human fallibility in railway engineering. His results are given in the following table:—

CAUSES OF RAILWAY ACCIDENTS

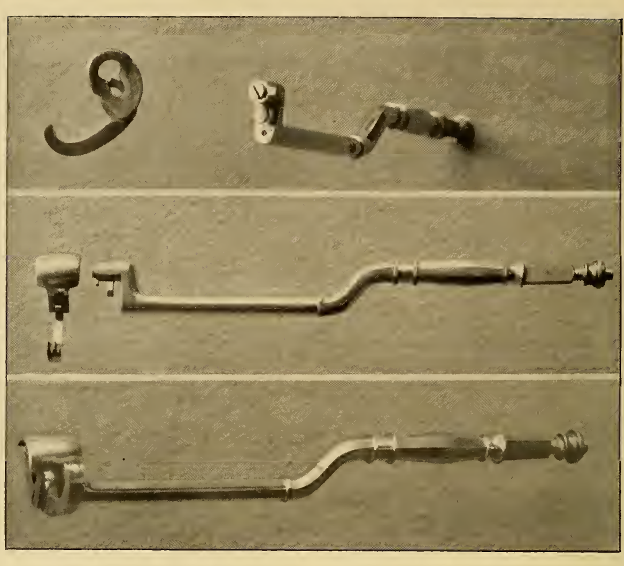
Nature of Cause	Percentage of Accidents Due to the Cause Assigned	Remarks and Explanations
"Mistake,"	28	Mostly mistakes in receiving or giving signals, or in writing or reading orders.
"Forgot,"	24	Just "forgot to carry out orders."
"Confused,"	8	Properly classifiable as mistakes, but separated here because attributable to excitement.
Physically incapacitated	8	Men fell asleep, presumably on account of previous exposure or exhaustion.
Malice	4	Malicious interference from persons not employed by the railroad.
Elements	12	Fog; snow-storm; heat of the sun.
Defective equipment	16	Failure of air-brakes and of car-wheels.

The accidents tabulated resulted in the death of 31 persons, in the injury of 164 others, and in the destruction of property valued at something like $300,000. It appears that 68 per cent. of the accidents were due entirely to the mental or physical state of the human agent. This does not mean, of course, that the efficiency of railway employees is only 32 per cent., for no account is taken of the thousands of cases in which he does not fail. The table shows, however, that when there is an accident, the odds are two to one that the man is at the bottom of it.

DEFINITE conception as to what constitutes an engineer and what an engineer should be is much needed among the people generally, and, for that matter, perhaps also among many of those whose duty it is to train and teach engineers. Professor L. S. Randolph, some time ago, before the Society for the Promotion of Engineering Education, remarked that proof of this is supplied by the multiplicity of scholastic degrees with the word "engineer" attached. The civil engineer retains his high position more than any other class. By civil engineer Professor Randolph meant all those included in the broad term of civil engineer, with the exception of what are sometimes called dynamic engineers. In a few of the old schools of engineering, which are thoroughly acquainted with the history of the profession, the courses of instruction are well fitted to the work to be accomplished. The danger comes from those who, having for their own work nothing of the training and preparation which is given to the civil engineer, seize upon the title of such high renown and boldly appropriate to themselves the accompanying unearned honours and emoluments. We have the man who fires the boiler and pulls the throttle dubbed a locomotive or stationary engineer; we have the woman who fires the stove and cooks the dinner dubbed the domestic engineer, and it will not be long, suggested Professor Randolph, before the barefooted African, who pounds the mud into the brick moulds, will be calling himself a ceramic engineer. Those of the teaching profession have seen how this thing goes and are familiar with the tonsorial artists who are called professors, and the dancing masters who have the same high-sounding title. In order to place the matter briefly, it can be said that the profession of engineering is to-day at the parting of the ways. If the engineer is to fulfill the definition which is so generally accepted, " as one who applies the discoveries of the scientists to the structural needs of mankind," Professor Randolph was of the opinion that something should be done at once, and that there are but two ways of handling the question. One is boldly to adopt a new title and leave the title of engineer, which is rapidly falling into disrepute, to the locomotive engineers, the domestic engineers, the sugar engineers, etc., who have caused its fall; or to begin a campaign of education which shall bring clearly before the public, before college presidents and boards of control what the engineer is, or rather what he should be.

In discussing the maxium distance to which electric power can be economically transmitted, Mr. Ralph D. Mershon, in a recent paper before the American Institute of Electrical Engineers, remarked that for a given voltage, drop, and distance of transmission, the cost of all the apparatus and equipment, except the line conductors, will increase more slowly than the output of the plant. That is, the greater the output of the plant, the less the cost per kilowatt of all the equipment, except the line conductors. This will be true of the operating expenses also. Therefore, since the interest charges and the charges for depreciation and repair are dependent upon the investment, the greater the output of the plant, the less will be the quantities going to make up the annual cost per kilowatt of transmitting power, except those depending upon the line conductors. Since the weight of the line conductors under the conditions assumed will vary directly as the amount of power transmitted, those elements of the annual cost per kilowatt depending upon the line conductors will be practically constant for all amounts of power transmitted, and cannot be materially reduced by increasing the amount of power transmitted. With the same voltage, economic drop and output, the elements of annual cost per kilowatt due to the line structure (pole line) and to its extent (patrolling, etc.), will increase directly as the distance. But, as outlined above, any increase of cost in line construction due to increase in distance can be offset by increase of output. On the other hand, the weight of the line conductors increases as the distance (for the same economic drop), and the elements of annual cost per kilowatt due to the weight of the line conductors will, therefore, increase as the distance, no matter what the output.

It appears, therefore, that all the elements in the annual cost per kilowatt for transmitting power, except those dependent upon the line conductors, may be continually reduced by increasing the amount of power to be transmitted. The annual cost per kilowatt due to the line conductors cannot be so reduced. It can be diminished only by such other means as will reduce the first cost of the conductors. As the first cost of the line conductors can be reduced only by increasing the voltage of transmission, and as there is a limit to which such increase can be carried, it follows that the limiting distance to which power can be economically transmitted will depend, finally, upon the cost of the line conductors and upon this alone. The limit of voltage referred to is not necessarily that due to physical considerations, such as difficulties of construction, air losses between conductors, etc.; for, leaving such matters



A TURNKEY AS USED IN EARLY DENTISTRY

out of consideration, it is easy to imagine the voltage carried to such a high value as will reduce the line conductors to the point where the increased cost of transformers and insulators, due to a further increase of voltage, will overbalance the saving in the line conductors, due to such further increase.

OIL well pumping service has opened up possibilities for the electrically-driven pump which appear to have been very promptly developed. Fire risks in the oil regions are important items, and their entire suppression by using electric power has helped towards a general adoption of it for pump driving. The advantages of the electric pump in other respects, however, have not been without influence. Oil wells generally are scattered over so wide a territory that any other power than electricity for operating them is both inconvenient and expensive. But with electric wires readily extended in all necessary directions, both drilling and pumping have become much simplified. In the Russian oil fields several large central stations have been put up,—the first one in 1901 on the shores of the Caspian Sea,—supplying power for pumps all over the district.

IN an early number of this magazine Professor John E. Sweet, in an article on "The Mechanics of Dentistry," mentioned a turnkey applied by the local cooper to the first tooth he ever had extracted. It is likely that to most readers this instrument of torture is unknown,—hence the probable interest of the accompanying illustration of the business part of one, which not only shows the instrument, but a fine specimen as well of the design and workmanship of the smith of three-quarters of a century ago. In addition to what is shown, there was a cross handle, like that of a gimlet, secured to the square at the end, which the operator could grasp and give a twist to the instrument. The hook shown separate in the upper figure could be slipped on either side, too, so as to make the instrument either right or left hand. When this hook was hooked over a tooth and a twist given to the handle, there was no such thing as slipping off, and if the assistant was able to hold the patient's head and the operator had a strong enough hand, the tooth had to come out. Often the jaw-bone was split open, and the victim, when complaining of the punishment, was always consoled by the assurance that the performer twisted it the wrong way.

LYMAN BUSHNELL BRAINERD

President of the Hartford Steam Boiler Inspection and Insurance Company

A BIOGRAPHICAL SKETCH

UPON the death, in December, 1903, of J. M. Allen, under whose guidance as president the Hartford Steam Boiler Inspection and Insurance Company grew from the smallest imaginable beginnings to the proud position of being the largest company of its kind in the world, the directors of the company were confronted with the sorrowful and difficult task of selecting a successor to him, who should be able, not only to maintain the high standard that he had established for the company, but also to carry on the work of its development in the future as efficiently as he had carried it on in the past. After much earnest deliberation, the board, last summer, elected Mr. Lyman Bushnell Brainerd to the position, by a unanimous vote, paying him, at the same time, the compliment of requesting him to continue to serve the company also in his previous capacity as treasurer.

Writing of Mr. Brainerd in *The Locomotive*, the organ of the Hartford Steam Boiler Inspection and Insurance Company, Mr. A. D. Risteen, the editor, says:—

The directors, in choosing Mr. Brainerd, based their decision upon his admittedly broad knowledge of finance and of insurance, and upon his ability as an executive officer. Of these qualifications, however, it is not necessary to speak further at the present time, for if the board has chosen wisely, Mr. Brainerd will speedily demonstrate them for himself. Mr. Brainerd was born in the town of Westchester, New London County, Conn., on March 27, 1856. He was the son of Asa Brainerd and of Susan E. Brainerd, and was one of a family of children consisting of five sons and three daughters. After leaving the public schools Mr. Brainerd attended Wilbraham Academy, at Wilbraham, Mass., and upon completing his studies there he began his career in the world by teaching school at Moodus, Conn. This school is reputed to have been one difficult to control. The pupils had taught the previous instructor some few simple physical exercises, which ended by his landing upon his native sod, just outside the window; and when they learned that a new candidate for similar honours had been discovered by the committee, they formally notified him in advance that his life among them was in a fair way to be a strenuous one. The outcome was, that Mr. Brainerd had some valuable experience; but the executive faculties that he has since developed in larger measure were sufficient for the emergency, and after two or three test cases had been devised by the pupils and put into unsuccessful operation, the school was reduced to order, and the physical aspects of the education gradually gave way to more tranquil intellectual pursuits.

Although successful in teaching, Mr. Brainerd had no desire to make that his life work, and he followed it only for a short time. On March 27, 1876, he entered the employment of Mr. Anson F. Fowler, of Middletown, Conn., who was agent for the Agricultural Insurance Company, of Watertown, N. Y., and under whose tutelage Mr. Brainerd took his first practical lessons in the fire insurance business.

On May 14, 1878, he became a canvasser for the State Mutual Fire Insurance Company, of Hartford, Conn., remaining with this company until May 14, 1879, when he left it to accept a more advanced position with the Jersey City Fire Insurance Company, of Jersey City, with which he continued for seven years. At the outset he was special agent for the Jersey City company, but after a time he was promoted to the positions of general agent and adjuster.

On August 16, 1886, Mr. Brainerd entered the service of the Equitable Mortgage Company, of New York city, as negotiator of bonds and other securities. In 1887 he was made secretary of this company, and in 1890 he became the manager of its bond department.

In the course of his connection with the Equitable Mortgage Company Mr. Brainerd was often called to Hartford, and he met, there, the representatives of most of the leading insurance companies. A friendship with Mr. J. M. Allen, late the president of the Hartford Steam Boiler Inspection and Insurance Company, was one of the results of these visits, and from it came an invitation to Mr. Brainerd to connect himself permanently with that company, as its assistant treasurer. The invitation was accepted, and Mr. Brainerd entered upon his new duties on March 2, 1894. In the following five years he became thoroughly familiar with the details of the company's business, and the success of his administration was such that on February 7, 1899, he was elected by the directors to the position of treasurer. Four years later, on February 10, 1903, he was also elected a member of the board of directors itself, and on July 12, 1904, as is already recorded above, he was elected president.

Mr. Brainerd's influence has been widely felt in Hartford business circles, and his advice is very generally sought upon the most varied subjects in insurance and finance. In addition to his official connection with the Hartford Steam Boiler Inspection and Insurance Company, Mr. Brainerd is a director of the Case, Lockwood & Brainerd Company, a director of the Security Company and a member of its finance committee, a trustee of the Society for Savings and a member of its loaning committee, a trustee of the Hartford Theological Seminary and chairman of its executive committee.

Personally, Mr. Brainerd is a kind-hearted, fair-minded man, full of devotion to the company's best interests, yet approachable by all, and considerate of all. In a word, the reins of management are in good hands, and there is every promise of the continued growth and prosperity, under his guidance, of the Hartford Steam Boiler Inspection and Insurance Company.

THE LATE NELSON STOW

THE INVENTOR OF THE FLEXIBLE SHAFT

SEE PAGE 342

CASSIER'S MAGAZINE

VOL. XXVII FEBRUARY, 1905 No. 4

A MODEL ELECTRIC MINING PLANT

THE FIRST HIGH-TENSION TRANSMISSION PLANT BUILT IN AMERICA BY A MINING COMPANY FOR ITS OWN USE

By H. A. Pharo

SCIENTIFIC readers, in general, are familiar with the remarkable development, during the past few years, of power transmisson by means of high-voltage alternating currents. But perhaps only the travelled few fully realise the extent to which this method is being put to practical use, especially in the far west of America. In sections where fuel is scarce and correspondingly expensive industries which would otherwise be prohibited can be carried on

CARRYING WOOD TO THE MILLS BY BURROS. THE OLD METHOD OF POWER SUPPLY

WOOD WAS HAULED UP THE MOUNTAINS ALSO IN WAGGONS WITH LONG SPANS OF HORSES

THE ELECTRIC TRANSMISSION LINE NOW TAKES THE PLACE OF BURROS AND WAGGON TRAINS

A VIEW OF THE POWER HOUSE AND SECTION OF THE DAM, LOOKING UP-STREAM

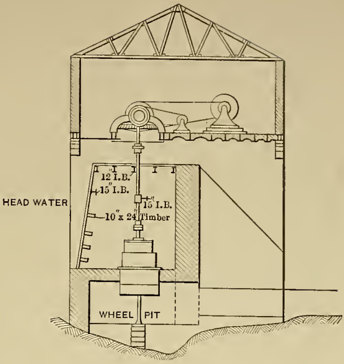
profitably by the use of electric power transmitted long distances.

Mining is one of the industries chiefly benefited by the use of electricity for motive power; primarily by reason of its cheapness it permits the treatment of ores of very low grades at a profit. The secondary consideration is that whatever power,—steam, air, or electricity,—be used in a mine, it must necessarily be very flexible and at the same time as efficient as possible. Although the two first-mentioned powers are flexible and efficient to a certain degree, they cannot compete with electricity in these respects. A comparative test, under average conditions, would show a wide margin in favour of electricity, especially if the latter be derived from a water-power generating station. It is not the intention of the writer, however, to enter into any mathematical comparison of the relative motive powers, but to give a simple description of a model electric equipment,—the first so-called high-tension system to be installed in America by a mining company for its own use.

About three years ago The Trade Dollar Consolidated Mining Company, which owns and operates extensive mining properties near Silver City, Idaho, decided to substitute electricity in place of steam for driving its mining and milling machinery. Coal at that time cost $17.50 per ton, and wood $9 per cord, delivered. This being an old camp, all the wood fuel supply had been exhausted, and the choice of water power for generating electricity with which to run the mines was a necessity. The immense amount of fuel used prevented satisfactory returns from portions of the output of the mines.

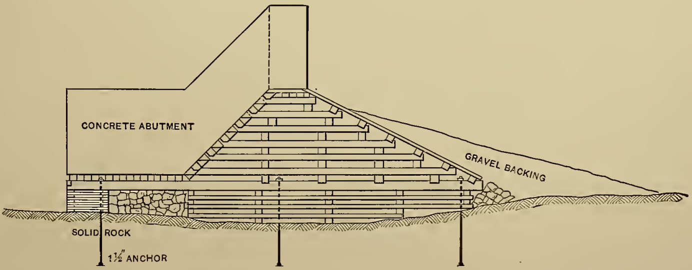
Having decided on the construction of a power plant, the power station was located at a point on Snake River known as Swan Falls, the river at this point flowing in a lava cañon about 700 feet deep. A sufficient water supply is obtained for power purposes by means of a dam, the artificial work of which is in two sections,—one part on either side of a small island in the centre of the river which is thus divided into two equal channels, each about 450 feet wide. During the survey it was found possible to utilise this island as a part of the dam, thus materially reducing the cost of construction. To the right is the overflow constructed after the manner usual under similar conditions.

The foundation is of heavy timbers, built up to a height sufficient to form the lower part of the apron. These are secured to bed-rock by anchor bolts, and are reinforced by rock filling and cemented boulders. Upon these foundation timbers are built the triangular-shaped sections of cribbing. This crib is 6 feet wide on top, with slopes of 2 to 1 on the up-stream and 1 to 1 on the down-stream side, with an apron 17 feet long on the down-stream side. To form the apron, the down-stream side of the cribbing and the top of the supporting timbers are covered with very strong selected planking, the covering of the top being 12 inches thick, and that of the apron, 10 inches thick. After having been rock filled, the rear or up-stream side of the cribbing was similarly covered with 4-inch planks, laid very close and backed with gravel. Each end of the overflow, which is 424 feet long, is flanked by masonry wing dams.



A CROSS SECTION OF THE POWER HOUSE

To the right or power house side of the island the dam is of solid concrete, 5 feet wide above and 9 feet wide below the river-bed, and 456 feet long. It is built up from bed-rock an average height of 26.5 feet, making its crest 12 feet above the crest of the overflow dam. To increase the strength of this portion, buttresses 5 feet wide were built at right angles to the dam on the down-stream side, 17 feet apart, and extending 20 feet down the stream from the main



A CROSS SECTION OF THE DAM

ANOTHER VIEW OF THE POWER HOUSE

wall. The entire construction in this channel is of concrete, made of Portland cement and gravel, usually in the proportion of 1 of cement to 9 of gravel.

The flow of water varies from 7000 to 70,000 cubic feet per second, depending on the season of the year. During extreme high water the effective working head is 17 feet, and 19 feet at extreme low water. At the lowest stage the theoretical horse-power of the water is 11,700, or something over 7250 electrical horse-power.

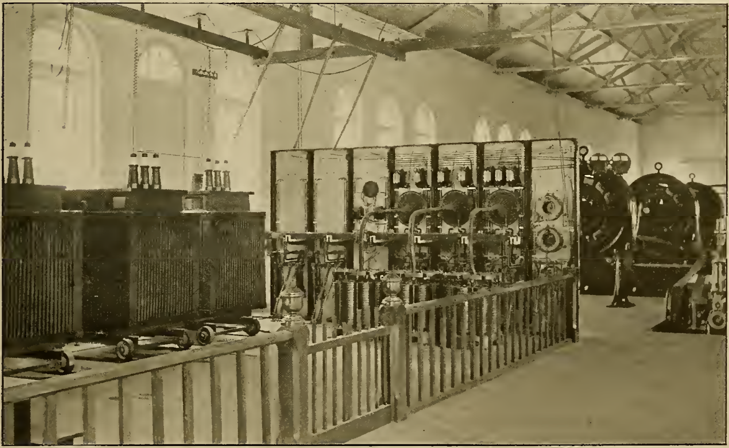
Serving both as the foundation for the power house and dividing walls for the wheel bays and draught tube outlets are seven concrete piers on either side of the dam; these are 5 feet wide at bedrock and 3 feet at the top of the dam, and form six wheel bays, each 19 feet wide. Each bay is walled up across the front to within 31 feet of the power house floor; covering the inlet openings of the bays are iron gratings for collecting débris from the water before passing through the wheels.

The power house measures, inside, 130 feet by 45 feet, and 17 feet to the top of the side walls, and special attention was paid to lighting and ventilation. The walls are composed of concrete blocks, 24 inches thick, moulded and laid after the manner of brick work. The end walls rest longitudinally on the outer piers, described above, while as supports for the side walls arches were built across the spaces intervening between the piers and surmounted by steel I-beams. The roof is of slate over pine sheathing, and is supported by steel trusses spanning the entire width of the building.

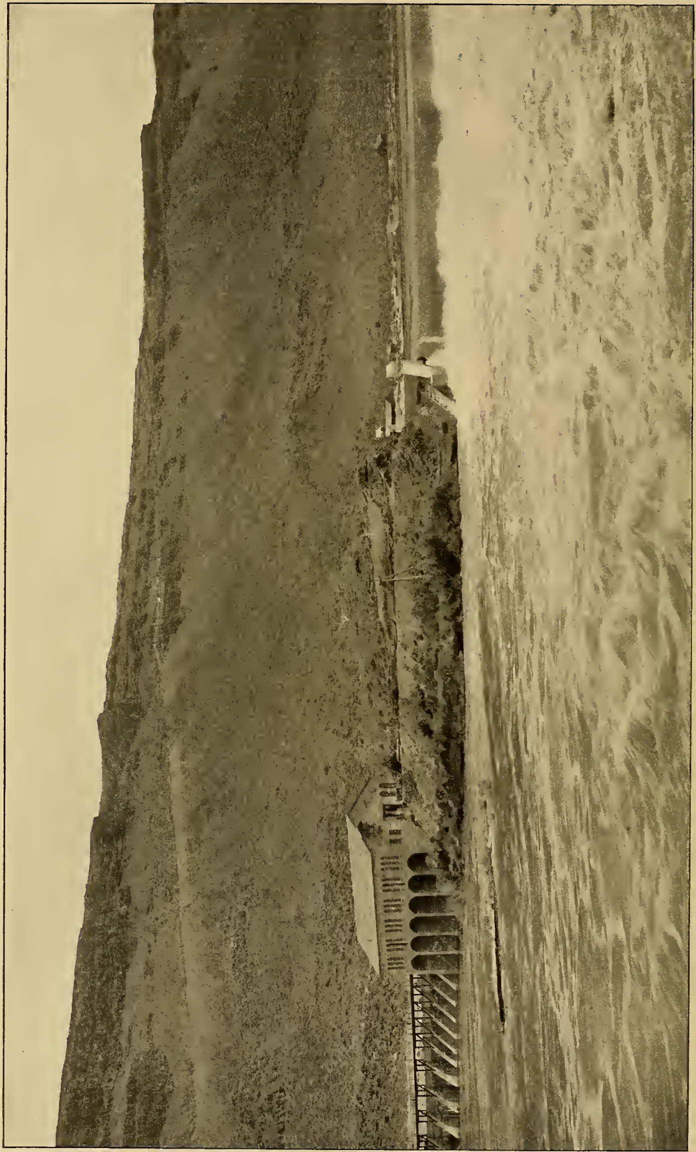
The power house structure, bulkhead, and such portions of the dam as are visible present an appearance of solid construction, combined with careful design, and the exterior of the station, while severely plain, presents, with its supporting arches and the still mill pond above, or with the white water of the spillway below, a picture that is most pleasing from every point of view.

The hydraulic machinery and appliances represent the latest practice of the S. Morgan Smith Company, of York, Pa. The plant comprises four 72-inch McCormick vertical turbines, each capable of developing 759 horse-power on a 17-foot head. The frames are bolted to a concrete flooring, 31 feet below the power house floor, the discharge tube being directly underneath. A feature of these turbines is the runner bearings. Each bearing consists of a stationary cup of lignum vitæ supported by a steel spider. The revolving part is a conical-shaped piece of the same material as the cup, or, more properly, the step, and these parts are turned to exactly fit each other. To compensate for wear in these bearings an adjusting device is provided to raise the stationary part.

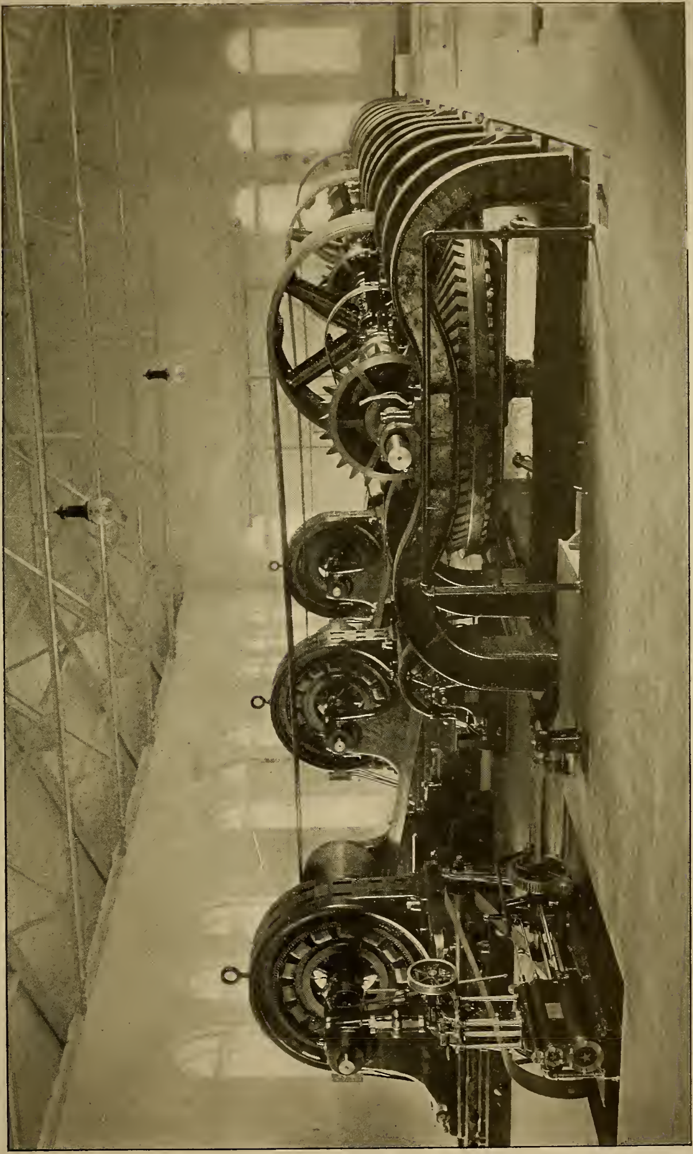
Attached to the top of each turbine shaft is a 72-inch crown gear, fitted with wooden teeth, and each of these gear wheels meshes with an iron pinion, keyed to a horizontal section of 6-inch shafting. These sections of shafting, as well as similar sections carrying the driving



THE INTERIOR OF THE POWER HOUSE, SHOWING THE STEP-UP TRANSFORMERS, AND A REAR VIEW OF SWITCHBOARD. THE 500-VOLT TWO-PHASE GENERATOR CURRENT IS TRANSFORMED TO 22,000 VOLTS THREE-PHASE



POWER HOUSE AND DAM, LOOKING UP-STREAM. THERE ARE FOUR VERTICAL TURBINES OF 759 H. P. EACH, MADE BY THE S. MORGAN SMITH COMPANY, YORK, PA.



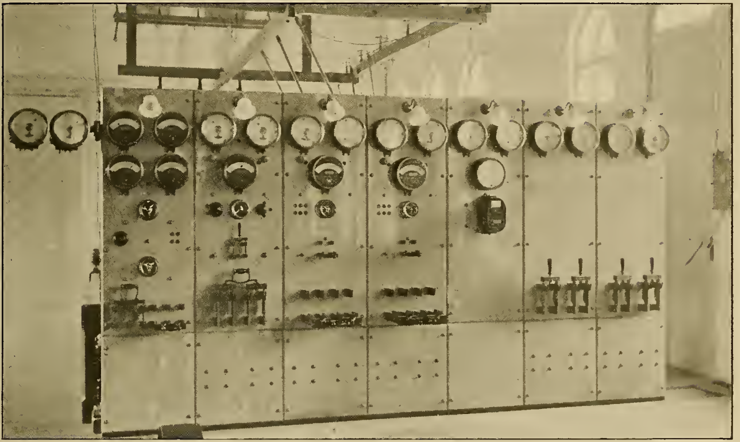
INTERIOR OF THE POWER HOUSE, SHOWING THE GEARS BETWEEN THE TURBINES AND COUNTERSHAFTS. THERE ARE THREE 300-K. W. ALTERNATING-CURRENT WESTINGHOUSE TWO-PHASE GENERATORS

HIGH WATER OVER THE DAM

pulleys, are supported by iron yokes bolted to I-beams, which set into the concrete piers. Either of the three sections, two of which carry smaller pulleys for driving the exciters, can be connected to one of two wheels by means of jaw clutches.

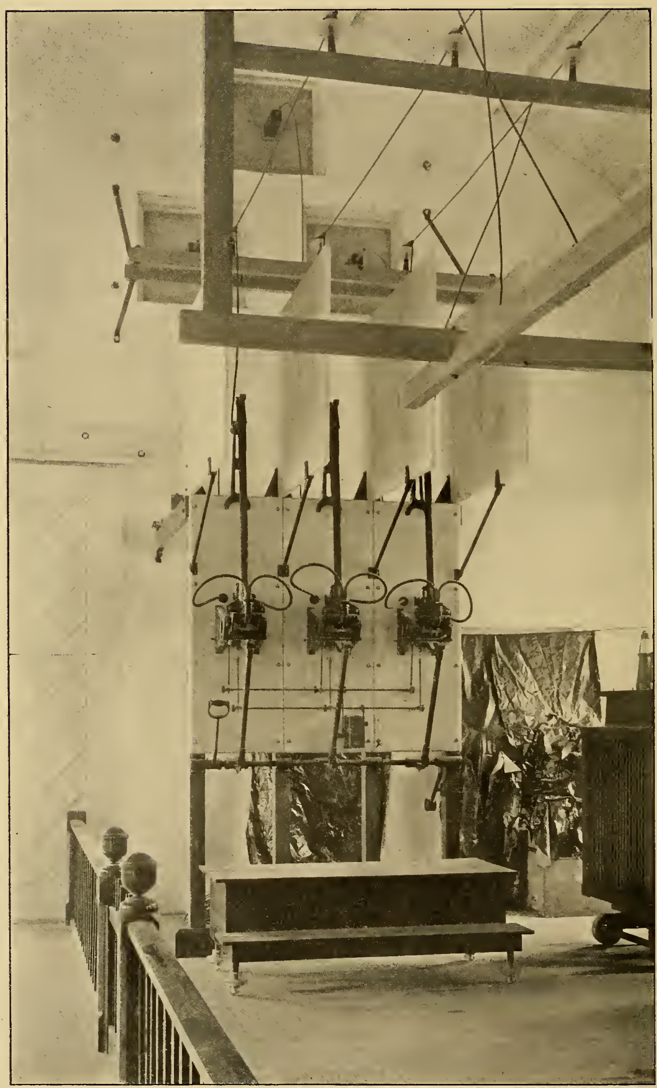
The turbine shafts revolve at 77 revolutions per minute, driving the head shafting at 230 revolutions per minute. One motor-driven governor, made by the Lombard Governor Co., of Boston, Mass., controls the speed of all wheels, in the following manner:—Running the entire length of the water-wheel harness, through bearing brackets, is a reciprocating rod, to which the governor is connected by means of a rack and pinion. The rod also passes through four similar rack blocks, having the teeth on the under side and meshing with 36-degree sectors, keyed to rock shafts. These rock shafts are mounted on the under side of the I-beam supporting the head shafting, directly over the centre of each wheel bay. Each shaft carries two tumblers; one end of each tumbler is connected to the cup gates, and the other to counter weights. To make the governor or hand wheel operative on a certain wheel, a key is inserted into keyways cut through the reciprocating rod at each end of the rack. Thus any movement of the rod will be transmitted to the rock shaft through the rack sector. Each gate can also be opened or closed by means of a hand lever, for which sockets have been provided on each of the rock shafts.

From the same countershaft driving the governor pump is belted a 4 × 6 double-acting pump, which forces water to a 25,000-gallon tank, placed at such an elevation on the hillside as to give a pressure of 100 pounds at the power house. This arrangement provides excellent fire protection to the community. The power house is equipped with two lines of 2-inch fire hose, allowing all parts to be quickly reached in case of need.



A FRONT VIEW OF THE SWITCHBOARD

The station equipment consists of three 300 KW, alternating-current generators, of the revolving-field type. They are driven by 44-inch belts at a speed of 514 revolutions per minute, delivering a two-phase current of 7200 alternations per minute at 500 volts. Exciting current is supplied from two 15-KW, direct-current generators at



FUSES OF THE HIGH-POTENTIAL CIRCUIT

125 volts. The exciters are also belted to the head shaft, the armatures revolving at 600 revolutions per minute.

The switchboard is simple, though of complete and attractive design. There are several panels of blue Vermont marble,—an exciter panel, three generator panels, a load panel, containing the instruments for indicating and recording the output, and two panels for controlling the feeders to the low-tension ends of the transformers. The wiring and bus-bars on the back of the board are well supported, and the whole construction is firmly braced to the floor, there being no vibration to the board. The generator field rheostats are of the railway type, mounted in iron frames, and are connected to the regulating dials which are attached to the back of the generator panels.

There are four raising transformers, each of 150 KW capacity, comprising two banks connected according to the Scott method; they transform from 500 volts, two-phase to 22,000 volts, three-phase. The transformers are mounted on iron trucks for easy handling, and the cases are grounded, the middle point of all low-tension windings being brought out to a non-arcing spark gap, one side of which is grounded. Each bank can be disconnected from the station high-tension bus-bars by means of bayonet switches. The high-tension current is admitted to the transmission line through a set of automatic circuit breakers, fitted with time limit relay. This device prevents the opening of the main breakers at once, when the trouble might possibly be on one of the branch lines.

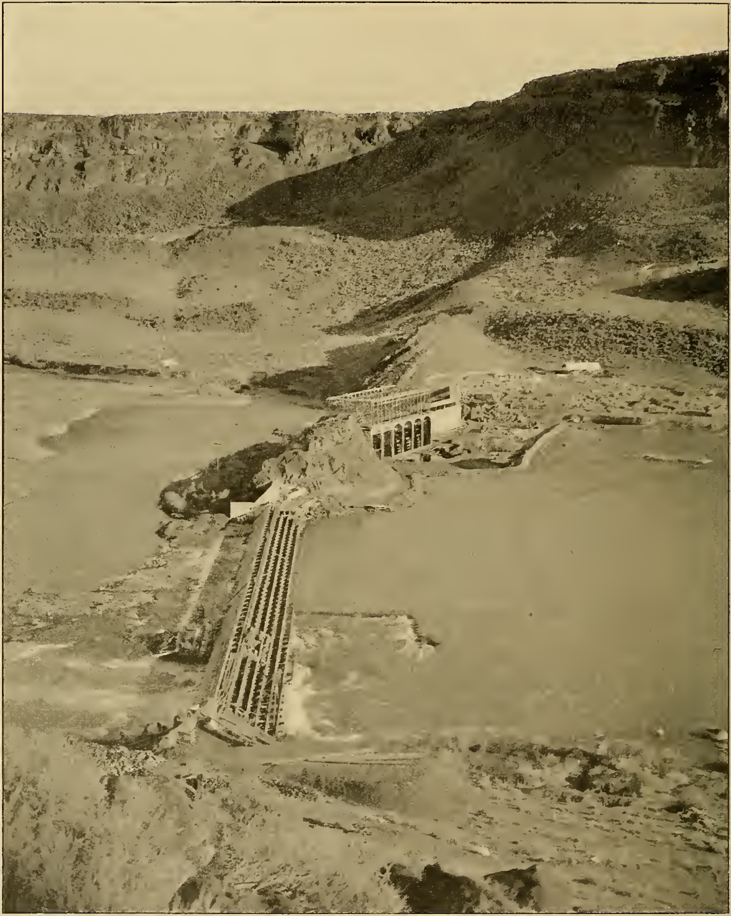
Single-pole static interrupters and low-equivalent lightning arresters protect the station apparatus from injury by lightning discharges and static disturbances on the line. All of the above electrical apparatus, in fact, the electrical apparatus used throughout the entire system, was furnished by the Westinghouse Electric & Manufacturing Company, of Pittsburgh. The station is lighted by numerous incandescent and three enclosed arc lamps; it is also heated by electricity, and a line is run to the dwelling house used by the operating department for the same purpose.

The line wires are passed through the wall of the power house in a very effective manner, consisting of insulated wire in two concentric hard rubber tubes, which are all threaded through the centre of a pine block boiled in paraffine. This entire construction is then passed through the centre of rectangular slabs of marble set in the wall. No mechanical strain is allowed on the central wire core, the strain of the line being taken on the bracket construction outside the building; the bracket arrangement is protected by a hood.

The pole line for the transmission of current from one end to the other is an excellent piece of work. The poles are straight cedar sticks, average 30 feet in length, have 7 inch tops, and are set 5½ feet in the ground. No measures were taken for the protection of the bases of the poles; but the tops, gains, cross-arms, and pins are painted with a preservative compound. The cross-arms measure 5¼ × 3½ inches, are 5 feet long, and are fastened to the pole by a ⅝ × 12-inch bolt. The poles are set with mathematical exactness alternately 106 and 107 feet centres on tangents; this, with the cross-arms placed on the sides facing each other on the longer spacings, gives an approximately constant span for the line wires. On curves the poles are placed nearer together and braced, no guys and stubs being used.

At turns a short cross-arm at the top of the pole is provided with an insulator on the side away from the centre of curvature, and to this insulator the top wire is anchored; this is to prevent the top wire from falling on those below in case it should become loose from its own insulator.

At a point 5 feet below the cross-arms two No. 12 steel wires for telephone service are carried on regular wooded side brackets and insulators, affording a perfect working local service. Two long spans are required, one to cross Big Snake River at the power house, and the other to rise to the top of the bluff. On these spans the distance be-



THE POWER HOUSE AND DAM DURING CONSTRUCTION

tween wires is increased, and "Phono-Electric" wire, made by the Bridgeport Brass Company, of New York, is used to insure sufficient strength.

The line wires themselves are No. 4 B. & S. bare copper, with the exception of the 450-foot span across the river, which is of by-metallic wire,—that is, steel wire sheathed with copper. The insulators, which are of the Mershon type and of glass, are so placed that the line wires are at the three corners of an equilateral triangle having sides 52 inches long; the upper insulator pin is set directly in the top of the pole, which is prevented from opening out by a wrought iron ring, driven on tightly. The triple-petticoat glass insulators were tested to 40,000 volts, and 12-inch locust pins are used for their support.

The main transmission line is 27 miles long to the distributing station at Dewey, the line being transposed twice, giving three sections of 9 miles each. From Dewey substation one line runs to Black Jack Mine substation, 1½ miles away, and another to the Blaine Mine substation, 4½ miles distant. These lines are identical in construction with the line from Dewey to the power house, except that no telephone wires are carried.

With the exception of the lighting circuits, the secondary distribution is three-phase. The step-down transformers are all duplicates. The line loss being approximately 10 per cent., or 2200 volts, these transformers are arranged to reduce from 22,000 volts to a series of voltages ranging from 409 to 480 volts. In addition, taps are brought out to give 110 to 220 volts for the small amount of incandescent lighting. The transformers at all substations are protected by three-pole static interrupters and low-equivalent lightning arresters.

All substations are constructed of iron frames with the roofs and sides covered with corrugated iron, with the exception of the gable ends, through which the high-tension wires pass. The under sides of the roofs are lined to prevent condensation in cold weather. These buildings were put up by the American Bridge Company, of New York, and are of substantial design. The floors are of concrete, and all the cases for transformers and static interrupters are connected to a ground wire running to a plate embedded in charcoal, placed in moist ground. The high tension wires are brought into the substations through construction similar to that described for the power house, with the exception that no marble slabs are here used. They are supported on glass insulators on wooden pins.

THE SUPERINTENDENT'S HOUSE

The secondary bus-bars are supported by a light angle-iron frame and insulated by hard rubber bushings. The secondary switchboards are of marble, and are equipped with the usual type of commercial switch.

At the Dewey substation there are three sets of automatic circuit breakers, controlling the Blaine and Black Jack branch lines and the bus-bars feeding the local step-down transformers. There are also three 37-KW transformers, delta-connected, and supplying power for a 75 H. P. induction motor belted to an Ingersoll-Sergeant two-stage air compressor; also for a motor-driven ventilating fan in the mine, and for lighting the company's buildings.

The substation at the Blaine mill contains three 37½ KW transformers, delta-connected. These supply power to a 100 H. P. induction motor driving the milling machinery, and light the mill and adjacent buildings.

At the Black Jack mill there are six 37½-KW transformers, comprising two banks, delta-connected. From one bank current at 461 volts is carried to the Black Jack mill to a 75 H. P. motor driving the milling machinery, and to a 50 H. P. motor belted to a reserve air compressor. The other bank delivers current at 480 volts to a set of feeder lines carried 2100 feet into the mine to a station. Here is located a 100 H. P. motor belted to an Ingersoll-Sergeant air compressor, pumping into common receivers with the compressor at Dewey. Air is used only for the power drills and the hoists. From the feeder lines mentioned above branch lines are carried into many of the slopes and drifts, for small blowing sets and for series lighting.

The actual work of construction of this plant was begun July 1, 1900, and it was put in operation on April 10, 1901, although it was not entirely finished until the middle of May of the same year.

The plant was designed and installed under the supervision of Mr. Lewis B. Stillwell, of New York, consulting engineer, Mr. James J. Johnston, of Chicago, consulting engineer, being responsible for the hydraulic part of the work. Mr. A. J. Wiley, of Boise, Idaho, was chief constructing engineer. The Mountain Electric Company, of Denver, Colorado, installed the electrical apparatus and constructed the pole line.

THE DEVELOPMENT OF CANADA

By George W. Colles

TWENTY-FIVE years ago Canada consisted of the territory lying north of the United States, east of the Great Lakes, and south of a somewhat uncertain boundary line paralleling the Ottawa and St. Lawrence rivers; and it comprised but four provinces,—Ontario, Quebec, New Brunswick, and Nova Scotia. North of Minnesota lay a little rectangular block of land called Manitoba; and on the Pacific coast were located the two provinces of British Columbia and Vancouver Island. All the rest of the territory between the United States and the Arctic Ocean was denominated vaguely "British America." Since then the Dominion Government has assimilated the other provinces and extended itself over all the remaining territory, so that "British America" no longer exists, except as a synonym for Canada. This territorial expansion was an outward sign of a young and growing national sentiment.

The appropriated territory being, except that part immediately adjacent to the United States boundary, practically devoid of inhabitants, experienced no immediate change; but, being now an integral part of Canada, the government set to work energetically to develop it. It was parceled out into nine territories,—Assiniboia, Saskatchewan, Alberta, Yukon, Athabasca, Mackenzie, Franklin, Keewabin and Ungava, and great extension was made of the boundaries of the old provinces, Quebec and Ontario, which are now each given an opening on James Bay. Of the above mentioned, only the first four have any regular govermental administration; the remainder are mere paper-divisions, and at the present time cover territory uninhabited except by Indians or Eskimos.

In order to give an idea of the immense extent of territory involved, the several divisions, their areas and population (estimated 1902) are detailed below:—

AREAS AND POPULATION OF CANADIAN PROVINCES

Division	Area Sq. Mile	Population	Population per Sq. Mile	United States State of Same Approximate Area
Nova Scotia	21,428	459,574	21.4	West Virginia
New Brunswick	27,985	331,120	11.8	Maine
Prince Edward Island	2,184	103,259	47.2	Delaware
Quebec	351,873	1,648,898	4.7	Texas, Louisiana and Mississippi
Ontario	260,862	2,182,947	8.4	Texas
Manitoba	73,732	255,211	3.5	Nebraska
British Columbia	372,630	178,657	0.48	Texas and Arizona
Assiniboia	88,879	67,385	0.76	Idaho
Saskatchewan	107,618	25,679	0.24	Nevada
Alberta	101,883	65,876	0.65	Colorado
Yukon	251,965	27,219	0.11	Texas
Athabasca	196,976	25,490	0.01	Colorado and Wyoming
Mackenzie	562,182			Southern States and Missouri
Franklin	500,000			Southern States
Keewatin	470,416			Southern States, except Louisiana
Ungava	354,961			Texas, Louisiana and Mississippi
Newfoundland	42,734	220,000	4.0	Tennessee
Labrador	12,000			Massachusetts and Connecticut
Total	3,800,308	5,591,315		

The total area (including Newfoundland and Labrador), which have not yet become assimilated to the Dominion Government, but are here considered a part of Canada) is slightly larger than the whole of the United States, including Alaska (3,567,563 square miles), and very much exceeds in area the body of the United States proper (2,970,230 square miles).

It must not be imagined that this newly incorporated area, or even the greater part of it, is a barren waste. The fact is that only the most northerly and easterly parts, embracing the territories of Franklin (comprising the Arctic Islands) and Ungava and parts of Mackenzie and Keewatin, are considered barren and valueless, and even this area may hereafter prove of economic importance; while the southern territory is now known to be fully equal if not superior in its possibilities to an equal area of the United States to the south of it.

The natural resources of Canada,—both agronomic and mineral,—are indeed immense, and it is surprising that the country should have remained so long unnoticed and so little exploited. But Australia, New Zealand, South Africa, Mexico and the western United States have each had their turn, and that of the Canadian provinces cannot be much longer delayed.

The thing that most strikes the attention as one passes the boundary line from the United States into Canada is the abrupt transition from a state of bustle and activity to a leisurely and provincial existence; compare, for example, the neighbouring cities of New York and Montreal, Buffalo and Toronto, Detroit and Windsor. From a statistical standpoint, it is the disparity in population and wealth. In 1902 the United States had about 79,000,000 inhabitants; Canada, 5,600,000, or but one-fourteenth as many. Yet Canada had considerably the start of the United States in the matter of colonisation, and Quebec was a flourishing town when the Pilgrim Fathers landed on Plymouth Rock.

Compare, for example the two colonies of Nova Scotia and Massachusetts,—the natural opportunities all in favour of the former, the material wealth all in favour of the latter. First discovered and earliest founded of the continental colonies, endowed above measure by fortune with the opportunities for wealth, with a long coast line, numerous excellent harbours, proximity to Europe, insular climate, valuable forests, rich agricultural land, inexhaustible fisheries, and, above all, with mineral riches, such as coal, iron, gold, lead, and copper, in profusion, its comparative poverty and the miserable and illiterate condition of a large proportion of the population of Nova Scotia seem positively inexplicable when we turn to the Commonwealth of Massachusetts, with a rugged and infertile soil and none of these advantages, and yet the richest similar area of ground in the world. Have we here the parable of the talents?

We cannot justly account for this great disparity in growth of the two countries by any contrast in their natural resources, situation or climate. It is an open question whether the resources of Canada are not even greater than those of the United States. Canada lies much closer to Europe; and such differences in climate as exist are not such as to conduce to any slackening of activity, as is seen at a glance by comparing, for example, the cities of St. Paul and Duluth (in the latitudes of Montreal and Quebec, respectively) with their more southern rivals.

The real cause of the difference must be sought in the character of the population; and this has been the active cause from the first. Canada was originally a French colony,—New England and the other American colonies substantially English; and the different colonising abilities of the French and English races is a truism of history. But there is another consideration no less important. Only one province of Canada is really French; the others are Anglo-Saxon. Nova Scotia was settled by the Scotch,—a hardy race. But the Pilgrims and their descendants were the sturdiest of the sturdy,—the independents, the congeners of Hampden and Cromwell,—and when royal tyranny again asserted itself they were the ones to rebel. Here was a ground of solidarity between the colonies which did not extend to Canada, for it ill-fitted with the submissive, quiet-loving and unprogressive character of the French colonists; and the contrast was emphasised and confirmed by the settlement of Ontario province by our Tory refugees. Thus the United States were welded by the heat of the Revolution into a new nation, not only free, but eager to grow and to progress; while Canada had no such uniting influence, —on the contrary, the English settlement in Upper Canada introduced an element of racial discord which is still felt there and which has aggravated the condition of disunity.

With the growing prosperity and fame of the United States came an increasing influx of settlers, then of the best that Europe could afford; and these, of many nations, were welded into one, the effect being, as usual in crosses, to " ruin its blood, but much improve its flesh." A new race was produced, more fruitful and more vigorous than any of its component parts, and the development of the soil went on at an unprecedented rate.

Meanwhile, the racial antagonism in Canada between Ontario and Quebec was not allayed by the legislative union of 1841, and the maritime provinces held apart from both. Decades after the east and west of the United States had been bound together by railroads there was no means of intercommunication between the detached provinces of Canada save through the United States; not, in fact, until, despairing of private enterprise, the Dominion Government itself took hold and pushed through the Intercolonial Railway to Halifax on the east in 1876, and the Canadian Pacific to Vancouver on the west in 1885.

The above bit of history will lead the reader to a better understanding of the actual nature and situation of America's Canadian neighbours. Isolated from one another and from the world, with different manners and customs, each engrossed in its own household labours and dependent for its manufactured commodities on the United States, it is clear that nothing like a national spirit or characteristics could be built up; but each retained the sympathies and traditions of the mother country,—France, England, or Scotland,—and acquired withal a certain provincialism and (from the American viewpoint) old-fogyism. Their political union was brought about not by any sense of mutual attachment, but rather by their common and increasing fear and jealousy of the United States, the occasions for which were, first, that country's needlessly aggressive and short-sighted tariff policy; and second, the American Civil War and the fear of invasion aroused by it.

The formation of this new nation has had, and is having, vast results, which cannot but be beneficial to both nations. A new national spirit has been rapidly developed, and with it the desire to develop the national resources. Lands have been surveyed and laid out, inducements offered to settlers, agricultural stations established, and great public enterprises undertaken. Among these latter may be mentioned the new Grand Trunk Pacific Railway, destined to open up a wide zone of the northern territory extending from ocean to ocean; the dredging of the St. Lawrence River to permit deep-draught ocean steamers to reach Montreal, and the great Trent canal joining Lake Huron with Lake Ontario, which will give a short cut, saving hundreds of miles in the transportation of grain to the seaboard and deflect trade to Montreal.

As regards antagonism to the United States, it is difficult to say whether it is on the increase or decrease; but it is certainly a factor to be reckoned with in many districts. This anti-Americanism is confined to the English-speaking natives, and, so far as the writer's observation goes, to Ontario province; the aversion of Jean Baptiste is more universal, taking in, in fact, everything and everybody that is not French, but more especially the people of Ontario.

Much unfavourable comment has been made upon the recent action of the Dominion Government in excluding American engineers from the work on its new transcontinental railway; however, it must be said that, first, the government was entirely within its rights, and, moreover was doing no more than the United States Government does on like occasion; and, second, that the case seems to have been one of particular provocation. During a residence of nearly two years in Canada, and occupying a good Canadian position, the writer, though American, never met with the slightest antagonism on the part of the English-speaking Canadians, nor with anything but welcome and courtesy.

Canada's resources and their development may be classed under four heads: —agricultural, fisheries, timber, and mines. As this is written for engineers, the first two do not concern us directly; but a word or two will not be amiss, for there is no doubt that the question of food, and hence of labour-supply, and hence also of manufactures, is one of vital, if only indirect importance.

The profitable agricultural area of Canada, when communications are properly developed, extends over a belt having for its southern boundary the United States, and, for its northern, a line extending from James Bay east to the Gulf of St. Lawrence, and in a west-northwesterly direction to Skagway, on the Lynn channel. Needless to say, the majority of this vast area is still a wilderness; but a part of the remainder, especially in Manitoba, comprises the richest wheat-land in the world, and much more almost equally rich is being rapidly developed,—more rapidly, in fact, than new elevators and freight cars can be provided to care for the grain. The eastern plains of the Rockies, in Alberta and Assiniboia, lie in the subarid region, and can be tilled profitably only by the aid of irrigation, and great irrigation projects are now being carried out. In the meanwhile, the land is devoted to cattle ranches, which are even more valuable than those of Montana, Colorado, and New Mexico, for the snow is so light in winter as not to form any serious obstacle to grazing, and the ranches are not subject to the tremendous blizzards that sometimes wipe out whole herds on the American Western plains. The northern limit for grasses reaches to the mouth of the Mackenzie River.

The subject of agriculture must not be left without a reference to the lately discovered "clay belt" of Northern Ontario,—one of the features that new explorations are bringing to light. This clay belt stretches continuously from the Quebec boundary, near James Bay, westward, and contains 16,000,000 acres of farming land, thought to be equal to that of the neighbouring Temiscaming district at the headwaters of the Ottawa, recently opened for settlement by both the Quebec and Ontario authorities, and found to be very rich land. This great agricultural area is equal to four-fifths of the settled portion of Ontario.

The fisheries may be divided into those of the Atlantic coast, the Pacific coast, Hudson's Bay, and the fresh-water lakes and rivers. It is well known that the fisheries of the Atlantic offer a practically limitless field for expansion, as no human need can ever exhaust the supply of fish. Of this nothing further need here be said, save that these fisheries are now utilised chiefly by the United States and by foreign countries,—everywhere but in Canada. Here lies an immense field for profitable investment,—in the establishment of canneries and preserving factories. The Pacific coast fisheries, chiefly salmon, are also great and capable of great expansion.

The Hudson's Bay fishing-ground has been used up to the present time practically only by Americans, chiefly for whaling. No doubt exists as to their richness, but they can be properly developed only in the more distant future. The great value of the fresh-water fisheries is due to the immense extent of the Canadian lakes and rivers, and to the great size and fine flavour attained by the fish caught in them; this branch will, therefore, in the future form a most important element of the food supply and material wealth of the country.

The timber supply of Canada is far greater than that of any other country. With the exception of the prairie and subarid areas of the southwest, and the tundras of the extreme north, the whole country was originally covered with a continuous forest, from Labrador to the Pacific. Unfortunately, wherever civilisation has touched this great supply it has been most recklessly wasted. In Quebec great forest fires occur annually, but the people take these as a matter of course. Who starts these fires nobody knows, and nobody seems to care; but the reckless depletion of the already scanty supply of wood will surely lead to serious consequences before many years.

Logging on the Ottawa River was formerly a great industry, but the supply here seems to be reaching its end. Only those parts of the forest can be utilised which are near large streams and can be floated down to the mills, and the number of large streams which can be commercially utilised for sawmill operations at the present time seems to be limited to the area of the Atlantic seaboard, owing to the cost of transportation. With the removal of the American tariff on lumber, however, this would be no longer the case. The character of the timber is, for the most part, coniferous, with a large proportion of deciduous trees,—oak, ash and maple,—interspersed; hence, most valuable for commercial purposes. Indeed, with the supply of water and water-power everywhere abundant, the possibilities of the wood-pulp industry alone seem almost limitless, and with American forests rapidly disappearing, the utilisation of these Canadian fields, as a matter of necessity, cannot be long postponed.

The extent and wide distribution of the valuable minerals of Canada rest on two main facts; first, that the crystalline rocks, and more particularly the oldest series, known to geologists as Archæan, are the metalliferous rocks *par excellence;* and second, that these rocks cover the surface of almost the entire country. It is here that the Laurentian series, the oldest rocks yet found, reach their fullest development, extending in a broad *V*-shaped band, whose base lies in the angle between the Great Lakes and the St. Lawrence River, and which reaches northwardly to Hudson's Bay, eastwardly to Labrador and Newfoundland, and north-westwardly to the Arctic Ocean. In this great area are interspersed also wide zones of Huronian rocks, and it is more particularly on the borders of these areas that mineral veins are found.

The most important, perhaps, of all the minerals is gold, which is found in workable quantities in all the provinces. The Huronian rocks more particularly are well known as the most promising sources of this metal, and, in fact, most of the known auriferous deposits in the world seem to have been derived from them. Rivers running into Hudson's Bay from the west have been found to be nearly all gold-bearing, and the duplication of areas like the Klondike seems to be merely a question of sufficient exploration. There appears, moreover, to be a strong probability of finding rich metalliferous areas on the borders of the ridge of Huronian rocks which runs from the north shore of Lake Huron in a north-easterly direction and then easterly; but, of course, the development of all such land awaits the provision of suitable means of transportation.

With the gold (that is, in the same class of rocks) occur immense deposits of iron ore, principally magnetite and hematite, as well as in the form of pyrites. There are also known to exist abundant deposits of copper, and, to a less extent, lead and zinc. The nickel mines at Sudbury, which is near the southern border of the Huronian area just mentioned, as is well known, practically control the world's market at the present time. But copper ore of the same character (pyrrhotite) without the nickel, is known to occur in other parts of the same area, and other nickeliferous deposits are likely to be found.

In Ontario and Quebec also are found other important classes of deposits, of which asbestos, mica, barytes, molybdenite and arsenical pyrites (which usually carry gold and silver) may be mentioned. Of asbestos Canada has the complete monopoly, its source being the serpentine rocks of Thetford, Quebec; and Canada also controls the United States market for electric mica. Petroleum is obtained in Gaspe County, Quebec, on the southern shore of the Gulf of St. Lawrence and in the extreme south-western corner of Ontario.

For mineral exploitation Newfoundland offers great promise of future development, as immense quantities of rich iron ore are to be found there, besides gold, silver, copper, nickel, and lead; also asbestos, petroleum, and coal. These are known to occur, for the most part, at or near the coast, the deposit at Belle Island, for example, lying so close to the surface that it can be hoisted directly into the holds of vessels lying in deep water. Other natural facilities would seem to exist here for the establishment of blast furnaces, in addition to which this colony has the advantage of proximity to Europe.

In Nova Scotia, as has already been mentioned, occur important mineral deposits, more particularly gold, iron, and coal, which have been developed to a large extent. This colony is, in fact, the only domestic source of coal for Eastern Canada.

Turning to the Pacific, we find British Columbia to be probably the richest of all the colonies in mineral wealth. The gold fields of this province have been well known since 1858, but they have not been worked to anything like the extent of those in the United States. British Columbia possesses a very complicated geological system, embracing rocks of all ages, and including immense coal-bearing areas in close proximity to iron-ore deposits, not to mention other minerals. The coal and lignite occur chiefly in the Rocky Mountain system and along the coast, and the lignite extends northward to the Arctic Ocean. This fact, namely, the existence of an abundant supply of fuel, is, needless to say, of vital importance to the development of the country. A curious fact in this connection is that one of the great lignite deposits on the Mackenzie River has been continuously burning over an extent of several miles ever since its discovery in 1788. Large quantities of coal, both bituminous and anthracite, are found on Vancouver and the Queen Charlotte Islands.

Enough has been said to indicate the extent of the mineral wealth. The deposits, however, except in a few districts, are hardly worked at all. In travelling over Quebec and Ontario, the writer saw a great abundance of openings, or "shows," as they are called, but very little actual working, and only two or three places where what might be properly termed mining was seriously carried on. This is due obviously not to any fault of the deposits themselves, but to scarcity of labour, and more particularly of capital, which is very difficult to obtain. The British or native Canadian is over-cautious as regards mining ventures, and for some reason or other American capital does not seem attracted to the Canadian field. This condition of things, however, cannot last indefinitely; in fact, there are strong signs that it is about to change.

There is, it is true, one great lack to which the whole of the eastern territory is subjected, and that is coal. On the other hand, there are two important resources which will ultimately largely replace this lack; first, the limitless supplies of peat, and second, the abundant water-power; and here, again, are great fields for the utilisation of engineering talent as soon as capital can be induced to enter on a large scale. As one instance of such development may be mentioned the Shawinigan Falls power, equal to about 100,000 horse-power, where are located aluminium smelting and calcium carbide works, besides a power station whence 8000 horse-power are transmitted eighty miles to the city of Montreal.

But the most important element which has prevented the development of Canada by American capital has been the tariff wall which has been erected between the two countries, to the great detriment of both. And aside from political union, which it has tended to drive farther and farther away, it has, from the American standpoint, prevented American utilisation of Canadian products, as well as stunted, to a large extent, the trade in American manufactures; while from the Canadian standpoint, the price of manufactured articles and machinery on the one hand has been raised to such a point as to seriously impede the development of Canada's natural resources, and, on the other hand, has withdrawn from them a profitable market. It is to be hoped that this fatuous and purposeless policy of the two countries is to be dropped in the near future; and the lowering of the barriers against Canadian products is certain to mark the beginning of a great era of development, such as Canada has never hitherto seen.

In comparing Canada with other new countries as a field for commercial exploitation, an American cannot fail to note several points in which Canada undoubtedly has superior advantages. It is not only close to American doors, but it is inhabited by a race speaking the same language as, and nearly identical with, Americans. The laws and customs of the country, saving Quebec, are a joint heritage of the two nations. In Canada life and property are everywhere secure, and no fears of revolution or other political disturbances need ever be entertained. Canada is, in fact, more conservative, both in its laws and in the habits of its people, than is the United States. The interests of the masses are better cared for.

On one point strictures may well be drawn; I refer to the restrictive, and, as we naturally view it, somewhat oppressive legislation regulating labour in particular, the Sunday laws of Ontario and Manitoba. But this is only one expression of the general provincialism which must necessarily be outgrown as the country advances and comes into closer contact with the world.

Besides this, there is one important point of difference, most important for the engineer, between Canada and the Latin-American countries, such as Mexico, namely, that while labour,—that is, labour wholly unskilled,—is dirt-cheap in the latter country, skilled labour has to be imported; a condition which makes the country's development impossible except from without. Now, in all the settled parts of Canada intelligent and more or less skilled labour can be had at a fair price, and skilled labour is always in demand for some purpose. While capital is urgently needed, yet the services of a good man are always in demand, as they are in America, and one cannot there become stranded for lack of employment and die of starvation. There are always possibilities, always new enterprises and projects, which can be taken advantage of by the man who has his eyes open.

As regards the particular province which seems to offer the most desirable openings at present, it is difficult to advise, as each possesses such an undoubtedly great possibility for the "entrepreneur"; and, moreover, it depends to a large extent on the line of work or action chosen. In general, however, the writer may say that the three most promising provinces are British Columbia, Ontario, and Newfoundland. Those who have been for several years in British Columbia say that they would not care to live in the east again, as it is too slow for them. But those who have studied the north shore of the great lakes may well take exception to the absolute superiority of the western country. Newfoundland, again, is a practically new and untouched country,—a country for the future; but for the present it must be developed wholly from without, and development should not be attempted except with considerable foreign capital or the possibility of obtaining it.

Although Quebec has great resources of its own, the writer would not advise outside exploitation of this province for a number of reasons, depending on the nature of its inhabitants, who, as before mentioned, are suspicious and distrustful of outsiders, unprogressive, obstructive, and under the domination of their ecclesiastics, whose policy is opposed to progress in almost every direction.

New Brunswick, for similar reasons, and also because of its natural inferiority, does not offer many attractions, while the opportunities of Nova Scotia are now largely in the hands of big syndicates.

An interesting indication of the comparative energy, enterprise and intelligence of the various provinces is offered by a comparison of the number of patents for inventions per million inhabitants, issued to their natives during the ten years ending 1901, which is as follows:—

British Columbia, 2128; Ontario, 2065; Quebec, 1007; Manitoba and

Northwest Territories, 862; New Brunswick, 583; Nova Scotia, 469; Prince Edward Island, 281. During the same period the corresponding number for United States citizens was 3167, that is, 50 per cent. greater than British Columbia or Ontario, and 67 per cent. greater than for Canada as a whole. Were such states as Connecticut and Massachusetts to be compared with Ontario, it is needless to say the figure for these states would be several times as great. It is worth noting that during this period 60 per cent. of the total number of patents, or more than for all the other provinces put together, were granted to natives of Ontario, where, in fact, the great body of the wealth and population of Canada is at present centered.

One word as to climate. If you are unsophisticated, you doubtless imagine the inhabitants of the Northwest Territories passing their winters in sleeping-bags and snow-huts; but perhaps you will feel relieved by a glance at the isothermal map of North America, from which you will see that the average annual temperature at Calgary and Medicine Hat is substantially the same as at Milwaukee and Detroit. As a matter of fact, these Rocky Mountain towns are much less subject to extreme variations of temperature than are American interior towns, partly on account of the aridity of the air, but chiefly on account of the Chinook winds, which descend from the crest of the Northern Rocky Mountains after having been deprived of their moisture, and are warmed by the adiabatic compression which they undergo. The even and mild temperature of the whole Pacific coast is due to the ocean currents, as is well known, and needs no further comment. As regards Eastern Canada, the climate of Montreal and Ottawa is in no respect less agreeable than that of Milwaukee, that of Ottawa being particularly genial. It is true that there are many who prefer the Southern climate to the Northern; but the average denizen of the American Eastern or Middle States will certainly prefer the climate of Canada to that of Mexico or Cuba, than which unquestionably it will be found more conducive to vigour and enterprise.

THE WIDENING USE OF SMALL ELECTRIC MOTORS

WITH SPECIAL REFERENCE TO AMERICAN PRACTICE

By F. H. Kimball

TWENTY-FIVE years ago the electric motor was scarcely more than a toy, and was hardly to be found outside of the precincts of some scientist's laboratory or the collection of rather crude electrical apparatus on the shelves of an academy or high school. Its future possibilities as a leading adjunct in manufacturing industries and the economics of the life of the twentieth century had hardly been dreamed of.

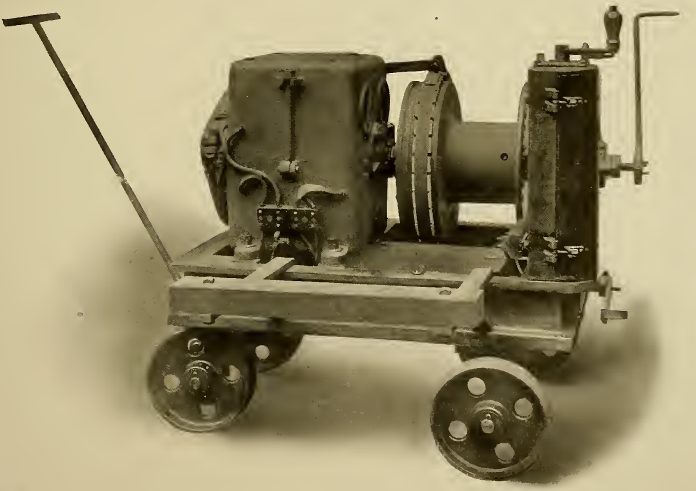


FIG. 1.—A PORTABLE ELECTRIC HOIST, MADE BY THE LIDGERWOOD MFG. CO., NEW YORK. CAPACITY 1000 LBS. LIFTED 200 FEET PER MINUTE. MOTOR SUPPLIED BY THE GENERAL ELECTRIC CO., SCHENECTADY, N. Y.

The number of electric motors in use at the present time in the United States is enormous,—probably more than 250,000, exclusive of fan motors,—and the variety of uses to which they are put can hardly be catalogued. While the extent to which the larger machines of this class are employed is but little realised, the variety of purposes in connection with which the smaller sizes of motors have been used is still less known to the majority of people. It may, therefore, be interesting to briefly glance at a few of the varied uses to which small electric motors have been applied and observe how widely their employment is associated with the life and industry of the present period of most strenuous activity. Notwith-

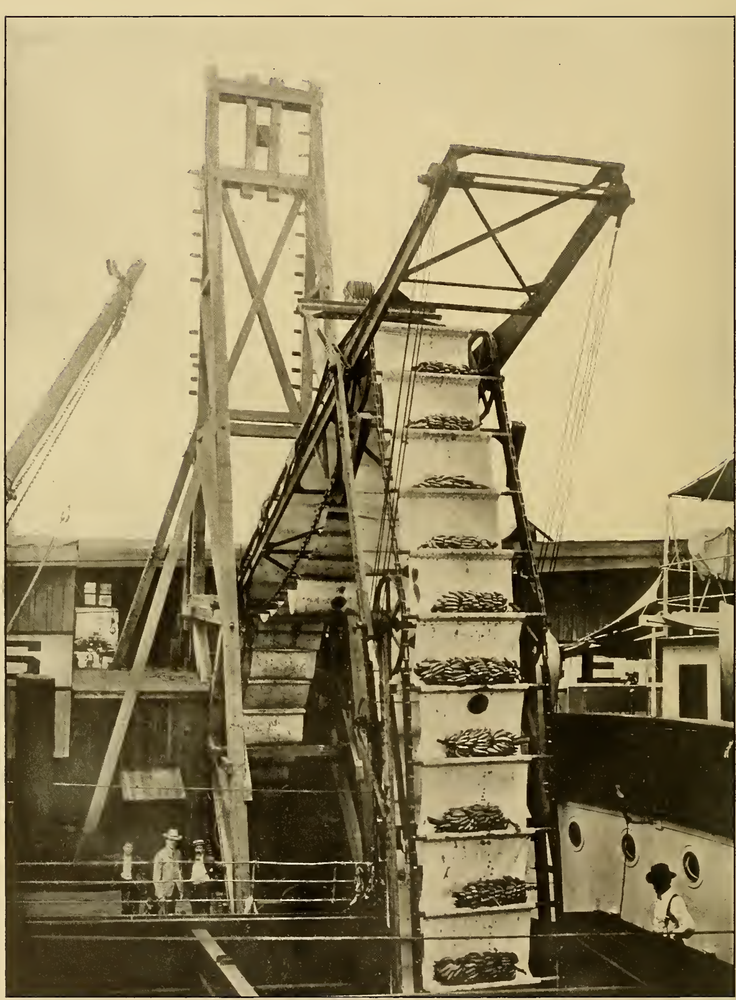


FIG. 2.—AN ELECTRICALLY DRIVEN BANANA CONVEYOR AT NEW ORLEANS. THE CONVEYOR LEG IS SHOWN EXTENDED FROM THE WHARF INTO THE HOLD OF THE SHIP ALONGSIDE

FIG. 3.—THE BANANA CONVEYOR SEEN FROM THE WHARF SIDE, SHOWING WHERE THE BANANAS ARE LANDED, TO BE PASSED INTO CARS FOR FURTHER TRANSPORT

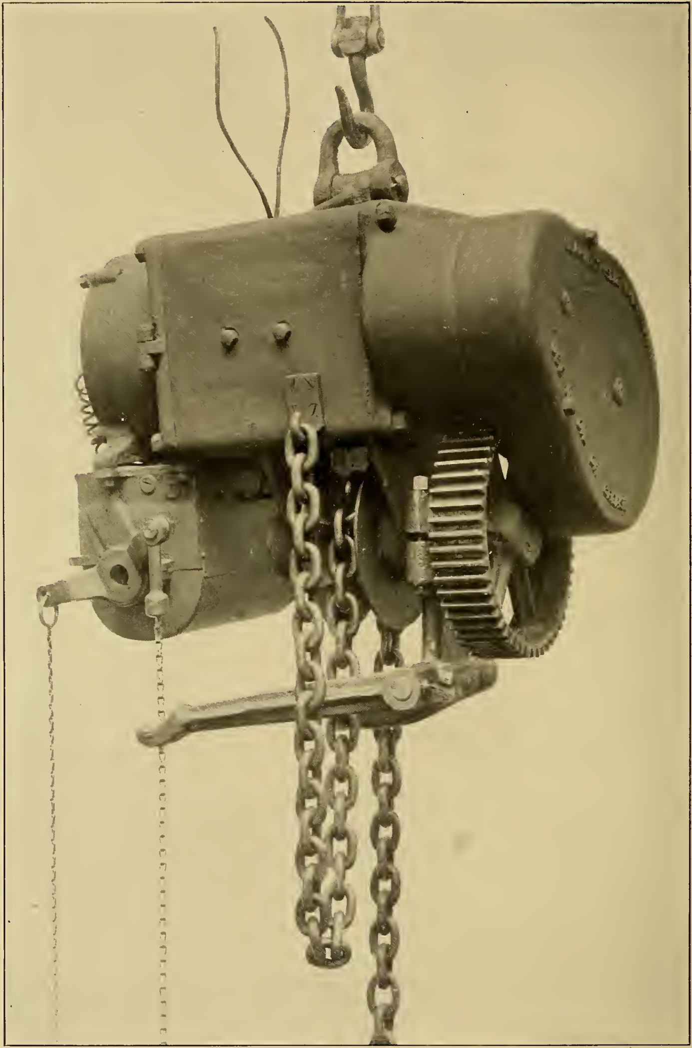


FIG. 4.—A CHAIN TYPE ELECTRIC HOIST OF 2000 LBS. CAPACITY. SPEED OF HOISTING, 15 FEET PER MINUTE. MADE BY THE GENERAL ELECTRIC CO., SCHENECTADY, N. Y.

standing the fact that the application of motors to industrial purposes has been the subject of various magazine articles which have appeared during the past two or three years, there is still much to be said in regard to the diversity of their uses. It is the writer's purpose, therefore, to mention some of the more recent as well as less widely known applications where individual or direct motor-drive is used, and which latter cover, in the aggregate, the employment of fully as large a number of motors as are used in shops and factories for group or belted driving.

In Continental Europe the employment of electric motors for operating hoists and derricks for handling ships' cargoes and other similar purposes was undertaken at an early date in the chronology of the commercial use of electricity. America was somewhat slower to take this matter up energetically, but at the present time she is probably much in advance of her older neighbours in the breadth of application of motors for kindred purposes.

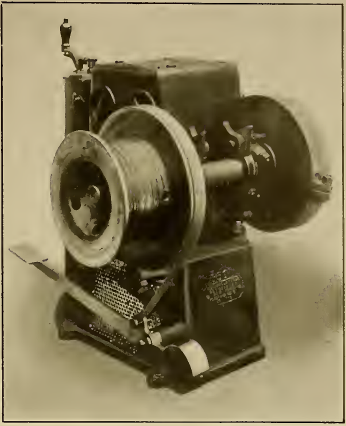


FIG. 5.—A LIDGERWOOD AMMUNITION HOIST WITH GENERAL ELECTRIC MOTOR AND CONTROLLER. USED ON THE U. S. BATTLESHIPS "KEARSARGE" AND "KENTUCKY"

At New Orleans, Mobile, and elsewhere along the American Southern Atlantic seaboard, may be found interesting installations of conveyors operated by motors, used for unloading fruit and other similar fragile articles. A notable example of this is seen in the

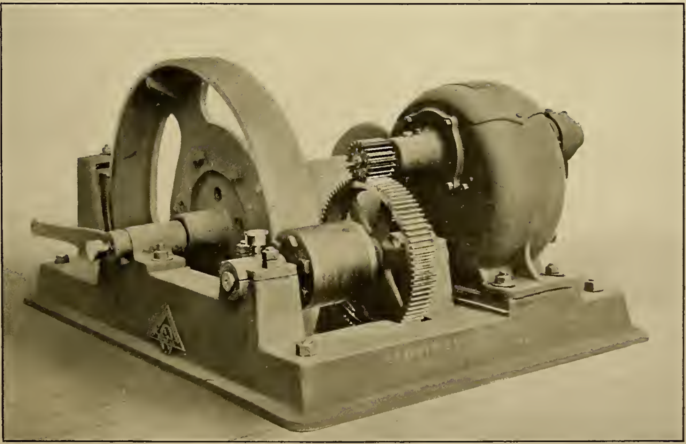


FIG. 6.—ONE H. P. MOTOR DRIVING A HOIST MADE BY THE DENVER ENGINEERING WORKS CO., DENVER, COL.

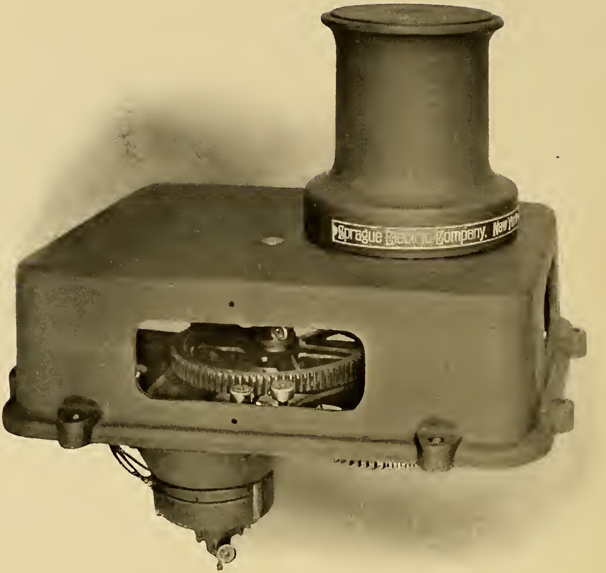


FIG. 7.—AN ELECTRIC WINCH MADE BY THE SPRAGUE ELECTRIC CO., NEW YORK. CAPACITY 12,000 LBS. PULL AT A SPEED OF 10 FEET PER MINUTE

banana conveyor (see Figs. 2 and 3), a labour-saving device without which no modern fruit-receiving pier is complete. A long belt, carrying canvas pockets, is so arranged that one end may be introduced into the hold of a steamer through the hatchway and the other located contiguous to the railway tracks which extend onto the wharf. An electric motor, properly geared, keeps this band in continuous motion; the bunches of bananas, in the ship's hold, are laid into the moving canvas pockets, and are thus elevated and conveyed to a point opposite the door of the freight car, where they are removed and hung or piled in the car for shipment.

Formerly these bunches were brought out by labourers, a large number of whom were employed for carrying on the work. In raising the bunches of bananas onto their shoulders, carrying

FIG. 8.—AN ELECTRICALLY DRIVEN DOUBLE ICE-CREAM FREEZER, MADE BY F. E. WHITNEY, BOSTON, MASS. THE MOTOR IS OF GENERAL ELECTRIC MAKE

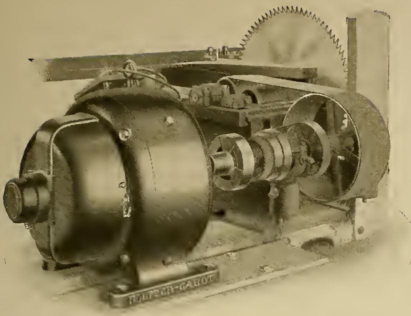


FIG. 9.—DRIVING A CIRCULAR SAW WITH A DUST-PROOF MOTOR MADE BY THE HOLTZER-CABOT ELECTRIC CO., BOSTON, MASS.

them over a rather uneven way from the ship to the wharf and thence into the car, a great deal of fruit was destroyed, and the bunches themselves were frequently jammed and disfigured. The present method, in addition to assuring the transfer of the fruit from the ship to the cars in thoroughly good order, results in the saving of a notable amount of labour.

At Boston, New York, Philadelphia and other seaboard cities, a large number of hoists, particularly designed for discharging coal from vessels, are driven by electric motors. Nearly all American battleships and cruisers use electrically operated ammunition, coal and ash hoists (Fig. 5), while in many cases the boats are handled at the davits by similar means. Many merchant vessels are now provided with electric lighting plants, and, when so equipped, the use of motor-driven windlasses for serving cargo booms and deck hoists is quite general.

At Norfolk, where many oysters are received, it was formerly customary to employ either a horse or two or three labourers to whip up the bivalves from the holds of the oyster boats. Within the past two years a number of oyster operators have equipped their docks with back-geared electric motors, the back-gear shaft carrying a " nigger head " or winch; this arrangement en-

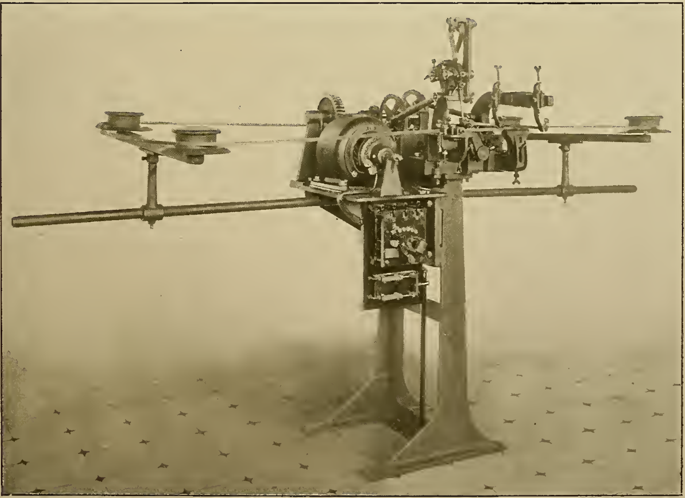


FIG. 10.—AUTOMATIC BAND SAW SHARPENER DRIVEN BY A MOTOR MADE BY THE CROCKER-WHEELER COMPANY, AMPERE, N. J.

FIG. II.—ICE-CREAM FREEZER DRIVEN BY A WESTERN ELECTRIC COMPANY (CHICAGO) MOTOR

ables an oyster boat to be discharged in one-half the time required under the older methods and at a very considerable saving.

It is often convenient to have some easily available means of warping a vessel along a dock, and it is also convenient to be able to move freight cars in terminal yards and elsewhere without calling for a locomotive on every such occasion. To meet this requirement electrically operated windlasses have been developed, forms of which are shown in some of the accompanying illustrations, which enable this object to be readily accomplished. These windlasses may be located at convenient points on the dock or in the freight yards, and the construction and method of control is of such a nature that they may be used by the labourers about the yards and docks without fear of damage.

In modern woodworking establishments the band-saw has largely superseded the circular saw for certain purposes; to sharpen a band-saw by hand requires a very considerable expenditure of time, and the results are not always satisfactory. Motor-driven machines are now purchasable which will do this work automatically in the most perfect manner and at small expense. They require no attention beyond putting the saw in position and starting the machine.

Organ blowing is also largely accomplished by motors. The apparatus is under the immediate control of the organist from his bench, and dispenses with the necessity of the pump boy, whose services often are performed in a perfunctory and unsatisfactory manner. The electric blower is free from difficulties often experienced heretofore when hydraulic pumps have been used, in that there is nothing to freeze and the apparatus serves its purpose equally in cold or hot weather, and without particular adjustment or care being required.

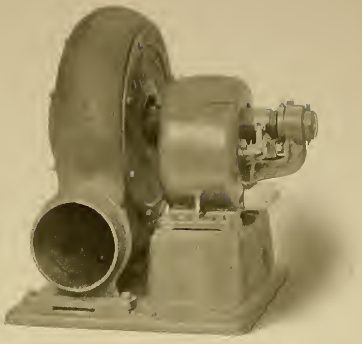


FIG. 12.—A BUFFALO FORGE COMPANY EXHAUSTER WITH ELECTRIC MOTOR DRIVE

An especially unique electric organ blower is that known as the "orgoblo,"

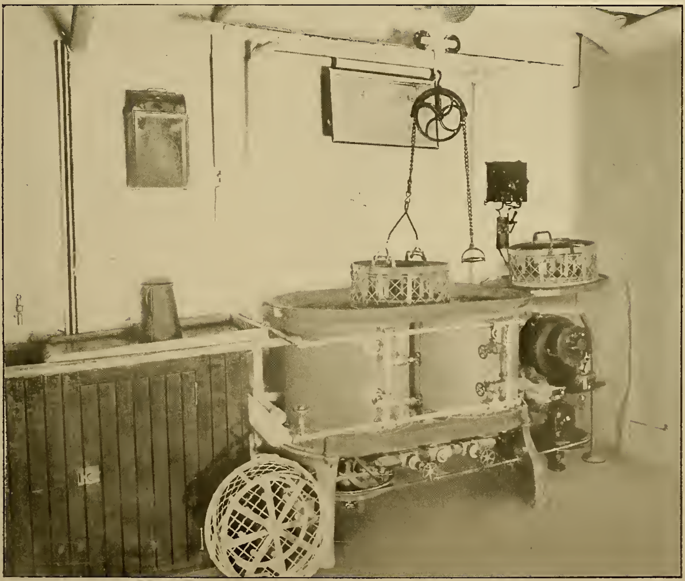


FIG. 13.—GALLEY OF A STEAMSHIP, SHOWING DISH-WASHING APPARATUS OPERATED BY A GENERAL ELECTRIC MOTOR

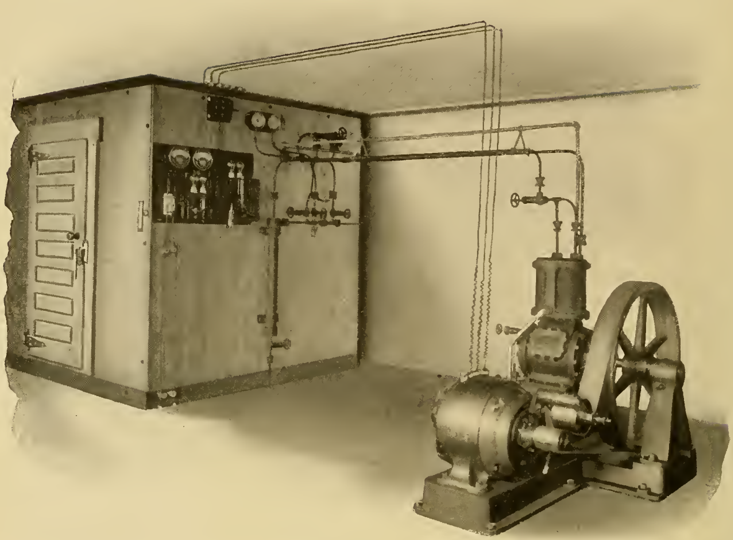


FIG. 14.—AN ELECTRICALLY OPERATED REFRIGERATING MACHINE, BUILT BY THE FEDERAL AUTOMATIC REFRIGERATING COMPANY, NEW YORK

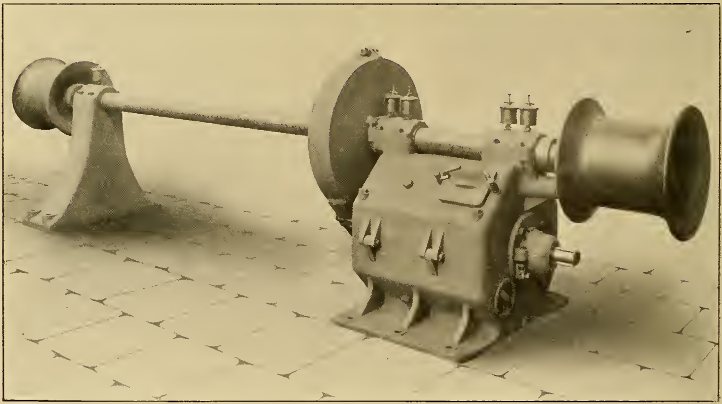


FIG. 15.—A 25-H. P. GENERAL ELECTRIC DECK WINCH MOTOR

made by the Organ Power Company, of Hartford, Conn. This apparatus consists of a non-resonant case of cylindrical form, which is virtually the shell of a pressure blower. Within this case is an electric motor carrying on its shaft a vaned fan which furnishes the blast. The apparatus is much more compact for a given output than any of the previous combinations of motor and bellows or motor and fan. The motor, although fully enclosed within a practically sound-proof chamber, where it is well protected against damage, is thoroughly ventilated by a strong current of air, thus enabling it to operate at maximum output without danger of overheating. The blast is exceedingly steady, and is automatically regulated to the varying requirements of the instrument.

For the freezing of ice cream, motor-driven apparatus is largely superseding the older manually operated forms. The expense of operation is materially reduced and the grain or texture of the product largely improved. In a recent test with a moderate sized electrically operated freezer (Fig. 11), the cost of power was about 0.003 cents per gallon, the price of electricity being 10 cents per kilowatt-hour.

Where electrically operated freezers are used, ice crushing machines, adapted to be driven by similar means, are ordinarily employed. The mechanically crushed ice is far superior to ice crushed by the usual methods in that the size of the fragments is more uniform,—less ice is pulverised and thereby lost,—and as the operation is very quickly done, it is necessary to prepare only a little at a time, as occasion requires. This results in a considerable saving over the older methods, where a quantity of crushed ice was prepared, sufficient for the day's requirements, perhaps. As finely crushed ice exposes much greater surface to the air than block or coarsely cracked ice, the melting is more rapid, and in preparing only a small portion at a time with the electrically actuated crusher an appreciable saving is effected where much ice is used.

FIG. 16.—A PUMP DRIVEN BY A HOLTZER-CABOT ELECTRIC COMPANY MOTOR

Automatic electrically operated refrigerating machines also afford an interesting illustration of the various purposes to which motors may be applied. The machine shown in Fig. 14 has a capacity of heat absorption equvalent to that obtained from about one and three-quarter tons of ice melted in twenty-four hours. Such machines are particularly applicable to the requirements of restaurants, hotels, clubs, dairies, markets and private dwellings requiring considerable refrigerating service. For a machine of this size a motor of about three horse-power is employed. The regulation of the power supply, as well as the temperature of the cold box, is effected entirely by automatic devices. Under fairly favourable conditions of current and water supply, the cost of operating such a machine may be quite competitive with ice at $2 per ton, outside of any consideration of the many other advantages derived from the elimination of the use of ice.

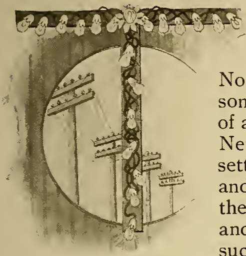
Within the past few years the electric motor has been largely employed in domestic and household uses, and now serves an important function in relieving some of the drudgery incident to the routine work of the home, the hotel or the restaurant. Several ingenious machines for washing dishes mechanically have been invented, and many of the large hotels, restaurants and steamships are now supplied with them. The general scheme of design comprises a suitable tank, into which may be lowered a wire basket containing the dishes to be cleansed. A powerful pump, operated by an electric motor, supplies a constant circulation of hot soapsuds through and over the basket and dishes. In some of the machines the basket is also moved up and down in the soapy water by power from the same motor that drives the pump. When the cleansing has progressed sufficiently, the soapy water is discharged, and a stream of hot, clear water is turned on. The dishes, when removed from the washer after this treatment, are quite clean, very hot, and practically dry themselves.

To be concluded in the March issue.

BREAKS IN OVERLAND TELEGRAPHIC COMMUNICATION DUE TO STORMS

SOME PROPOSED REMEDIES

By William Maver, Jr.



THE severe wind and sleet storm in the United States last November that partook somewhat of the nature of a cyclone in Eastern New York, Massachusetts and Pennsylvania, and which prostrated the overland telegraph and telephone wires to such an extent that the city of New York was cut off from the rest of the country for nearly twenty-four hours, renewed the agitation for some more stable means of telegraphic communication than is furnished by overhead wires.

The business communities were insistent in their demand for relief from these periodical disarrangements of the business of the country, and it was even suggested that the national government should undertake to provide a system of communication that would be dependable regardless of weather conditions.

It is not difficult to imagine the seriousness of a situation that might, in certain contingencies of national importance, arise in the event of the capital being deprived of telegraphic and telephonic communication by severe storms for possibly several days at a time. The situation would, of course, be worse if railway communication should also be temporarily cut off or seriously hampered, as it was at the time of the great snow storm of March, 1888 During the storm of last November the railways were not seriously delayed, and it was, therefore, possible to send special messengers by train from Chicago to New York with important orders for the purchase and sale of stocks that could not be handled by telegraph or telephone, owing to the collapse of the overland wires between those cities. Some messages of importance were also sent from New York to San Francisco by cable via Europe and Asia.

The possibility of the collapse of telegraphic communication was forcibly brought to the attention of telegraph officials and the public at least as long ago as 1849. In that year a heavy sleet storm visited Tennessee, Kentucky, Northern Mississippi and Alabama, levelling the wires and poles so completely that the territory named was without telegraphic communication for over four weeks. And since that time hardly a winter has passed during which the telegraph service has not been badly crippled in one section or another of the country by sleet or snow storms, notably by the great storm of March 12, 1888, already mentioned. This storm raged fiercely for three days in the neighbourhood of New York, Philadelphia, and Boston. Eastern New York was deprived of telegraphic and telephonic communication in every direction. In the city of New York not an overhead telegraph, telephone, or fire alarm circuit was left intact, and the town was in darkness at night, except for the street gas lights. There was in operation at that time one underground telegraph circuit about twelve miles in length, which was used as far as possible for fire alarm telegraph purposes. To-day practically all the electric light and power circuits and the telegraph and telephone circuits in New York City are in underground conduits. The consequence is that, notwithstanding the severity of the recent storm, as manifested by its effect upon the overhead wires outside of the city, the operation of the electric light circuits, as well as of the telephone and telegraph circuits in the city, was not disturbed.

The matter of securing uninterrupted telegraphic communication regardless of weather conditions is, therefore, one that has been frequently discussed during the past half century, and perhaps because of the observed beneficial results of placing the wires underground in cities the lay mind has, at every recent recurrence of a break in the telegraph service, demanded that the wires everywhere be placed underground forthwith, where they would be safe from the assaults of wind, snow, and sleet storms.

It may be premised that the officials charged with the management of the telegraph and telephone interests in America have not been blind to the enormous losses that these interests sustain by every extensive collapse of their poles and wires, and it may be safely assumed that every possible remedy has been very carefully considered by those most concerned.

Sleet storms and soft snow storms, which are the most disastrous in their wire-levelling effects, are not confined to any one part of the country. They occur in the Mississippi valley, in the vicinity of St. Louis and Memphis; in Illinois; on the Atlantic coast between Boston and Baltimore; and one of the worst sleet storms the writer has ever known occurred in Nova Scotia and New Brunswick, in 1871. The damage done to the poles and wires is not always directly due to the sleet and the wind, but is often occasioned by the weight of the sleet breaking huge limbs of trees which fall on the wires. Frequently miles of sleet-laden pole lines fall, like rows of bricks, when one gives way, and in numerous instances fifty and more miles of pole line have been so completely demolished in one storm that the cost of repairing the line has been equivalent to building new lines.

Not only are overland lines subjected to widespread damage by abnormally severe sleet and snow storms, but they are also in many places exposed to the ravages of forest fires, to avalanches of snow, to washouts due to floods, and to destruction by lightning. Furthermore, the average normal life of a pole line in all parts of the country probably does not much exceed ten years. Consequently, if the financial and engineering difficulties in the way of placing and operating telegraph and telephone wires to long distances underground had not been deemed well nigh insurmountable, there is not much doubt that the proposed underground cable plan of avoiding the enumerated difficulties which beset overland telegraph and telephone lines would long ago have been adopted.

From an operative standpoint it may be said that for telegraph purposes an overland wire is from fifteen to twenty times more efficient than an underground or a submarine cable of equal length. For example, an Atlantic cable, operated with the apparatus employed in overland Morse telegraphy, would not have a rate of transmission exceeding two or three words per minute. On cables 400 to 500 miles in length a rate of not more than six or eight words per minute would be possible with the ordinary Morse telegraph apparatus.

It is only by using the most sensitive receiving instruments that rates of twenty-five to thirty-five words per minute can be obtained in long-distance cable working, and if receiving apparatus of this high sensitiveness were employed on land lines it would entail using twisted and paired circuits to avoid the effects of mutual induction. It would also involve equipping the various offices with the necessary apparatus and the keeping of a staff of expert operators at such stations to manipulate the cable apparatus.

The agitation for underground telegraph wires between important business centres in order to insure the maintenance of communication in times of severe storms has not been confined to America. In fact, the discussion of the matter on the American side of the Atlantic has been mild and desultory in comparison with the agitation that has been maintained in Great Britain for the past ten or fifteen years for the same object. Repeatedly during these years and prior thereto the breaks in the telegraph lines have resulted in cutting off London from other parts of Great Britain for days at a time, so far as telegraphic and telephonic communication is concerned. At the time of the severe storm of January, 1901, in Great Britain, the city of Glasgow was cut off from telegraphic communication with other parts of the Kingdom for two days, and in the December storm of the same year London could communicate telegraphically with Manchester only by way of Ireland, and with Glasgow by way of New York.

Owing to these frequent breaks in telegraphic communication in Great Britain the government, in 1897, began the laying of a so-called experimental underground cable between London and Birmingham,—a distance of 113 miles,—which cable was completed after some delay. The cable used is composed of seventy-six conductors, each weighing 160 pounds per mile. The conductors are insulated from one another by spirally wound strips of brown paper, and the whole is enclosed in a lead pipe 2½ inches in diameter. The cable is drawn into 3-inch iron pipes in lengths of about 600 feet, the pipes being laid in the earth about 2½ feet below the surface. The total cost of this cable, laid, was £160,000 ($800,000), or approximately £1400 ($7000) per mile. Subsequently other sections of underground telegraph cable were laid in Great Britain as stand-bys in case of collapse of the overland wires. For example, a cable has been laid underground between Manchester and Leeds, 58 miles, and between Warrington and Carlisle, 42 miles, together with an extension of 20 miles to Beattock Rise, the cost of which was about £1120 ($5600) per mile.

The routes for these sections of underground cable were selected with a view to protecting the portions of the country most exposed to violent storms. The difficulties and delays due to breaks in the telegraph lines were not, however, overcome by these and other portions of underground cables, and delegations representing the merchants and officials of municipalities of various parts of the country urged upon the government the completion of underground cables to Glasgow and Edinburgh and to Portsmouth, Bristol and Land's End.

In answer to these urgent and continued demands for underground telegraph wire facilities the government intimated that it did not feel warranted in proceeding upon so extensive an undertaking, especially in view of the expressed belief that poles and wires could be constructed of sufficient strength to weather the severest storms. Subsequent experience, however, controverted this view, for, despite the best efforts in this direction, the Secretary to the Post Office, in the latter part of 1901, tacitly acknowledged that the heavy snow which accumulates on the wires either breaks them by its weight or tears the poles out of the ground.

It was admitted at the same time also, although the details furnished of its operation are meagre, that the London to Birmingham underground cable was not an assured success, inasmuch as to avoid the effects of mutual induction two wires must be employed for each telegraph circuit,—practically as in the case of telephony,—and that otherwise the underground circuits were less efficient than overland wires, the speed of the Wheatstone automatic telegraph system, which is in extensive use in Great Britain, being considerably reduced by the presence of the cable in the circuits.

To be able, however, to maintain communication, even if only at a comparatively slow rate, is so much more satisfactory than to be without any means of communication whatsoever that at each recurring snow or sleet storm and consequent loss of telegraphic communication the Post Office authorities continued to be waited upon by delegations from different sections of the country, and finally, on the occasion of the visit of a delegation from Glasgow in 1902, the government officials stated that the matter of providing emergency underground cables for use in times of collapse of the overland wires had resolved itself into one of finance; that a suitable underground cable from London to Glasgow would cost at least £700,000 ($3,500,000), and that the settlement of the question, therefore, must rest with the Chancellor of the Exchequer rather than with the Postmaster.

As it does not often happen that all sections of the country are visited by severe storms at the one time, it has been pointed out that an emergency underground cable, when completed, need be used only in the sections in which the overhead wires and poles are temporarily prostrated. By substituting the underground circuits temporarily for the overhead wires for such distances as the severity and extent of a storm may require, the retarding effect of the underground circuits might not be very pronounced. It may also be noted that when longer distances are necessary, the introduction of automatic telegraph repeaters at shorter intervals than is customary or necessary in overland working would also reduce materially the retardation of signaling.

To give an idea of the cost of placing the existing overland wires in America in underground cables, it may be stated that a conservative estimate of the expense of laying a fifty-conductor telegraph cable underground between New York and Philadelphia places it at approximately £120,000 ($600,000), or, say, £1200 ($6000) per mile. This would afford facilities for only twenty-five telegraph circuits, as, for reasons already mentioned, two wires would be required for each circuit. As there are, perhaps, three hundred telegraph wires on the various pole lines from New York to Philadelphia, it is clear that such a cable would carry only a moiety of the business ordinarily transmitted over these circuits.

When the extent of territory traversed by the telegraph pole lines in America is considered, the conclusion is almost inevitable that the placing of all of these wires in cables underground is impracticable, owing to the enormous expense and the reduced efficiency of operation that such action would involve. This is true to even a greater extent, perhaps, of the telephone wires.

The financial, engineering and operating difficulties of placing the telegraph wires underground have, indeed, been so fully appreciated in America that the matter has never been seriously entertained by the telegraph companies, except in cities. In all the principal cities, however, the telegraph and telephone wires are now in cables underground. As already intimated, this disposition of the wires in cities has aided materially in keeping the wires in operation during the prevalence of storms.

The introduction of these underground cables, however, in the cities, comparatively short as they are, has noticeably lessened the efficiency of the automatic and quadruplex circuits, as well as the long-distance telephone circuits. The alternative appears to be to endeavour to employ more substantial poles or wires, or to lay comparatively small underground cables between the principal cities of the country, over which the most important business or government messages might be transmitted during breaks in the overhead circuits. Both of these alternatives have received careful consideration on both sides of the Atlantic.

About fifteen years ago, for instance, the Pennsylvania Railroad Company, in order to obtain a reliable telegraph service at all times, had under consideration the laying of an underground cable along its tracks between New York and Philadelphia, and perhaps for greater distances, and at that time the writer suggested the employment of a cable insulated with fibre or paper, to obtain low electrostatic capacity, and over which a rubber coating should be placed to exclude moisture; but the proposition was not carried out.

Appreciating the difficulties that attend the placing of telegraph wires underground between cities and towns, the question of building stronger pole lines and employing larger and stronger wires has frequently been mooted. One plan suggested several years ago consists of using two poles side by side, between which the cross-arms for the wires would be placed. It was proposed, further, that such a pole line should be placed along a private right of way, and that it might be patrolled by linemen on overhead bicycles suspended from the poles by wires.

This plan has not, however, been acted upon, and when it is considered that sleet has been known to form on wires to a thickness of 6 inches, it is apparent that entire reliance cannot be placed on any type of overhead telegraph wire construction,—a conclusion to which experience has pointed in Great Britain.

It is probable that for a few years, while the pole line is new, the poles might resist breaking; but after the lapse of several years their resisting strength would be uncertain. It is possible that a light armoured emergency cable, properly strung on the poles, would in many instances maintain its continuity even when the poles had collapsed.

In some instances where the wires are exposed to very high winds, or where the number of the wires on the pole line are excessive, the plan of doubling up the number of poles to the mile has been adopted, so that instead of fifty poles to the mile there are a hundred. This obviously divides up the weight on each pole very materially, and the results thus far obtained in these experiments have been very satisfactory. These lines have yet, however, to stand the test of a heavy sleet storm with wind.

It has also been suggested quite frequently during the past four or five years that wireless telegraphy should be available in the emergencies under consideration, but up to the present time it has failed to manifest its value on such occasions. In fact, there is no absolute surety that the masts or towers, or at least the vertical wires, would not be victims to the heavy storms that play such havoc with the overland telegraph and telephone wires, for it has already happened more than once that the masts of wireless telegraph systems have succumbed to severe wind storms. The reconstruction of these masts could not be effected during the continuance of the storm, and the overland wires would probably be in operation as soon as the wireless telegraph masts and wires could be reconstructed.

This is said on the assumption that if the vertical wires were intact, wireless telegraphy would be available for long distances overland. This, however, is not at present known to be the case, and there is no definite assurance that wireless telegraphy will be available for such purposes in the immediate future. But granting that wireless telegraphy were available for long-distance overland service, the utmost aid it could afford in the present state of the art would be the equivalent of one overland circuit working in one direction at a time, and at a low rate of transmission. Wireless telegraphy may, therefore, be disregarded in present calculations as a substitute for overland wire telegraphy in times of total collapse of overland telegraph wires, although its importance would be undoubtedly great if it should be found capable of providing but one circuit at such times.

SPECIAL FORMS OF CRANES

By Joseph Horner

CRANE-MAKING, like many other industries, has been too much dominated in the past by the trammels of custom. Many cranes are made even now of which the models date back a quarter of a century, and only within the last few years has there been much departure from old designs. This is due partly to the much greater importance which is now attached to the value of hoisting tackle; but in a greater degree it is a result of the new agencies, electricity and compressed air, which were not at the service of the older crane makers. Experience is a grand possession, but it sometimes acts as a wet blanket on design. Men feel safe in the ruts and grooves in which they have lived and worked, but it is wise sometimes to get out of these and seek new worlds to conquer. Things have been moving rapidly within the last few years, and it is well, therefore, at intervals to take stock of the later advances and see where we stand.

Crane makers are exercised at present over the same problems that occupy the minds of machine-tool makers, engine builders, and others,—those of general manufacture and of specialised products. The industry was never greatly specialised until recently, the sole excep-

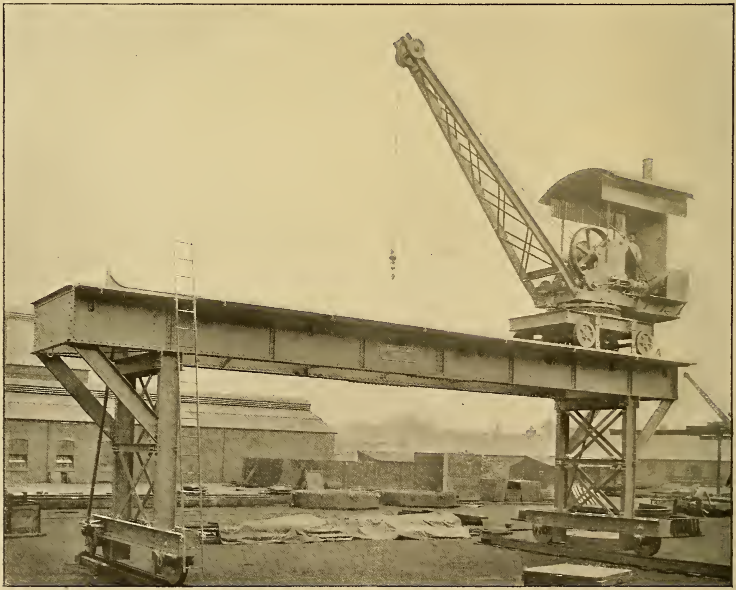


FIG. I.—A 4-TON STEAM GANTRY CRANE, BUILT BY MESSRS. RANSOMES & RAPIER, LTD., IPSWICH

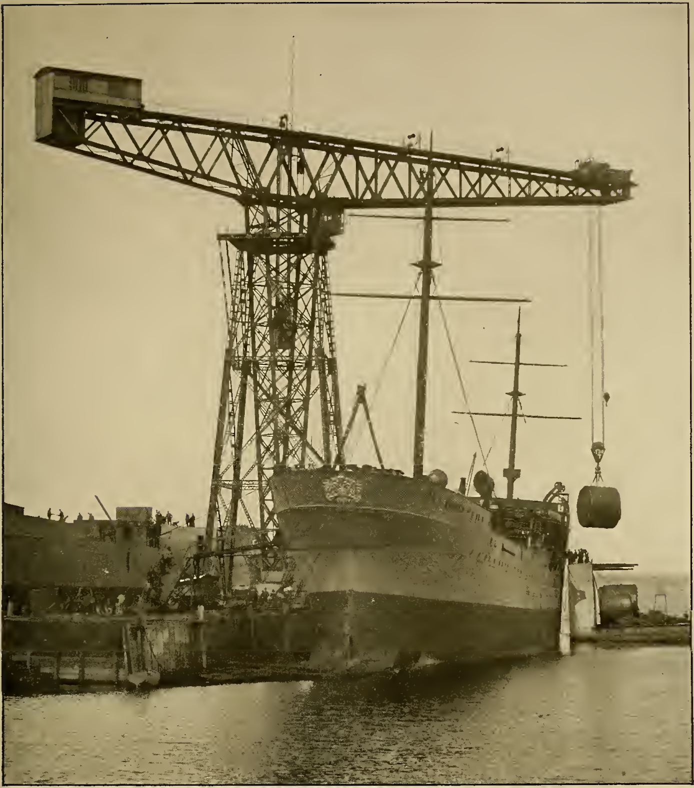


FIG. 2.—A 200-TON GIANT CRANE, ELECTRICALLY DRIVEN. BUILT BY THE BEURATHER MASCHINENFABRIK, BEURATH, GERMANY

tion being that of lifts, which, however, formed part of the work of many general crane makers. In the regular crane shops almost every type of crane is tendered for and orders are secured, cranes of thirty or forty distinct types being regularly made, and each in different sizes. Nor is this all, for these shops also, as a rule, extend their operations even farther afield and undertake general construction work, such as outside castings, turntables, small engines, hydraulic work, pumps, gas plant and plant for water-works. Though these are being narrowed down at the present time, they were until recently, and are still, the staple products of many crane-making firms. The inevitable disadvantages of general practice are, therefore, sometimes apparent, when competing firms, who specialise in one or a few products only, come into rivalry with the general crane shops. These specialising firms are increasing, some of them making nothing but overhead travellers, others long-armed cranes only, others electric hoists, and some common steam cranes, portable and fixed, and nothing else.

Although these firms ought to be able

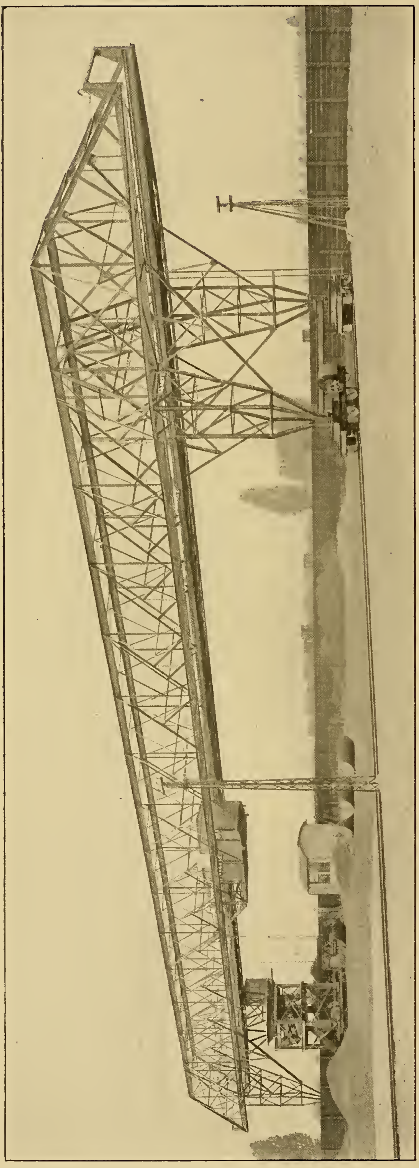


FIG. 3.—A GOLIATH TYPE OF COAL-HANDLING CRANE, BUILT BY THE ELECTRICAL COMPANY, LTD., LONDON

to give a better crane at a lower cost than the general shops can, they do not always do so; while carrying, so to speak, all their eggs in one basket, they are, therefore, less able to tide over bad times than are their rivals who handle general work. The very accommodating policy of the general shops insures their getting a considerable amount of trade, because there always is a large demand for cranes to perform special, or particular, and local service. It must be so when these mechanisms are required to work under the very diverse positions and peculiar conditions, both indoors and out, which so many have to do. Strict standardisation must go, then, if the orders of customers who desire to be accommodated are to be secured. What these crane-making firms do is to standardise when they can and utilise sets of work for cranes differing in certain other details. Engines are thus taken in sets and put bodily on cranes differing in other details. Hoisting drums and sets of gear are similarly taken, and jibs of standard lengths and sections are stocked. Even superstructures are taken bodily and put on trucks differing in size and varying in mechanism, and similarly with jibs; or standard trucks receive superstructures of different types. There are then some kinds of alterations which do not add much to the cost over that of strictly standard cranes, while a large class of customers is accommodated.

The term "special" is used to denote a thing that is novel or a design that is correlated to certain working demands which are nearly constant in character. Every great group

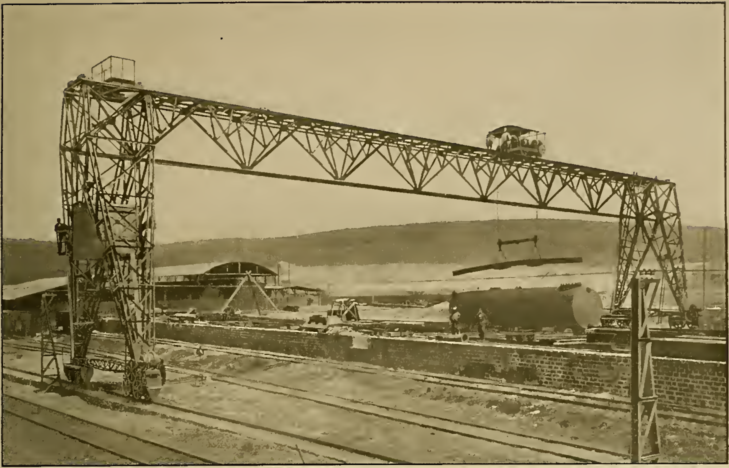


FIG. 4.—A GOLIATH CRANE BUILT BY THE ELECTRICAL COMPANY, LTD., LONDON

of cranes answers to a definite demand, and, therefore, is a specialised product; but within these groups greater specialisations occur.

Many things operate in fixing the designs of the great groups of cranes. Thus, there were no "Titan" cranes previous to the manufacture of cubical blocks of concrete of 40 tons weight and thereabouts. The Titan is, therefore, a special crane, used for nothing but the setting of concrete blocks and work related to it; but around this,—the main type of massive travelling crane, with overhanging horizontal jib,—many details in design have been produced.

The influence of the big and costly cargo steamers is seen in several types of recent cranes,—the long-armed coaling cranes, the portal cranes, the hydraulic coal tips, taking the place of the older slow wharf cranes with racking and derricking jibs, mostly of limited range of action. Rapid loading and unloading is rendered necessary by the capital cost of the mammoth vessels, which is inconsistent with lengthy spells of detention by wharf or dock.

Again, the requirements of industrial establishments have been the direct cause of much radical improvement in crane design. The overhead traveller, spanning the entire area of a shop, and the lighter hoists and cranes covering more limited areas are the present-day system, and these form immense groups, within which many variations occur.

At the awakening to the inefficiency of the lifting tackle of ten or fifteen years ago, electricity was waiting to supply what was wanting to render the new requirements practicable, and has influenced the mechanical details of cranes also to a remarkable extent for the better. Indifferent fitting, bad design and poor materials are inconsistent with electric driving, in which high initial speeds are unavoidable. The modern electric traveller resembles its predecessors in little except general outlines and functions, or even the earlier electric travellers in which a single shunt-wound motor was attached to an existing crane, effecting, by means of wasteful and undesirable gears, its conversion from hand, steam or cotton rope drive to electricity. Electricity has given us new types of light hoists, perfect in all details. It has also simplified

FIG. 5.—ELECTRICALLY OPERATED JIB AT THE END OF A COAL-HANDLING CRANE, INSTALLED BY THE ELECTRICAL ENGINEERING CO., LTD., LONDON

many of the movements in big cranes that were formerly effected clumsily by shafts and gears or by pitch chains. It has been the greatest help and the best tonic that crane makers have received since the distant periods when water and steam first supplanted hand power.

Nor has the reaction which has taken place on the electric details themselves been less marked. There is a great deal of difference in these by comparison with those, say, of only five years ago, besides which a new and extensive department of electrical work has been created. The present-day electrical equipments bear little resemblance to those which were made the subject of early experiments. Motors, controllers, brakes and careful co-ordination of power to duty have resulted as a consequence. Electric crane work is now becoming very much " cut and dried," more so than the steam or hydraulic applications ever were. The early motors were exposed to dust, and their high speeds involved much reduction gear. Now there are few made which are not wholly encased, or nearly so, and lower speeds are employed. Castings are made of steel, instead of iron, to secure lightness with strength, and they are more compactly designed, to occupy less floor space. More important, too, is the fact that they are designed specially for the service that they have to perform,—an intermittent one,—hence the general preference for the series-wound rather than the shunt-wound type. The series motor runs faster as loads are lighter, exactly as a crane is required to work. It is made reversible also, to avoid the use of clumsy and noisy reversing clutches or gears that were formerly employed. And, further, motors are designed for either continuous or alternating currents, for varying loads, and also for voltages up to 500, to accommodate existing installations.

The shunt motor is started before the

load is taken by the crane, but the series motor has to start with the load. Herein lies the first difference, a starting torque of the latter being, as required, two or three times greater than that corresponding with the output of the crane.

The fact that crane service is intermittent in character is taken advantage of in making crane motors with a special winding for giving a large starting torque and a high output for short periods, so that an overload of about 50 per cent. can be safely taken for a short period. This period is mostly taken at about five minutes, which is seldom exceeded in crane work, and is often considerably less. If the overload lasts a few seconds, it may exceed the normal by two or three times. The Electrical Company, Limited, of London and Berlin, some of whose cranes are illustrated here, term this high output the " crane output " of the motor, or the " crane horse-power," and this is a very practical method of rating. The value of this output depends largely on the length of the period of rest between working loads. This period must be at least double that of full load; but if it is considerably more, then the motors can be used for a much higher output than the crane rating, because they are capable of taking overloads of two or three times the rated " crane output " for some seconds.

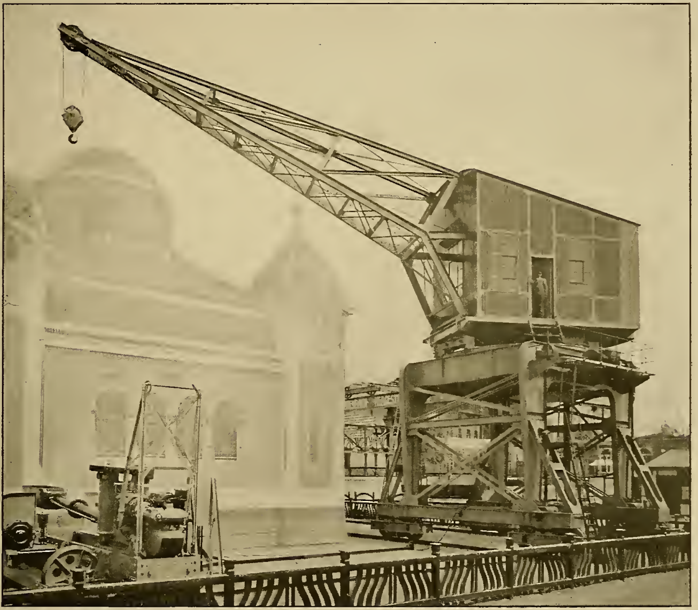


FIG. 6.—A 10-TON PORTAL WHARF CRANE, 49-FT. RADIUS, ELECTRICALLY DRIVEN. BUILT BY THE BEURATHER MASCHINENFABRIK, BEURATH, GERMANY

From the point of view of overload, the method of " rating " of Messrs. Siemens Brothers & Co., Limited, enables a motor to be selected of suitable power for any class of duty. Each motor, in this system, is rated to give three outputs, or maximum effects, which it will exert during a run of six hours, without exceeding a rise of 80

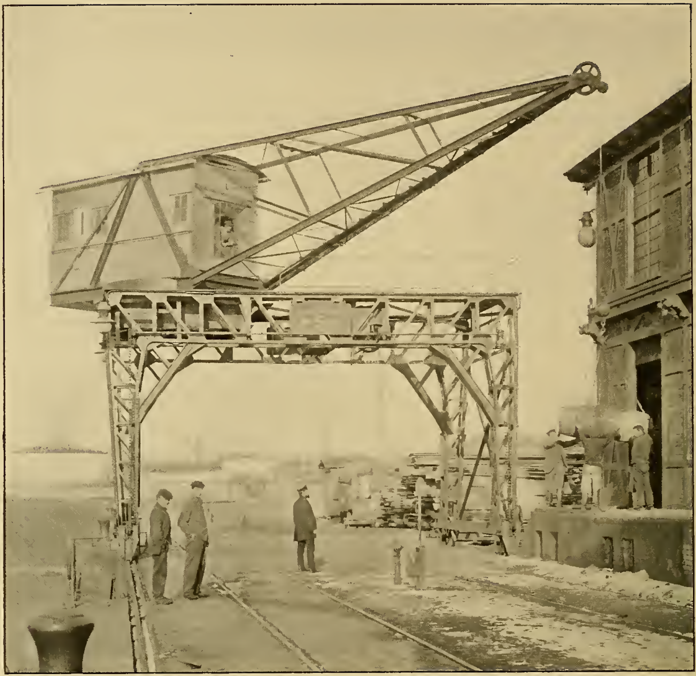


FIG. 7.—A 4-TON ELECTRIC PORTAL CRANE, 37-FT RADIUS. BUILT BY THE NAGEL & KAEMP IRONWORKS CO., HAMBURG, GERMANY

degrees F. in temperature above the surrounding air. These outputs correspond with full or maximum load factors of one-sixth, one-fourth, or one-third, respectively, equivalent to two, three, or four minutes out of every twelve minutes.

Both continuous and three-phase currents are used for series motors. The disadvantage of the former is that the motors will race on sudden throwing-off of the load, while little variation occurs when the latter kind of current is employed. To obviate risks of racing, some firms, as Siemens Brothers, make compound-wound motors, in which the current is sent by a special form of controller through a shunt field each time the motor is shut off. The capacity for overload and the large starting torque are obtainable equally well whatever current is adopted.

The controllers and the brakes have been specialised for crane service in several ways,—to simplify the work of attendants, diminish risk of false movements, and to reduce the chances of accidents to a minimum. Controllers are designed for crane service in which the hoisting and slewing motions are operated by one lever in vertical and horizontal directions, respectively. The lever is also moved in the direction in which motion has to take place, upward for hoisting, downward for lowering, and to the right and left for slewing in those directions.

The greatest successes of electricity

in hoisting work, after the electric traveller, have been scored in the wharf cranes of the gantry portal type. The application to the overhead traveller of the new power agency preceded that of the wharf cranes, because the difficulties to be surmounted were less. The mechanism of the existing power travellers driven by steam, cotton rope or square shaft, seemed better adapted to the substitution of a motor for steam, cotton rope or hand, according to the ideas of the time, than did that of the gantry cranes.

The traveller lifts heavy loads slowly, the wharf crane light loads rapidly. The latter absorbs considerably more power than the traveller does, while the rapid acceleration of speed of lift, the equally rapid slowing down, and the quick reversals give rise to problems that were not at first easy of solution when the high-speed shunt motors were being employed to the exclusion of series-wound types. As these cranes operate mostly with warehouses on one side of the wharves, the steam boiler with its flying sparks has always been deemed objectionable; but in cold districts the hydraulic pressure system, otherwise generally valuable, gives trouble, due to the freezing of water in the pipes. To prevent this, the expedients have been adopted of warming the water at various locations, or the cranes have been kept running while doing no work. Glycerine has also been used in considerable proportions in the water, but has added to the expense. The first successful attempt to apply electricity to gantry cranes was made at Hamburg in 1891, since which time these installations have become very numerous at the German and other ports.

Fig. 2 shows a remarkable crane of the gantry or portal type, of recent development and designed for wharf work by the Beurather Maschinenfabrik Actiengesellschaft, of Beurath and Lon-

FIG. 8.—ELECTRICALLY-DRIVEN "ANGLE PORTAL" CRANE AT MANNHEIM, GERMANY. CAPACITY, 1¼ TONS; 29 FT. 6 IN. RADIUS. BUILT BY THE NAGEL & KAEMP IRONWORKS CO.

don. The type is usually termed the giant, or sometimes hammer crane, so-called from its rude resemblance to the outline of that instrument. Imagine the jib of a revolving "Titan" crane perched up on a lattice-braced structure, high enough to clear the funnels and poles of steamers, and you have the hammer crane in outline; but the latter machine is fixed, instead of being portable, as the "Titan" is. There is, however, the long horizontal arm, or jib proper, in the front, and the short arm, or counterbalance, behind the centre. The pivoting portion, a skeleton post, comes down to the base where it pivots.

This design has long been desirable, but it was not really practicable until electricity came to simplify the problems of transmission of power. Being mounted on lattice-braced staging, the hammer crane is a portal crane. The shape of the support in plan is either trilateral or rectangular, according to circumstances. Differences occur in the locations of the lifting and travelling gears, according to whether the crab carries its own motors and gears, or whether these are located elsewhere, reducing the crab to a jenny.

Fig. 1 shows a 4 ton steam gantry made by Ransomes & Rapier, Ltd., of Ipswich, which differs from many gantry cranes in the fact that the crane travels along the gantry instead of rotating merely on a fixed bed upon it. The stability when lifting full loads across the rails is ensured by rail clips. The ring of live rollers is more conducive to steady rotation than the three or four rollers usually fitted to cranes of this type. The "Goliath" or gantry framing is made to travel by the crane engines by diagonal shafts and bevel gears.

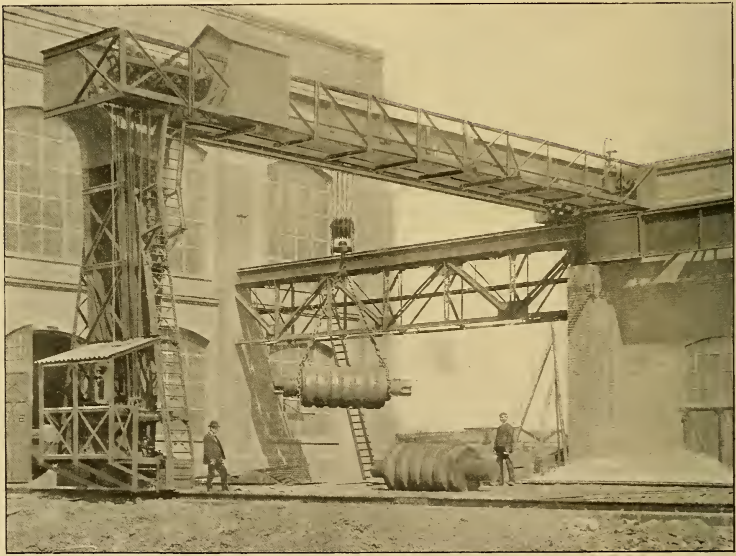


FIG. 9.—A 30-TON ELECTRICALLY-DRIVEN ANGLE PORTAL CRANE, BUILT BY THE DUESSELDORFER KRAHNBAUGESELLSCHAFT C. W. LIEBE, M. B. H., DUESSELDORF-OBERKASSEL

The number of "Goliaths" of abnormal span now used and being constructed is striking. As in America, so in Germany they are taking the place of wharf cranes, of ordinary "Goliaths" and gantry cranes of moderate radii and

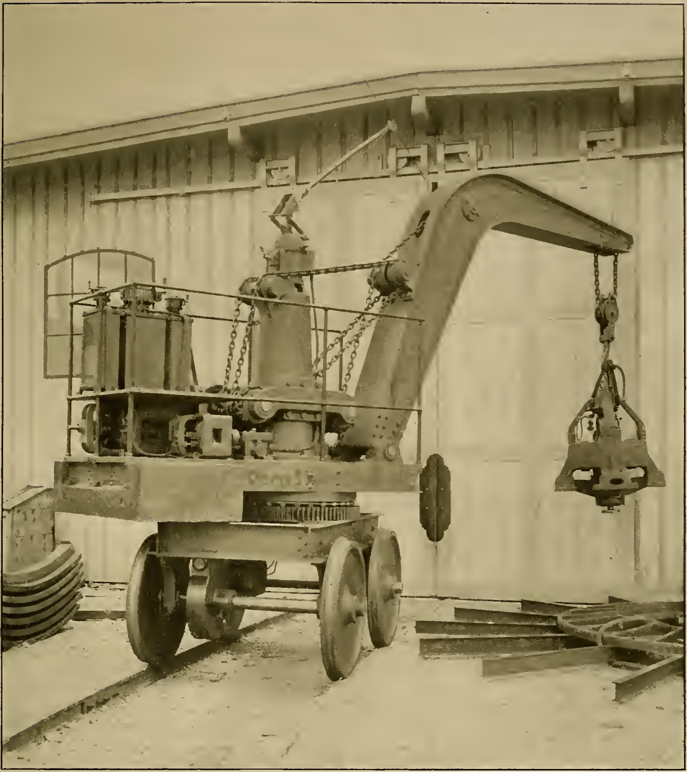


FIG. 10.—A 5-TON ELECTRIC LOCOMOTIVE CRANE, BUILT BY THE OERLIKON MACHINE WORKS, ZURICH, SWITZERLAND

spans. The term sometimes given to them,—bridge cranes,—is one that fits the design exactly, for they are travelling bridges of 100 to 200 feet or more in length, spanning lines of track on railways and wharves and reaching over ships and barges. Here, too, designs are already modified variously. There is the bridge carrying a crab,—shown in Fig. 4,—the length of whose travel terminates with the end legs, and there is the type,—shown in Fig. 3,—in which the ends overhang like short jibs. Both of these were built by the Electrical Company, Limited. Fig. 5 shows one of the latter with a curious crab which runs on the lower booms of the bridge, but which has a horizontal jib standing out beyond to reach over the water. The nose form of jib in smaller designs, examples of which are being now attempted, may probably become a favourite in shops also.

A travelling bridge crane,—not shown,—made by the Beurather Maschinenfabrik for the Rhenish-Westphalian Coal Syndicate, has the record span of 393 feet 8 inches. A central leg is fitted to take the weight about the middle. In these immense bridge cranes it is much more necessary to economise the metal than in those of smaller dimensions.

The bellied form which has been generally deemed most suitable for traveller girders is seldom adopted in these vast spans, trussing being relied on solely. Then the legs, very broad at the top and small at the base, fulfilling in one the functions of the legs and of the angle brackets in the common designs, are admirable solutions of the difficulty. Such framings would have been deemed quixotic a few years since; but then the mind of crane makers ran in grooves, and old designs were reproduced that were unsuited to changed conditions.

An ordinary gantry or portal crane cannot be classed now among special cranes, but a " Goliath " carrying a jib crane is unusual. It may be termed a portal crane of unusually large span. Considered as a " Goliath," the substitution of a jib for a crab gives a swing of the jib over the ends not possessed by the crab. In this design the horizontal beams are tied together This type of crane is shown in Figs. 6, 7 and 8, the last-named being of the angle portal type. Fig. 9 shows the angle portal crane without the jib crane.

To be concluded in the March number

ELECTRIC TROLLEY OMNIBUS LINES

By George Ethelbert Walsh

ANOTHER evolution in surface rapid transit for country districts is impending. Not satisfied with criss-crossing the country with steam railways, electric railways, stage lines and automobile routes, the modern engineer proposes to monopolise a part of the highways with so-called trackless trolleys which will carry merchandise and passengers through regions undeveloped by the modern transportation lines. The trackless trolley is an innovation that has been practically tested on the Continent of Europe, and experimentally tried elsewhere, with fair promise of future success. The legal difficulties of securing certain rights on the public highways appear now to be the main obstacles to its early and complete development.

The trackless trolley is a sort of hybrid,—a cross between the automobile and the electric railway. Partaking of the nature of each, it can be classed as neither. It is not as serviceable as the electric railway in transporting passengers and freight along its line, and it is not as mobile and independent as the automobile stage coach; but its construction and equipment are much cheaper than the former, and its efficiency is greater than that of the latter.

The most serious item in the construction of any railway is the cost of the road-bed. This great initial outlay prohibits the construction of railways in parts of the country where the traffic of passengers or goods is not heavy enough to insure fair returns upon the capital invested. The development of electric railway lines is limited to comparatively thickly-populated suburban sections. It cannot penetrate far into the country unless there are reasonable indications that population will increase rapidly in the near future. The question of using automobile lines as feeders for the electric railways has been under serious consideration for the past two years; but, with the exception of a few isolated instances, no practical demonstration has been made of the feasibility of this idea.

The trackless trolley serves as the

A GERMAN SNOW AUTOMOBILE OMNIBUS ON THE HAIDEBAHN, BETWEEN DRESDEN AND KLOTZSCHE, GERMANY

"missing link" in this chain of country and suburban traffic development. Its route is permanent, but its cost of construction and equipment is so low that it can operate through a sparsely settled region and still return good interest on the investment. It taps the little hamlet a few miles back from the steam or electric railway; it skirts the isolated farms in agricultural regions to carry goods and farm produce to town or city; it connects two parallel steam railways so that residents of the country can take their choice in going to distant points; it follows the line of fertile valleys where scattered farm houses are shut off from direct communication with the rest of the world, and, finally, it opens up new regions for settlement, promising serviceable goods and passenger transportation from the start.

The trackless trolley may prove the pioneer, in many parts of the country, of future important electric railway lines. As the old narrow-gauge steam railways opened the way for trunk lines, and were in time absorbed by the larger corporations which immediately converted them into standard gauge lines, so the trackless trolley promises to develop new regions until the population warrants the construction of standard electric railway lines to accommodate the increasing traffic. As an important factor in the future growth of a country, the trackless trolley enters the field of transportation with every promise of immediate success.

The several trackless trolley lines in operation in Continental Europe afford abundant evidence of their future possibilities elsewhere. One of the most important of these new types of suburban lines is the "Haidebahn," running between Dresden and Klotzsche, in Germany, and operated by the Allgemeine Electricitäts Gesellschaft, of Berlin. This road is about two miles long, and has been in active operation for some time. The regular overhead trolley wires were strung along the highway as feeders to the omnibuses. The cost of putting up the poles and wires was about the same as for an ordinary electric railway, but there was comparatively little expense for the building of the road bed. This consisted of one side of the regular highway, which was

THE TRACKLESS TROLLEY IN GERMANY. SINCE THERE CAN BE NO RAIL RETURN, THE DOUBLE-TROLLEY SYSTEM MUST BE USED

ONE OF THE OMNIBUSES HAS ITS TROLLEY POLES PULLED DOWN, SO AS TO LET THE OTHER VEHICLE PASS

smoothed out and hardened on the surface by a layer of fine stones and gravel. The estimated cost for the line construction, including poles, wires and road improvement, was in the neighbourhood of $13,500. An electric railway of the usual type would cost probably six or seven times as much.

The trolley omnibuses run over this trackless line have a capacity of twenty-two passengers. They are provided with broad tires to reduce the wear and tear on the highway as much as possible. The difference in the cost of operation of this trackless trolley and an ordinary railway is chiefly in the amount of current used, greater expense in the maintenance of the omnibuses, and increased cost for lubrication. The trackless trolley omnibuses used about 25 per cent. more current than the regular trolley cars. But the final cost is in favour of the trackless trolley, owing to the more expensive cost of maintenance of steel rail lines and the installation of safety devices and their operation. The saving on the cost of initial construction of the road-bed is, however, the chief point in favour of the trackless trolley.

Another trackless trolley line in the Bila valley, after an experiment covering three months, reported similar results. On this road the consumption of current was much higher than on the Haide road, but this was partly due to the use of unnecessarily heavy omnibuses.

The Dresden-Klotzsche line, in Germany, was in operation all last winter and summer, and a further innovation has been made this winter in the form of an electric sleigh. This vehicle is for use when snow and ice cover the route, and ordinary electric omnibuses have difficulty in running. It is the first of its kind to be used anywhere for public purposes. The vehicle is similar to the ordinary trackless trolley car, except that the hind pair of wheels have been replaced by a pair of sleigh runners, and the driving wheels are fitted with tires especially designed for taking hold on slippery surfaces. Experiments were made with the electric sleigh on the road last winter, and, with new improvements, it is expected to prove very serviceable. The utility of the trackless trolley was further demonstrated in France last year. According to tests made in that country, the practical speed of the cars on level stretches of roads is about 8½ miles an hour.

The price of the specially constructed trackless trolley cars used in France was from $3,000 to $3,500, completely equipped with powerful brakes, lighting arrangements, and electric heating radiators. The German cars cost a little more than this sum. A large part of the income of the trackless trolley must come from goods traffic, and heavier cars built for this purpose cost somewhat more than the figures given above. The omnibuses are provided with very broad tires, which, instead of injuring road-beds, help to roll them down, and, in the tests made in Germany and France, they have given less cause for road repairs than the ordinary vehicles with their usually narrow tires.

While the trackless system avoids all expense of track-laying, it is probable that many of the lines will have to pay for the franchises over well made roads and turnpikes. The question of regulating their use and rights of public highways is a legal one that is now being settled in several places. One trackless trolley company recently had its application for a franchise denied by the ruling of a court that there was no law on the statute books to control their operations, and, therefore, they would be outside of the jurisdiction of the courts if permitted to run.

The question of using trackless trolleys as feeders for railroads has been under consideration for some time in America. In New England in particular, where electric railways and the steam roads have overlapped one another's fields, the value of the trackless trolley lines may before long prove of great importance. They would be used chiefly for collecting goods and passengers from farms and inland towns and villages where the service has not yet reached the point of development sufficient to pay interest on heavy investments in laying down rails and rights of way. Another function of the trackless trolley in that section of the country would be to supply summer traffic along the seaside resorts. The travel in summer is sufficient to pay a railway, but in the winter season the places are practically dead, and interest cannot be earned on the heavy railway investments during the short season. The trackless trolley, by virtue of its small initial investment, might prove a paying investment, and tend toward creating and building up a line of travel which, in the end, might be profitable enough for more expensive investments. Stage coaches, and, more recently, automobile lines, have hitherto connected some of these small beach resorts with the railways.

MODERN LABOUR-SAVING MACHINERY

By George Frederick Zimmer, A. M. I. C. E.

TO say that this is the age of machinery is, no doubt, to utter a truism, yet few people realise how profoundly the conditions of modern life have been modified by the use of machinery. Regarded from the broadest point of view the substitution of machinery for hand labour means an infinite expansion of the power of production. But the positive value of the service of the engineer to modern civilisation is not to be measured by mere productivity, weighty as that consideration must be. The advantages of the use of labour-saving machinery extend far beyond the purely industrial plane.

It is the hackneyed complaint of the æsthete, of the blind worshipper of Ruskin, that machinery has turned the worker into a blind, soulless tool. Never was there a more complete fallacy. What do labour-saving appliances mean but the subjugation of inert matter to the intelligence of man? In the long run, cheaper means of production must spell larger wage-earning capacity as well as larger capital returns, of which fact a splendid example is furnished by the Carnegie enterprises.

The Carnegie millions were made largely by the use of labour-saving appliances. From the moment that the ore was taken in hand, many miles away from the Pittsburgh furnaces, to its final conversion into steel rails, the best mechanical intelligence available was employed in constantly devising fresh means of cheapening production, and, therefore, of increasing profit. The co-operation of the humblest operative in the company's employ was enlisted in the all-important work of reducing the cost of production. Any man who had any likely suggestion of any kind for saving hand labour or increasing the efficiency of the output of the plant was sure of an attentive hearing and of substantial reward for any practical outcome from it. Over and over again did the Carnegie works relegate to the scrap heap machinery which had cost vast sums, because it was found that more money could be made by installing a new and improved plant.

There is probably no field where labour-saving devices can render more signal service to industry and public work than in the handling of bulky and heavy material. Ore, coke, coal, stones, sand, etc., can be most advantageously handled by machinery. In fact, it is difficult to conceive any constructional or manufacturing operations where large masses of heavy material come into play in which machinery cannot take the place of hand labour entirely or partially. It may not be possible to entirely eliminate hand labour, but the cases where machinery is not justifiable, from an economic point of view, are the exception and not the rule. If ever hand labour could hold its own against machinery it would seem to be in the Far East, where human labour is almost incredibly cheap, as judged by our standards. Yet tea planters there, to take only one case, have again and again found it profitable to invest in ropeways for carrying the leaf over the long distances that would otherwise have to be traversed by coolies or beasts of burden. Light railways are largely used for conveying the raw berry from up-country Brazilian coffee plantations to the coast. Such lines are frequently taken up and relaid several times in the course of one year. They are moved about from one estate to another, as required, and though this involves a good deal of hand labour, its cost is more than defrayed by the expeditious and cheap carriage of the raw berries. These are only general illustrations of the economy that may be realised by the mechanical handling of the material.

It may be as well to consider the natural divisions and sub-divisions into which modern labour-saving appliances fall. First of all, we have appliances that handle material continuously; that is to say, which receive and deliver it in an uninterrupted stream. These appliances are to be found in factories, mills and workshops, in coal and other mines, and in gas works and power stations. The distance traversed by material under such conditions is comparatively limited.

On the other hand, material may be moved over relatively long distances by such appliances as light railways, whether automatic or not, or by rope and cableways. In such cases, however, the material is not lifted or carried in one continuous stream, but intermittently, in specified quantities which will be dependent on the capacity of the separate trucks or buckets, also known as skips, in which the material is contained. Again, material may be intermittently removed through relatively short distances, as in the case of steam navvies and grabs, which, in conjunction with high-level cranes or cableways, are of great use in almost all excavating and dredging work, as well as for unloading purposes.

To take, first, appliances for handling material continuously, we may divide these under two heads:—

I.—Appliances for lifting in a vertical direction, or from one level to another, commonly known as elevators.

II.—Appliances for moving material in a horizontal direction, usually called conveyors.

Essentially elevators, as here to be understood, are endless belts or chains which carry buckets or other receptacles of suitable size and shape for lifting the material to be handled. Elevators for handling light material, such, for instance, as grain and its derived products, flour, etc., are usually cased in wooden or occasionally iron trunks, and run vertically. The buckets will be attached to an endless band of leather, cotton, or india-rubber, with insertion, or some similar material. On the other hand, such materials as coal, coke, cement, ashes and ores are carried in buckets of more solid construction supported on chains running over sprocket wheels. Such elevators are generally inclined at an angle which will vary according to the material and other conditions. In almost all types of elevators the lower terminal is fitted with tightening gear to keep the belt or chain taut.

The position of elevators and the speed at which they run depends upon the material they have to lift. An elevator raising material of low specific gravity may be driven at a much higher speed than one intended to handle material of high specific gravity. This is because a speed which would not injure a material like grain, would, at the point of delivery, fracture and seriously deteriorate the value of coal. Moreover, the mere impact of heavy bodies would much shorten the lives of the receiving shoots or spouts. While grain and flour elevators, therefore, need not be taken out of the perpendicular, and can be run at a speed of 250 to 350 feet per minute, elevators that raise heavy material should not exceed from 50 to 130 feet per minute. Under these conditions the elevator cannot be placed vertically, but must be fixed at an angle of 45° to 60°; only by this means can a clean delivery be combined with the requisite gentle handling of the material.

In antithesis to elevators which run in either a vertical direction or move from one level to another, we have conveyors which move material in a horizontal direction only. The conveyor has a pedigree of great antiquity. In the form of the Archimedean screw it is thousands of years old. A rude kind of screw made by driving pegs of hard wood into a spindle of soft wood seems to have been used in flour mills of olden times. The writer has seen such screw conveyors in an ancient mill, in which, too, there were some wooden pulleys, believed to be at least 200 years old. The modern worm conveyor consists of a spindle made of a steam pipe, which is converted either into a continuous worm or into a so-called paddle worm, the latter formed by fan-like metal blades arranged round the spindle so as to form a broken-threaded screw. This is, in a sense, a reversion to the primitive form of screw conveyor roughly fashioned out of wood.

Screw conveyors can carry all kinds of material in a horizontal plane, but they are not without drawbacks. They are relatively large consumers of power, and require careful attention to details of construction, such as the bearings. As to the power actually absorbed by them, this varies with the material; the more cutting the nature of the latter, the greater will be the frictional resistance, and consequently the heavier the consumption of power. But to convey a load of, say, 50 tons of grain a distance of 100 feet per hour on an 18-inch or 20-inch continuous worm would require a driving power of nearly 20 H. P. This presupposes a suitable and well-designed worm. On the other hand, the first cost of worm conveyors is relatively moderate, and, in short lengths, this appliance will, on many classes of material, prove efficient and economical. But any kind of worm conveyor used for handling harsh and refractory substances will wear rapidly.

Another type of conveyor is the push-plate conveyor. This, in principle, consists of a fixed, open trough, formed of sheet iron or steel, and angle or channel irons. The material to be conveyed is pushed or dragged along this trough by a series of plates set at right angles to the bottom of the trough. These plates are attached, preferably at the centre, to an endless chain, which, with its attachments, passes over terminal pulleys. The plates are not allowed to touch the bottom of the trough, and are usually fitted with a skidder bar, which slides on well greased angle bars forming portions of the framework, as in the case of bucket elevators. The skidder bar may preferably be replaced by a pair of small rollers running on channel or angle bars.

Push-plate conveyors are used for handling various kinds of heavy material, such as coal, cement, ashes, etc., and can be built for any capacity in reason. The speed must be varied to some extent to suit the nature of the material. For instance, coke, which is a friable material, should not be carried at a greater speed than 50 to 90 feet per minute, while in cases where breakages are of minor consequence a speed of 180 feet may be reached. The use of this kind of conveyor for coal and all substances with sharp edges means rapid wear.

Types of push-plate conveyors are often used for hot coke, a most difficult substance to handle mechanically. A conveyor fitted with a 27-inch trough and malleable iron plates 24 inches apart, running at 50 feet per minute, can deliver 20 tons of coke per hour. A push-plate conveyor for coal with a trough 20 inches wide and plates 18 inches apart, running at 180 feet per minute, can deliver 40 tons per hour.

A modification of the push-plate conveyor is known as the cable conveyor. This consists of a V or U-shaped trough of wood, through which passes a wire rope with disc-like attachments. The trough is lined with sheet iron or any other substance suitable to the nature of the material to be handled. Conveyors of this kind are well adapted to carry bulky material of relatively low specific gravity, such as timber, peat, hay, etc., and may be run at 100 to 120 feet per minute.

The standard method to-day of conveying grain and other similar materials is by a band conveyor. This simple yet efficient contrivance was perfected less than two decades ago. It consists essentially of a band of canvas or rubber with insertion, which runs over two terminal pulleys and is supported by a series of intermediate rollers, these being more frequent under the carrying than under the return strand. Although originally band conveyors were used, as they are to-day, for carrying grain between ships and warehouses or mills, they are now widely employed as well for the carriage of heavier materials, such as coal and ores. In such cases the band must be made of stouter material, while the carrying rollers are so arranged as to give the top or conveying part the shape of a trough.

Endless bands used for heavy and bulky material cannot be run at a great speed; but the size, rather than the specific gravity, determines the speed. Thus, for large-sized coal, 150 to 200 feet should be the maximum speed, while with smaller pieces a higher speed is permissible, increasing in the case of small coal to 500 feet per minute. Band conveyors may be run uphill at angles not exceeding 26°. Bands used for either heavy or light material can be fitted with throw-off carriages which will discharge material at any desired point.

Another appliance for conveying material in a horizontal direction or at a slight incline is the travelling trough conveyor, which consists of an endless trough, the sections of which are riveted to the links of suitable chains. The trough travels over terminal pulleys, one of which is adjustable to take up the wear in the joints of the chain. This type of conveyor may be run at from 60 to 120 feet per minute, and may be compared with the push-plate conveyor in so far as the sections of the trough take the place of the push-plates on the endless chain.

The vibrating trough conveyor has within the past few years come into extended use for the handling of such material as coal, cement, ashes, coke, grain, chaff, etc., as well as minerals of all kinds. This conveyor consists solely of troughs which receive the material to be conveyed at one end and deliver it at the other by a series of backward and forward movements. Like the band and the travelling trough conveyor, the vibrating trough handles material with a minimum of friction,—an important consideration in dealing with material that is deteriorated by friction. The reciprocating motion by which the travel and discharge of the material are effected is obtained by a crank and connecting-rod, the trough itself being supported on rollers; or the trough may be actuated by a cam, or by cranks with some kind of quick-return motion. The best plan is to support the trough on flexible legs placed obliquely to the trough, which is set in motion by a small countershaft and crank. The result is that the material is made to gently jump with the tray, thus progressing, not with a sliding, but with a hopping motion.

When swinging conveyors are used in greater lengths than, say, 50 feet, they are balanced; that is to say, they are made in two parts, one being placed at a slightly higher level than the other, the two parts delivering into each other. In such a case the troughs are actuated by a double or multiple crank, the centres of which stand at an angle of about 180° to one another, so that as one-half of the conveyor moves forward the other half moves backward, while the material moves from end to end in the same direction, because all the spring legs are of the same inclination.

The distinct operations of carrying in a vertical and horizontal direction have been combined in the gravity bucket conveyor, which has some affinity to an elevator in so far as it consists of two endless chains or ropes held apart at a fixed distance by bars, fitted with small rollers at each end. To every link, or every second link, is attached a bucket, not like an ordinary elevator bucket, but movable and suspended from a point above. It follows, then, that as the endless chain moves, the buckets are always in an upright position, whether they are travelling vertically or horizontally. The buckets carry their loads to the determined point of discharge, where they are tilted by an adjustable device.

Combined elevators and conveyors of this description are very useful in coal stores where delivery has to be effected to overhead bunkers. Such an appliance will perform, in one single operation, what would otherwise require the use of two conveyors and one vertical or inclined elevator. Conveyors of this type do not require much power, but can travel at only a low speed, not exceeding 25 feet per minute.

Another and totally different kind of combined elevator and conveyor is the pneumatic elevator, which appliance has been brought to great perfection in recent years. An elevator of this type is in constant use at Millwall Docks, London. The pneumatic elevator, however, is suitable only for grain, which is withdrawn from ships' holds by suction and discharged into granaries by air pressure.

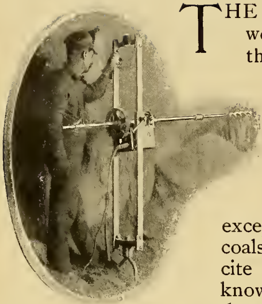
There are many other devices for moving materials at a minimum of labour and expense, such as ropeways and aerial cableways, not to mention automatic truckways and self-discharging railway trucks, but only passing mention can be made of them here. The ropeway, of which the cableway is a modification, is a device of some antiquity. In a crude form ropeways were in use over two centuries ago. A ropeway consists essentially of an endless rope stretched between supports and carried over pulleys between two fixed points. From the rope are suspended buckets or skips in which the material is carried, sometimes over many miles. If it be desirable, the skips can be stopped and discharged at any given point by being led on shunt rails.

The cableway differs from the ropeway in that the span is usually much shorter, while the cables, which, as in the case with ropeways, consist of steel wire, are carried between two towers that may be, and generally are, movable. The head tower, as it is termed, contains the engine by which the cables are actuated, the latter being wound around drums. To one rope, known as the fall rope, the buckets or skips are attached. Cableways have been found of great utility in such operations as quarrying, dam and bridge building, and even coaling ships at sea.

The ropeway proper may be either single or double; that is to say, the skip may be suspended and conveyed by a single rope, or two ropes may be employed, one as a track rope for supporting the load on a trolley, and the other for hauling the load along. Both systems have their advocates; but, generally speaking, single lines are laid over short distances, though it is only fair to say that single ropeways have successfully spanned relatively long distances and have been carried over very difficult ground. Ropeways need but comparatively little power, and in some cases where the loads are run down an incline, the surplus energy generated can be used for other purposes. But ropeways, like other means of mechanically handling material, have their limitations. They must be taken in as straight a line as possible, as the rounding of sharp curves means the introduction of angle stations which add to the working expenses.

VIRGINIA ANTHRACITE COAL

By L. S. Randolph



THE coal fields of the world, or such of those as have been discovered and sufficiently developed to make their character known, are almost entirely bituminous, and except for some Welsh coals, the only anthracite coals previously known were those of the great Pennsylvania fields in the neighbourhood of Scranton, Wilkesbarre, and Mauch Chunk. In the latter part of the fifties another field was discovered in South-western Virginia on the waters of New River. This field was developed and mined prior to the American Civil War, but not in an extensive way. Manufacturers were few, and the mining of coal for domestic purposes was too insignificant a matter to justify any outlay of money or energy. With the abundance of cheap labour in the slaves and the abundance of wood, no one could afford to pay for coal such prices as were demanded at that time.

The coal field lay for thirty years after the war wholly and entirely unknown, except for the extreme local market. Geologists now and then were astonished to find it, considering it more of a freak than any regular mineable deposit of coal. A few promoters examined it from time to time, but refused to consider it for the reason, very tersely expressed by one capitalist, "that so good a thing could not have lain there so long a time without having been picked up."

In 1893 the writer of this article came into the region and found in the investigating of these deposits a never-ending source of interest. The consensus of opinion of the best geologists is that this coal formation is in what is known as the Pocoano sandstone, or the earliest coal-bearing formations. These formations are barren of coal in the Pennsylvania region, except in one or two instances where a seam of coal one or two inches thick has been discovered. At Meadow Branch, near Cherry Run, on the Baltimore & Ohio Railroad, the seam is again apparent, having thickened up to about 18 inches; but the whole formation is inverted and very much distorted, so that the coal is useless for market purposes.

It has been known for the last forty or fifty years that such coal deposits existed at this point, and numerous futile attempts have been made to develop the property. The coal formation again shows back of Winchester, Va., in Highland County, in Roanoke County west of Salem, and in Montgomery County in the vicinity of Blacksburg, the formation running on up through Pulaski, extending from there a short distance into Wythe county, and showing again in North Carolina. All of the paying coal of these deposits lies in Montgomery and Pulaski Counties. Outside of these two counties the coal is either pinched out or so broken or crushed as to be valueless commercially, except for some special metallurgical purposes.

Unfortunately, the deposits above described, except in Montgomery and Pulaski Counties, are along the seat of violent geological disturbances, which, occurring after the coal was formed and hardened, caused it to crush, and in many cases become powdered. It is for this reason that the paying deposits of coal have occurred in Montgomery and Pulaski Counties only, and even in Pulaski County the crushing and distorting have occurred to such an extent

THE COAL BREAKER OF THE VIRGINIA ANTHRACITE COAL COMPANY AT THE MERRIMAC MINES NEAR BLACKSBURG

that the coals are in many cases worthless.

So far, the only paying mining has been done in the Blacksburg region and in the Pulaski region on the Norfolk & Western Railroad, where the outcrop crosses the New River. The old Bell Hampton mine was opened and operated ten or fifteen years ago, and a number of miles of narrow gauge railroad were built to carry the coal to the Norfolk & Western Railroad. After having been operated for a few years the property was abandoned and the rails were taken up from the railroad.

The mines at Dry Branch, or Kimball, on the Norfolk & Western, and on the banks of the New River, have been mined extensively, but apparently not at any great profit. This seam carries a belt of bituminous dust 3 feet thick, which it is practically impossible to burn under any ordinary boiler, but which is used successfully in the smelting of zinc, and possibly could be used very successfully in the dust burners. This coal otherwise is of very good quality. The main seam through Pulaski County is but a continuation of the seams of the south slope of Brush Mountain; in fact, Brush Mountain is but a continuation of Cloyd's Mountain and Little Walker Mountain, in Pulaski County. The character of the coal is the same, except that the dirt seam in Montgomery County seems to lessen in thickness.

Price Mountain, which is a short spur running parallel to Brush Mountain and about six miles east of it, practically extends from the divide at its eastern end to the New River. The coal here lies on both sides of the mountain, the anticlinal axis of the basin being coincident with the axis of the mountain. There is no parallel formation either north or south corresponding to the Price Mountain formation. In other words, the field has only one outcrop, except in Montgomery County, where there are three separate outcrops, only one of which, the Brush Mountain, is continuous from Pennsylvania to Wythe County.

The character of the coal changes quite rapidly, and all developments are dependent upon the most thorough prospecting. On the cross-section of the Pulaski seam, which is an extension of the Brush Mountain field, the band of dust, or minings, is very much greater than in the Brush Mountain field. Again, the marked similarity between the Brush and Price Mountain fields shows these formations to be the same, and it has been held that the similarity of the deposits, together with the fact that they are dipping towards each other, indicates that the coal lies under the Blacksburg valley, and that the synclinal axis of the basin is coincident with that of the valley. This is unquestionably incorrect; the true condition is that shown on the cross section where the upheaval of the Trenton or underlying limestone is indicated.

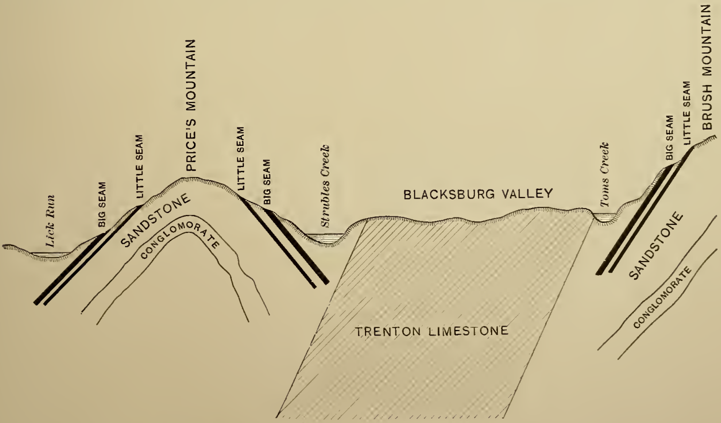
ENTRY IN MERRIMAC MINE

The character of the coal in the vein varies very much from top to bottom. In the sections shown of the Brush

THE FIRST ANTHRACITE COAL-BURNING LOCOMOTIVE IN THE AMERICAN SOUTHERN STATES FOR BURNING VIRGINIA ANTHRACITE. BUILT BY THE RICHMOND, VA., WORKS OF THE AMERICAN LOCOMOTIVE COMPANY

Mountain field and of the Price Mountain field, the coal near the bottom is rather soft and tender, but very low in ash, running as low sometimes as 3 per cent. and 4 per cent. As we go towards the top of the vein, the coal becomes harder and higher in ash. The slates are all rather dark in colour, and some of them are so filled with bituminous matter as to make it practically impossible to tell them from coal except by their weight and their flinty character. Some of these bands of slate are made up of small pieces which are covered with a thin layer of coal, making it impossible for the ordinary person to recognise them as slate.

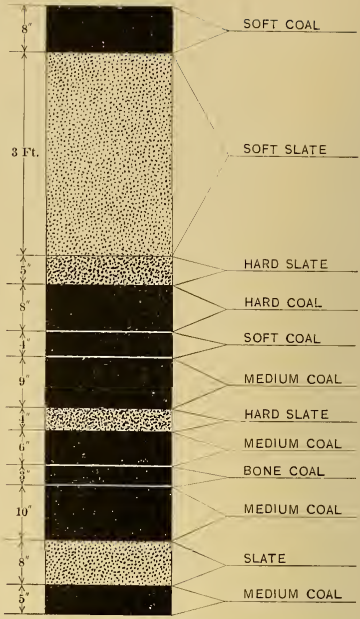
The gravity of slate is very much greater than coal, making automatic separation very easy. The coal is very light, the most marked difference between it and the Pennsylvania coal be-



A CROSS-SECTION THROUGH THE BLACKSBURG COAL FIELDS ing in this characteristic. A 60,000-lbs. car seldom will hold more than 55,000 to 57,000 lbs. of coal. The fossils of this formation are comparatively few. The fire clay which overlies the coal is filled with grasses. In some cases ferns are found in the slate bands and in the formation immediately under the coal. The fronds of the ferns are blunt, not pointed, as in ferns of the present day. One or two quite large sections of the lepidodendrids have been found. These are all of the fossils so far discovered. No molusks, or similar animal life, have been brought to the writer's attention. It should be said that these deposits are near the summit of the mountain, or rather, on the divide separating the waters of the Roanoke River and the New River, the former emptying its waters into the Atlantic Ocean and the latter into the Gulf of Mexico, thus forming the summit of the Allegheny Mountains.

The total estimated acreage of the Montgomery field is about 7000 acres. This includes the coal between the coal outcrop and the limestone outcrop. Indications are that the coal is mineable within a few hundred feet of this limestone fault; hence, the entire region between the coal outcrop and the limestone fault is included. On this basis the total estimated tonnage of the Blacksburg field would be 70,000,000 tons in the big seam alone, with possibly 25 per cent. of this amount available from the little seam, making a total of 100,000,000 tons of coal in the Blacksburg field alone. The developments in the Pulaski field are not sufficiently numerous and recent to enable any definite tonnage to be fixed on this region. Any figures which can be given on this field are too uncertain to be trusted. This estimate also throws out considerable property where the strata are so faulty and broken as to make mining impracticable.

The extent of the deposits in the Pulaski field is yet to be determined, but it is almost as extensive as the Montgomery field. It extends, and has been more or less developed, from New River to the city of Pulaski; but all operations except those at New River have been practically abandoned. The coal, as shown by chemical analysis and its physical characteristics, has rather a striking resemblance to the deposits in the Lykens Valley region of Pennsylvania. In fact, it is almost impossible to tell the two apart. Its lustre is not so great, however, as the usual run of Pennsylvania coal, nor is the fracture so decidedly concoidal. It is more tender and carries more volatile combustible, but it gives absolutely no smoke, except with very careless firing; chimneys are entirely free from soot, and the ash is white, though in some places there is sufficient iron to give it a reddish tinge. For ordinary domestic uses there is little or no clinkering except where fires are very heavily forced. Certain constituents of the ash seem to melt and form just the right amount of clinker to give satisfactory results for steam boiler work. The chemical composition is shown by



SECTION THROUGH THE PULASKI COAL FIELD

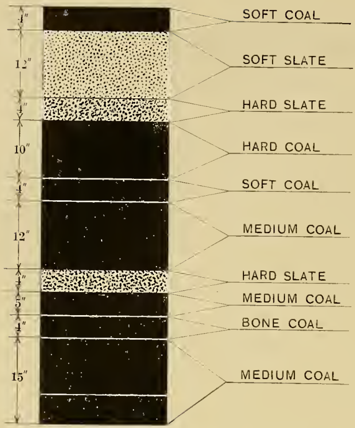
IN THE MERRIMAC MINE

the following results obtained from samples selected by the writer:—

	Price Mountain Per cent.	Brush Mountain Per cent.	Pulaski Per cent.
Volatile Combustible and Moisture.	10.2	9.3	10.7
Fixed Carbon	79.4	79.6	73.1
Ash	10.4	11.1	16.2
	100.0	100.0	100.0

The above represents average results obtained from analysis made by the writer and by Prof. Robert C. Price, of the Virginia Polytechnic Institute. The coal seems to carry a considerable amount of occluded gases; but only at one point, viz., on the south side of Price Mountain, at Merrimac Mines, has fire-damp been discovered to an appreciable extent.

The coal outcrops on the flank of the mountain, usually pretty well towards the top. So far, five seams have been discovered, running in thickness about as follows:—No. 1, 5½ feet; No. 2, 2 feet 3 inches; No. 3, 6 inches; No. 4, 4½ inches; and No. 5, 2 inches. No. 1 is mined in the Price Mountain field; but in the Brush Mountain and Pulaski field both No. 1 and No. 2 seams are worked, particularly in parts of the Brush Mountain field, where the No. 2 seam widens out to 3 feet, and, as it has only one thin slate parting, it can frequently be mined to greater advantage than the larger seam, where only a small amount of coal is needed for home consumption. The development of this re-



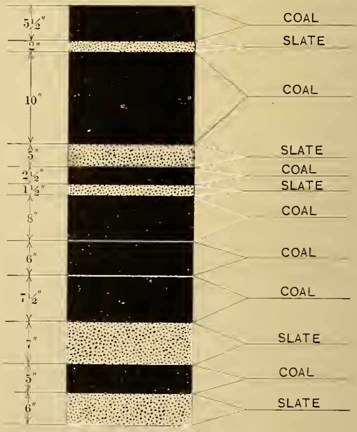
SECTION THROUGH THE BRUSH MOUNTAIN COAL FIELD

gion has been very singular. Prior to the Civil War coal was mined on the south side of Price Mountain near the eastern end and marketed in rather an extensive way, considering the times. The late Mr. Montague, of Christiansburg, Va., and Mr. Isaac H. Adams, now a resident of Lynchburg, Va., were operating at that time, and had sunk slopes to a depth of 450 to 500 feet, finding good coal all the way. Their mines were destroyed in a raid made by General Averill near the close of the war. It is claimed that some of this coal was in the bunkers of the *Merrimac*, or more correctly the *Virginia*, in her fight with the *Monitor* in Hampton Roads, the coal being shipped by the Norfolk & Western Railroad from Christiansburg depot, which is about four miles from the old Montague operations near the present village of Merrimac.

Since then the field has been handled entirely by local men, digging a little here and there, seldom over 50 or 100 feet, where the difficulty of removing the water would become too much for their engineering skill and so forced them to abandon their workings. The fact that nearly all of the coal had to be handled over mountain roads, which are for months utterly impassable, made the season—practically from the middle of August to the last of November,—so short that it did not pay for any large amount of capital to enter into the venture.

The whole outcrop, however, in the Blacksburg and Pulaski region is honeycombed with these small openings, many of which have fallen in, and all surface indications thus erased by the hand of time. While these openings have done nothing more than to enter the outcrop, thus taking the coal which is usually left in all good mining operations, they have served to develop the region and to show very thoroughly the character of the deposits, and hence, when carefully examined, prevent very effectually capital being wasted on unprofitable seams.

Much that has been said in regard to the Blacksburg region can be said of the Pulaski field, with this exception, however, that in the Pulaski field in the last eight or ten years practically all operations have been abandoned except one, the Kimball mine, and in one case, as already mentioned, a narrow-gauge road was taken up and the mine closed on account of the unprofitable character of the deposit. The large amount of slate and the large seam of dust in the centre of the seam, amounting in the seam



SECTION THROUGH PRICE'S MOUNTAIN FIELD

shown to 3 feet, makes the cost of mining excessive. The only mine that has been kept running in this region is what is known as the Kimball mine, where the outcrop crosses the Norfolk & Western Railroad on New River, and the mine mouth is immediately at the railroad. This property was recently acquired by the Pulaski Anthracite Coal Company, which is making extensive improvements, and which has a promising outlook.

The developments in the Blacksburg field, except the amount of coal handled by local parties, were largely abandoned after the Civil War, and all deposits lay idle until the spring of 1898, when the Brush Mountain Coal Company was organised, with L. S. Randolph, president, and Guy F. Ellett, secretary and treasurer; J. W. Walters, Dr. R. T. Ellett and Mr. Ed. Gardner as directors and stockholders. These gentlemen purchased a large amount of the Price Mountain field, which, being much nearer to the Norfolk & Western Railroad, and controlling the only feasible route for a railroad through Price Mountain, practically controlled the situation. They carefully studied the region, leased one mine to a competent local party, and in other ways developed the mines carefully and thoroughly and put the whole region on a good basis, showing what the property was worth, and demonstrating thoroughly its enormous value. To these gentlemen is due the rediscovery and development of the region.

In the fall of 1902 they became associated with Mr. W. J. Payne, of Richmond, Va., and the latter, after having the field examined by Mr. William Griffith, of Scranton, Pa., leased the coal-mining rights of the Brush Mountain Coal Company, organised the Virginia Anthracite Coal Company, and, taking over a charter for a railroad from Christiansburg to Blacksburg which had been secured by the Brush Mountain Coal Company, organised the Virginia Anthracite Coal & Railway Company. Mr. W. J. Payne, of Richmond, Va., is president of the coal company, and Mr. T. L. Newell, of Kingston, Pa., is president of the coal and railway company. The Virginia Anthracite Coal & Railway Company has extended its road to Merrimac Mines, in Price Mountain, and to Blacksburg; in the near future the road will be extended to the Brush Mountain field.

The companies now operating in the Blacksburg region, with the exception of the Virginia Anthracite Coal Company, own but a few hundred acres of coal land. With the exception of these, practically all of the coal property which contains mineable coal has been acquired by the Virginia Anthracite Coal Company, which holds, by lease or direct purchase, 1000 acres in the Brush Mountain field. That is all of the mineable coal north of New River, except the previously mentioned small acreage owned by other companies or in the hands of private parties.

The mining operations of the Pulaski Anthracite Coal Company, which is operating the old Kimball mine at Dry Branch, on the Norfolk & Western Railroad, are in charge of Mr. J. H. Rarrott, of Salem, Va., who was for many years manager for the same company at Lonaconing, Md., in the George Creek bituminous field. This company is erecting a large tipple at Dry Branch, together with about forty miners' houses.

The mining operations of the Virginia Anthracite Coal Company are in charge of John R. Wilson, who was born and raised in the Pennsylvania region, and, until coming to the Virginia Anthracite Coal Company, was prominently connected with the Delaware, Lackawanna & Western Railroad. He is thoroughly posted in mining and handling coal of this character. The coal company has erected a breaker, and in this the coal, after being hauled from the slope, is prepared for the market by a thorough screening and sizing. The breaker has a capacity of 500 tons a day with the machinery at present installed, and by installing duplicate screens and other machinery, the capacity can be more than doubled. The breaker also has a storage capacity of 500 tons. The coal is hoisted direct from the mine mouth to the top of the breaker, where it is dumped into a large pocket, and from which it is drawn onto the picking table where all the lumps of slate are removed. The coal is then again hoisted to the top of the breaker and run through screens, which sort it into the various sizes, these being the same as those adopted in the Pennsylvania field. The coal, after being sized, is again run over automatic slate pickers and again hand-picked. The breaker is now running forty to fifty cars per month.

Work is being pushed very rapidly on the mines, sinking the slope and driving the entries, and as soon as sufficient ground is opened up, additional machinery will be installed, so that the breaker may be raised to its maximum capacity of 1000 tons a day.

The company is erecting a large number of employees' houses, and is rapidly extending its facilities for handling business. It has a commissary, and is now employing seventy to eighty men. Agencies have been established in Cincinnati, St. Louis, Roanoke, and Richmond, where the coal sells in competition with the Pennsylvania coal.

Thus far, the market has been readily absorbing the supply of coal at prices comparable with the Pennsylvania product, and it seems the quantity yet to be mined is almost unlimited in extent.

Current Topics

After the South African war, when the water had been pumped out of the mines in that country, a number of the dynamo machines that had been used in the mines and which had been submerged for over a year were brought to the surface. It was at first thought that these generators were injured beyond repair; but, much to the surprise of all concerned, after the machines had been thoroughly dried out by heat, it was found that they were as efficient as before the flooding of the mines. Perhaps this result would not have been so astonishing if it had been known to the persons interested that for some years a small motor used in electric launches has been operated successfully under and in the water. In this instance the propeller is mounted directly on the shaft of the motor, which is enclosed in a spherical steel or brass case. There is no stuffing box to prevent the entrance of water into the case. On the contrary, small holes are made in the case to admit the water around the bearings and the armature. The result is that the friction of the ordinary stuffing-box is dispensed with, and, furthermore, the water lubricates and cools the motor, so that a higher efficiency and greater durability are obtained. When the motor is employed in salt water, the electrical conductivity of which is much higher than that of fresh water, the motor is contained in a nearly watertight case, the shaft passing through a bushed bearing. To prevent any leakage of salt water into the case, the latter is filled with fresh water through a suitable opening, and is renewed as often as necessary, say every three or four days. The propeller and motor, together with a rudder, are supported by an upright post bracketed to the boat that takes the place of the usual rudder post. Consequently, the propeller also assists in the steering. Whether these experiences contain the germ of a suggestion for the operation of more powerful, especially high-tension, dynamos in insulating liquids, remains to be seen; but for the purpose to which the idea has thus far been utilised it has been found very satisfactory in practice.

Niagara River develops eight and one half million continuous horse-power. This rate of work is entirely beyond human conception, but some faint idea of it may be got by reference to the amount of coal that would be consumed to develop energy at the same rate. If two pounds of coal were burned per horse-power per hour, the weight consumed in that time, to equal the work of Niagara River, would be 8500 tons. Continuous work for one year at this rate would require 74,460,000 tons of coal, or more anthracite than the United States produced in the year 1900, when the entire output was 57,464,235 tons. This prodigious power, except the relatively small amount that is devoted to useful work, is now continuously expended in carving a deep, narrow channel through the strata of rock, about twenty miles wide and more than 300 feet thick, that separate Lakes Erie and Ontario. Already the strong hand of the water, armed with stones and silt, has carved the great canyon of the lower river, about six miles long, from Niagara Falls to the foot of the escarpment at Lewiston and Queenston. In many thousands of years to come, if the work of the river is not interrupted, the 14 miles of canyon that remain to be excavated between Niagara Falls and the foot of Lake Erie will be completed. Then that lake will narrow down to a river and the falls will be transferred to Detroit River.

A warning against the careless use of boiler tube cleaners, given in a recent issue of *The Locomotive*, published by the Hartford Steam Boiler Inspection & Insurance Company, is worth bearing in mind by all boiler attendants. It is confined mainly to those forms in which the apparatus employed communicates to the tube that is being cleaned a series of shocks of greater or less severity, either by directly hammering against the tube or the scale, or by the rapid rotation of a cutter or other revolving device which is corrugated or otherwise irregular in shape, and which strikes its blows in virtue of that irregular shape, the rotation, and the centrifugal force by which it is urged out against the tube. In the case of one particular cleaner,—of the kind that hammers against the inside of the tubes of a fire-tube boiler, with the intention of rattling the scale off from the outside,—the apparatus, instead of being constantly rotated and moved along the length of the tube, had been allowed to remain in one position for a short time, so that the hammer had pounded against the tube in one spot. This was indicated by a bright area on the inside of the tube. The result was, that the tube was forced out into an oval shape, the greatest bulge coming opposite the bright spot, and the larger number of the tubes thus affected collapsed. The cumulative effect of the blows of a power cleaner of this type, when the cleaner is permitted to remain stationary for a short time, is said to have been shown also by the actual splitting of tubes in severe cases. Still another effect may be the stretching of the tubes longitudinally so as to loosen them in the heads and cause leakage and loss of holding power. These results, we are told, are not confined to cleaners which strike against the inner surfaces of the tubes of fire-tube boilers, but are liable to be observed in any type of power cleaner which operates by repeated concussion upon the tube or upon such scale as may be attached to the tube. Of course, it is proper to bear in mind that the effects in question are due to improper use of the cleaners.

In the case of cleaners whose action involves the discharge of steam into or through the tubes, leakage around the tube-ends, or the actual extension of the tubes through the heads or headers, is liable, according to *The Locomotive*, to be caused by the direct expansion of the tubes, due to the heating effect of the steam. If the tubes and the shell were all heated at the same time and by the same amount, there would be no stresses introduced by the heating, the danger being, not from the heat itself, but from the stresses caused by the fact that the expansion is local, and practically confined to the tube that is being cleaned. It is easy to see that if one tube grows longer from thermal expansion, while the rest of the boiler retains the dimensions that correspond to its lower temperature, a stress of some magnitude must be thrown upon the tube and upon the heads or headers into which it is secured. The rise of temperature of a tube that is being cleaned by such a device is often considerable, for if a tube is at all foul with scale, it may require twenty minutes or so to bring it into proper condition. Manufacturers of tools of this kind, being alive to the danger of starting the tubes by local heating, recommend that the boiler itself be heated up, before setting the cleaner at work, so that the effects of the subsequent warming from the action of the cleaner may be minimised. This practice, however, *The Locomotive* considers as of doubtful wisdom. In the case of a water-tube boiler the only method of heating the boiler that appears to be at all feasible is to build a light fire under it while it is dry. If the fire is handled carefully and by a man of good judgment, the boiler may, perhaps, be warmed in this way sufficiently to prevent subsequent injury from unequal expansion, and yet without being itself injured by the direct action of the fire; but the average attendant could in all likelihood not be depended upon to always strike the somewhat nice medium at which the warming of the boiler is effective, while the boiler itself is not overheated in any part by the fire. Moreover, the remedy would hardly be effective in any case, unless the slow fire were maintained during the entire time that the tubes are being cleaned. If the boiler were heated up only at the outset, for example, then it is evident that if from ten to twenty minutes are spent upon each tube, the majority of the tubes in the boiler would have ample time to cool down before the cleaner reached them. If, on the other hand, the slow fire were maintained during the entire time of cleaning, there would be a correspondingly greater danger that at some part of this period the fire would either become so light as to be ineffective, or so heavy as to overheat some part of the boiler. It is far better and safer to avoid the discharge of steam into a cold tube altogether, and to operate the cleaner with compressed air. This is sometimes inconvenient, but it is better to go to a little trouble and expense rather than to take chances of injuring the boilers. Of course, it is unnecessary to say that there is no objection to the use of steam in those forms of power cleaners which are operated by motors external to the tube, and in which the exhaust does not enter the tube.

Summing up the several points here made, *The Locomotive* offers the following rules, which it would be well to observe:—When power tube-cleaners are used, they should be kept in motion so that they cannot strike a succession of blows against any one part of the tube, and they should be operated by a pressure not exceeding 20 or at most 30 pounds per square inch. Steam should not be permitted to blow through the tubes of a cold boiler for a sufficient time to sensibly heat the tubes. Compressed air should be used to operate tube cleaners unless the motive power is entirely external to the tube. In any case the boiler should be carefully watched during and after the application of a power cleaner, especially around the ends of the tubes and on the headers, and at the first sign of distress of any kind, the use of the cleaner should be promptly discontinued. Lastly, a power cleaner should never be put in charge of any attendant save one upon whose judgment and skill the owner of the boiler can implicitly rely. But, after all, these are qualities which should be looked out for in every boiler attendant.

Another account in *The Locomotive* tells of a large steam plant recently installed in which it was found that quite a number of bolts, used to join the steam pipe flanges, were so short that it was impossible to screw up the nuts on them sufficiently to make the bolts enter more than from one-half to two-thirds of their depth. The work was subject to the inspection and approval of the Hartford Steam Boiler Inspection & Insurance Company, and when the defect was found the contractor was notified and a workman was sent to replace the short bolts with others of proper length. The piping ran across the upper part of the boiler room, and the air about it was exceedingly hot and uncomfortable, so that the task of replacing the bolts was a very unpleasant one. The workman bought the required number of bolts, but not liking the task of putting them in properly, he sawed off stub ends from them, and ran these stub ends into the nuts that were already on the pipe, so that the stubs projected one or two threads. To a casual observer it would appear, after this operation, that the old bolts had been replaced by others of proper length, and the company's inspection department was notified that this had been done. An inspector, accompanied by the chief engineer, then made a further examination of the piping, so that he could certify, from his own personal knowledge, that everything had been put into proper condition. Upon close examination, it was observed by the inspector that the projecting ends of the bolts showed marks as though a hacksaw had been used upon them. There would be no objections to the bolts projecting a little too far through the nuts, and as the air was very hot and uncomfortable about the pipe line, it was impossible to understand why the workman should have taken the trouble to cut off any such projection that might have been left. A still closer examination followed, and it was found that all of the short bolts, to which objection had been made, still remained in the pipe flanges, with these stub ends made into the nuts. It is to be hoped that the workman who did this rascally job was properly dealt with.

The facts here presented call to mind a number of other similar cases, all of them illustrating the need of extreme vigilance on the part of inspectors, be they inspectors of boilers or of other structures involving the safety of human life. Rivet heads in structural steel work, for example, are known to have been cleverly made of putty and painted over so as to convey the impression that rivets had been properly placed where they ought to have been. The inspector's hammer knocked off these imitations and exposed the fraud. Anchoring bolts in walls of buildings have, in several cases, consisted simply of short lengths built in to resemble the real thing and with no holding power whatever. Fortunately, however, these happenings prove the exception rather than the rule.

Alcohol motors seem to be coming into favour in Cuba, especially for driving small electric lighting and pumping plants. Consul Squiers, at Havana, for example, tells in a recent report that the city of Matanzas, with about 40,000 inhabitants, has installed an alcohol motor pump for its water-works, delivering in the neighbourhood of 1,000,000 gallons a day. The motor is spoken of as a 45 H. P. machine, and the fuel cost is given as 40 cents an hour, or $4 a day of ten hours. Alcohol sells at Matanzas at 10 cents a gallon. The water supply of Havana, we are told, is similarly to be handled by an alcohol motor pump installation, and the contractors who are to put this in are said to have also installed an electric plant alcohol motor of 45 H. P. One of the interesting points about these outfits is that they are of German manufacture. Germany and France, both, have in recent years given much attention to alcohol production and to the means of its utilisation industrially, and a relatively advanced state of the art of what might be termed alcohol engineering was, therefore, to be expected in those countries; but there seems to be no good reason why the example thus set should not be followed elsewhere with equally satisfactory results. Alcohol engines, of stationary, marine, and locomotive types, alcohol lamps for illumination, and alcohol heating apparatus of various kinds would seem to promise well commercially in many places with a prospective important demand for them.

CINDER concrete for making fireproof floors and for fireproofing columns is warmly advocated by Mr. J. T. Montgomery, in a paper read recently before the Western Society of Engineers. He states that, at the Baltimore fire, even concrete with a stone aggregate was affected to a depth of ¾ inch to 1 inch only, where used in fireproof floors. Cinder concrete, though not so strong, is less brittle, and resists fire better. Some exposed to a five-hour test, in the course of which the temperature reached 2000 deg. Fahr., proved quite tough at the end, holding nails as if it had been a hard wood. Being a good non-conductor, it forms, he claims, a better protection to steelwork than stone concrete. In a test at New York, a slab of cinder concrete 5 inches thick had a temperature of 1900 deg. to 2000 deg. Fahr. maintained at one side of it. Only at the end of four hours was the other side perceptibly warm to the touch, and not till four hours 24 minutes later did this surface become too hot to keep the hand on. In spite of containing a certain quantity of sulphides, the cinders do not prevent the concrete being an excellent protection to steelwork, the alkali of the cement being more than sufficient to neutralise any acidity thus arising. The concrete should, however, be mixed thoroughly wet and thoroughly well. Concrete has also the advantage of being easily fitted into place, as it is plastic, and mixing machinery can be used, so as to reduce the labour needed to a minimum. The cinders used are obtained from boiler plants, and contain little combustible matter, being really clinker.

THE question whether wooden poles or steel towers ought to be used for a high-tension electric transmission line depends, like many other things, upon circumstances. In countries where wooden poles are plentiful and inexpensive, it is probable that every expedient will be resorted to before steel towers are used. The latter, however, are generally considered to eliminate a great many line troubles. The spans can be increased, so that as few as eight towers per mile can be used with safety. This would greatly reduce the number of insulators which can be larger, and the means for their attachment to the towers can be quite elaborate without exceeding the cost of the other construction. The height of towers can be greater, which will decrease troubles from wires, branches, and other material being thrown or blown across the circuit and reduce the breakage of insulators from the heat of forest or grass fires. If galvanised or painted occasionally, their life would be greater than could be expected of wooden construction. Towers can be erected in places even more difficult of access, since they can be taken apart in pieces of lighter weight than a wooden pole. They would also offer a more or less good lightning path to ground, which would help to prevent the injury to connected apparatus. These points were enumerated by Messrs. J. F. Kelly and A. C. Bunker in a paper presented at the St. Louis Electrical Congress.

On the other hand, one of the principal advantages of wooden pole construction was there also mentioned to be that in case an insulator is broken, allowing the wire to come against the arm or pole, the burning which takes place almost immediately in most cases may continue for several minutes before a blaze is started which will make a short-circuit. Several times it has been observed that from twenty to thirty minutes elapsed from the time trouble was first noted by the ammeters or telephone until it was necessary to shut off the circuit. In one case a 40,000-volt (grounded neutral) wire lay on a dry cross-arm for several hours before the circuit could be shut off, and at the end of the time the arm was not badly charred. With a duplicate line, ample time would in most cases be given for changing from one circuit to the other, or to cut out the affected circuit, providing the telephone line was operative or the men at both ends recognised the difficulty.

In his recent presidential address before the Institution of Electrical Engineers, Mr. J. Swinburne, having taken for his theme "Some Difficulties in Getting On," remarked that if we examine the large industries we will find the commercial or business man with little or no technical knowledge at the top of the tree. If we confine our attention to engineers, we will find that the engineers who make the biggest incomes and occupy the most important and responsible positions are those who have most business or practical knowledge. Leading consulting engineers do not spend a large portion of their lives plotting curves, counting electrons, or even making anything more than arithmetical calculations. They spend their time dealing with large questions on purely commercial lines; and, as a rule, the bigger the engineer, the more he knows about practice and business, and the less he knows about text-book science. Most of us suffer from too little common sense in proportion to our scientific knowledge. The engineers occupying smaller positions, assuming the same age in both cases, are not necessarily deficient in technical knowledge; but they are generally wanting in business attainment and less able to take responsible positions. It is often said that to be a good master you must have been a good servant; but a good servant does not necessarily make a good master,—generally the reverse. There is a wide distinction between the man who can earn a few hundreds a year and the man who earns as many thousands. It is a very curious thing that there is hardly anything between. A given man will either earn his few hundreds a year all his life, remaining permanently as assistant, or he will undertake responsible work and get into fair figures. The engineer who is worth £750 a year seems hardly to exist, except for a short time on his way from one class to another. That is what is meant by the saying that there is plenty of room at the top of the ladder. It is not that the men who remain as assistants permanently are ignorant of science,—quite the reverse. The business man can rent a profound mathematician for a very few pounds a week if he wants him; but he probably does not. The real point is that the assistant is wanting in business knowledge or in push.

Twenty-one vessels of various types, including five battleships, four armoured cruisers, two protected cruisers, two gunboats, five torpedo-boats, two training ships and one training brig, are to be added to the United States Navy during the coming year, according to the estimates of the Navy Department.

In size and number these compare most favourably with preceding years, and the new vessels will do much toward making the American Navy one of the strongest in the world. Three of the ships, the training vessels, are being constructed by the government. The training ship *Cumberland* is being built at the Boston Navy Yard, and is scheduled for completion on May 1. The *Intrepid* will be finished two months later at Mare Island. The brig *Boxer*, under construction at the Portsmouth, N. H., yard, will be completed on July 1. Five torpedo-boats, the *Stringham*, *Goldsborough*, *Blakely*, *Nicholson* and *O'Brien*, are near completion, and will be ready for service soon. The battleships to be put into commission during the year, if finished as expected, are the *Virginia*, on October 15; the *Nebraska*, October 15; the *Georgia*, December 12; the *New Jersey*, December 3, and the *Rhode Island*, November 12. The addition of these five vessels will make the total number of battleships in the navy seventeen. The armoured cruisers are the *Pennsylvania*, to be completed February 13; the *West Virginia*, which was down for January 30; the *California*, December 10, and the *Maryland*, March 12. Two protected cruisers, the *Galveston* and *Charleston*, are to be completed on April 1 and June 17, respectively. The gun boat *Dubuque* was scheduled for completion on January 21, and the *Paducah* on April 21.

NELSON STOW

THE INVENTOR OF THE FLEXIBLE SHAFT

By Leon Mead

LIKE many other inventions, the flexible shaft was the product of suggestion or association of ideas. In the course of a chat with Nelson Stow just before his death, a few months ago, remembering to have seen the flexible shaft mentioned in an authoritative book as one of the twelve greatest inventions of the last century, I asked him how the thought first came to him of this new method of transmitting power.

"It was away back in 1857," he said, "that one day, while watching a workman in my whip factory twisting and bending back and forth a piece of whalebone to get it in proper shape for use, the idea of the flexible shaft came to me like a flash. So clearly did the idea take form in my mind that I ordered the man to quit the job he was doing, and together we immediately set about to work out some tangible result of this mental suggestion, which I briefly explained to him. Thus my first flexible shaft, or rather the so called core of it, was made of whalebone, but it demonstrated the value of the principle, and to all intents and purposes it was the same as the core afterwards made of wound wire."

Mr. Stow went on to say that for a time he was very enthusiastic over his invention, but meeting with discouragement, not only from mechanics in his own employ, but from others whose opinions he sought, he did not apply for a patent until twelve years later. His application was rejected, on the ground that the casing in which the core revolved was so nearly like the tubing of a certain drop light as to infringe on that patent. Considering this an absurd reason, as it doubtless was, he investigated the matter further, and finally, in 1872, obtained a patent.

It happened that Mr. Stow was a great lover of horses, and, quite naturally, when the idea of the flexible shaft entered his mind, he thought only of its application to the currying and cleaning of horses. Indeed, for some time his conception of it was confined to these particular uses. But gradually it began to dawn on him that this device for the transmission of power could be put to many other uses as well. At the time he received the patent, however, he was still unaware of its great importance to the world and of its many possible practical applications.

The value of his invention was soon recognised by other men, though when it came to them as a commercial enterprise they treated it in the cold, derogating manner so often assumed in business transactions. Mr. S. S. White, of Philadelphia, however, bought what was loosely called the "dental right," and which meant the use of the shaft in dentistry work, for $10,000; he also entered into a contract with Mr. Stow by the terms of which the latter was to manufacture the shaft for him, and this he continued to do until the patent expired in 1889.

Soon after selling the "dental right" to Mr. White, the inventor disposed of his half interest in his English patent to George Burnham, of the Baldwin Locomotive Works, for $4000, and engaged to manufacture the shaft on a royalty for Mr. Burnham, who was to market the output for all mechanical purposes, apart from dentistry.

At the Centennial Exposition in Philadelphia, in 1876, Mr. Stow received one of the three highest medals for new inventions, the other two being awarded, respectively, to Thomas A. Edison and George Westinghouse. From that time the flexible shaft, wherever it could be employed at all, was rapidly introduced.

"Yes," said Mr. Stow, in answer to my question, "its uses are almost limitless, to say nothing of its time and labour-saving advantages. It is indispensable to the dentist, who uses it constantly in boring teeth,—probably you have experienced the delightful thrills that attend the shaft's usually successful search after one's nerves; it may be used to crop your hair so close that you will hardly know yourself from a convict; it does the same kind of work on horses; it is invaluable in polishing marble, steel, and other materials; and it is used very extensively in mining, bridge building, and railway construction; it is found in every first-class machine shop."

He might have added that, as a driving factor, the flexible shaft enters into the work of wood carving, cloth cutting, sand papering, marble and mining drills, sash, door and blind boring, and into the construction of surgical instruments, time recorders, die work, etc. The greatest rival of the flexible shaft at the present time is compressed air; but, on the other hand, the development of driving power by electricity has wonderfully helped it. Its use has brought into existence many special portable tools which have a province peculiarly their own.

Besides the Stow Manufacturing Company, of Binghamton, New York, the original and largest manufacturers of flexible shafts in the world, there are four or five other firms in this country that make them, the patent having expired. In Europe about the same number of concerns make flexible shafts, identical in principle with the Stow, but varying somewhat in the details of construction.

Mr. Stow possessed many of the characteristics of the typical inventor, including the faculty of getting the worst end of a bargain. He belonged to that class of men of genius who are poor, but honest, and who seem fated to sell their patented rights for a mess of pottage. Along in the seventies, I am told, when he was in prosperous circumstances, his manly countenance beamed with a satisfaction most pleasant to behold; it was as Dickens said of Mrs. Fezziwig's face, "one vast, substantial smile." At that time he had cordial relations with men of wealth, such as S. S. White, George Burnham, and Mr. Struthers, of Philadelphia,—the Mr. Struthers who had the contract for building the Philadelphia City Hall for $6,660,000, and which, before its completion, cost far more than that amount. It was in fluting one of the granite columns of this building that the flexible shaft was first tested for this kind of work.

Mr. Stow was particularly proud of the confidence reposed in him by Mr. White, who allowed him the unwatched freedom of his large place of business, at the corner of Twelfth and Chestnut Streets. This privilege was granted to only two or three other outsiders, who were regarded as strong enough to resist the temptations to be found there in the shape of ideas for patents. At different times, while wandering through the rooms of this establishment and noting the many and varied labour-saving devices there collected, Mr. Stow gave Mr. White suggestions which afterward resulted in several valuable patents issued to the latter. It was in these rooms, too, that Mr. Stow learned not to tell all he knew, or to reveal his sudden inspirations, especially those that were patentable.

Nelson Stow was a thorough American on the paternal side, while his mother's ancestors were of Dutch-Huguenot descent. He delighted in showing his friends a time stained, crumpled discharge paper handed down from his grandfather, Samuel Stow, who served at intervals throughout the War of the Revolution, and afterward became one of the pioneer settlers of Broome County, New York. He would tell you that he himself was born at Windsor, Broome County, New York, on September 12, 1828, his home for many years past having been in Binghamton, New York. Like many country boys, he cared little for education, but attended the district school for several winters, and afterward a select school taught by an able instructor.

"I notice you spell your name without the final *e*," I remarked.

"Yes," he answered, "I suppose the Stows all came from the same stock."

Democratic simplicity distinguished the man in other ways than the retention of his name in its original form, though in his more prosperous days he is said to have been rather fond of driving fast horses. At one time he owned a unique span of horses, one black and one white; at another time he had a pair of beautifully matched black horses that he was wont to drive tandem through the streets of Binghamton, when that style of driving was something of a novelty. Though he cared little for his personal appearance, he always wore a silk hat, regardless of time, place, or the happy-go-lucky condition of his other apparel.

Mr. Stow engaged in various enterprises during his long life,—carriage-making, whip manufacturing, and early in the sixties, during the oil excitement in Northwestern Pennsylvania, he was one of the pioneer losers at Titusville. He secured the charter for, and built and equipped the first horse car line in Binghamton, in which city he later became involved in real estate speculation which left him penniless. At the time of his death he was in his seventy-seventh year. For a long time he had been feeble and broken in health; but, like an old war horse at the smell of gunpowder, when the subject of patents was breached, he aroused himself, his features brightened, and the old fires of ambition shone in his eyes. But the old energy had vanished long before he passed away, and in its place was the apathy of age, so far as the world in general concerned him. Where his sympathies were enlisted, however, he showed a noble kindliness of heart; perhaps the years healed the bitterness of his disappointments. Even in his old age he possessed a strong personal magnetism, and had very many loyal friends.

Mr. Stow, during his life, took out twenty patents. A few years ago he invented a pan or griddle greaser, important only as a stepping-stone to an idea for a novel kind of paint brush. The bristles of the greaser were held in place by pressure, thus doing away with the generally used glue and much of the consequent shedding of the bristles. The small royalties he received from the sales of this brush provided him with the bare necessities of life during his last years.

ASA MARTENS MATTICE

CHIEF ENGINEER OF THE ALLIS-CHALMERS COMPANY, CHICAGO

SEE PAGE 437

CASSIER'S MAGAZINE

Vol. XXVII MARCH, 1905 No. 5

AN AUSTRALIAN COAL CITY

By George A. King

THE story of Newcastle, the second city of New South Wales and the third shipping port of Australia, might be condensed into the single word "coal." The city owes its establishment to the discovery of this mineral, and the existence of the district practically depends upon it. Coal is, of course, obtained in various other parts of Australia, but the Newcastle district produces by far the largest quantity, and is also the most important centre. Up to the end of 1903 Australasia had produced about 140,000,000 tons of coal, and of that quantity 109,741,916 tons, valued at £44,021,103, had been obtained in New South Wales, which territory includes Newcastle.

The history of the coal wealth of Newcastle began soon after the colonisation of Australia. A few months after the establishment of the first settlement on the southern shores of Port Jackson (the splendid port which Sydney folk call "Our Beautiful Harbour") Captain Phillip, the commander of the first fleet and first governor of the new possession, wrote in an official despatch that he thought Australia would prove "the most valuable acquisition Great Britain ever made." The shrewd governor's prediction has long since been realised. Phillip possessed a big heart, and the disadvantages of a first impression of the new country, the hostile attitude of the natives, the worries of a threatened famine, and last, but by no means least, the fact that his colonists were men who, in the words of one of them, had "left their country for their country's good," did not prevent the naval governor forming an accurate opinion of the colony. He did not, however, fully realise the vast mineral resources of the country he was about to colonise, nor did he know its agricultural capabilities, nor the fact that 100 miles from his settlement lay one of the world's richest coal fields. In its infancy Australia had many vicissitudes, but all the trials of the new settlement were successfully overcome, and a bright and prosperous era ultimately set in.

Coal was first discovered in August, 1797, in Australia near Coalcliff, on the southern coast of New South Wales, and about fifty miles south of Sydney. The discovery was made in a remarkable way. A ship called the *Sydney Cove*, while on a voyage from India to Sydney, was wrecked on Furneaux Island, in Bass's Straits, in February, 1797. A portion of the crew, seventeen

TRAVELLING HYDRAULIC CRANES FOR HANDLING COAL CARGOES ON THE DYKE. BUILT BY SIR W. G. ARMSTRONG, WHITWORTH & CO., LTD., NEWCASTLE-ON-TYNE, ENG.

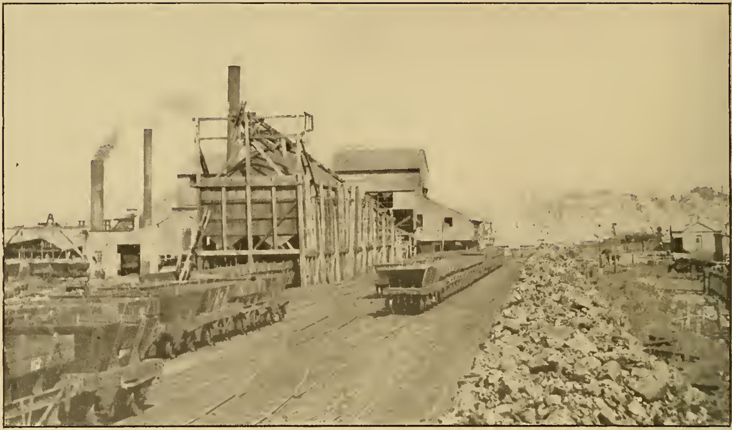
NOBBY'S, ORIGINALLY AN ISLAND AT THE ENTRANCE TO THE PORT OF NEWCASTLE, BUT NOW CONNECTED WITH THE MAINLAND BY A BREAKWATER, AS SHOWN

in number, together with Mr. Clarke, the supercargo, attempted to reach Port Jackson in the ship's longboat, which was saved from the wreck. In this, however, they failed, the boat being driven ashore near Cape Howe and lost. The little party, led by Clarke, then set off for the settlement at Sydney by land. The journey proved a difficult and adventurous undertaking, and only three of the seventeen succeeded in reaching Port Jackson, the remainder either dying on the way or being killed by the natives. On the way along the coast Clarke and his companions discovered a great deal of coal, and brought specimens of it to the settlement. Lieutenant-Colonel Collins, whose "Account of New South Wales" is one of the most reliable histories of the beginning of Australia, writing in regard to this matter, says:—

"Mr. Clarke, supercargo of the ship *Sydney Cove*, having mentioned that he had fallen in with a great quantity of coal with which he and his companions made a large fire, and had slept by it during the night, a whaleboat was sent off to the southward with Mr. Bass, the surgeon of the *Reliance*, to discover where an article so valuable was to be met with. He proceeded about seven leagues to the southward of Point Solander,† where he found in the face of a steep cliff, washed by the sea, a stratum of coal in breadth about six feet and extending eight or nine miles to the southward. Upon the summit of the high land, and lying on the surface, he observed many patches of coal, from some of which it must have been that Mr. Clarke was so conveniently supplied with fuel. * * * By the specimens of the coal which were brought in by Mr. Bass the quality appeared to be good, but from its almost inaccessible situation no great advantage could ever be expected from it; and, indeed, were it

---

† The southern headland of Botany Bay.



THE STOCKTON COLLIERY, WITH THE CITY OF NEWCASTLE IN THE BACKGROUND

even less difficult to be procured, unless some small harbour should be near it, it could not be of much utility to the settlement.''

The inaccessibility of the coal in the southern district has long since been overcome, for not only have the various mines been connected with Sydney by railway, but jetties have been erected from which the coal is shipped. In bad weather, however, the want of a good harbour is severely felt, there being but little protection afforded at the jetties.

The discovery of coal at Newcastle followed shortly after the confirmation of Clarke's report, and was similar to the preceding case in that out of evil came good. September, 1797, according to Collins, "began with a very vexatious circumstance. A boat named *Cumberland*, the largest and best in the Colony belonging to the Government, was, on her passage to the Hawkesbury, whither she was carrying a few stores, taken possession of by part of the boat's crew, being at the same time boarded by a small boat from the shore, the people in which seized her and put off to sea, first landing the coxswain and three others, who were unwilling to accompany them, in Pittwater, in Broken Bay. These men proceeded overland to Port Jackson, where they gave the first information of this daring and piratical transaction. Two boats, well manned and armed, were immediately dispatched after them, under the command of Lieutenant Shortland, of the *Reliance*. One of these boats returned in a few days without having seen anything of them, but Lieutenant Shortland proceeded with the other, a whaleboat, as far as Port Stephens, where he thought it probable they may have taken shelter; but on the 19th, having been absent thirteen days, he returned without discovering the smallest trace of them or of the boat. His pursuit, however, had not been without its advantages, for on his return he entered a river, which he named the Hunter River, about ten leagues to the southward of Port Stephens. * * * The entrance to this river was but narrow, and covered by a high, rocky island lying right off it, so as to leave a good passage round the north end of the island between that and the shore. A reef connects the south part of the island with the south shore of the entrance of the river. In this harbour was found a very considerable quantity of coal of a very good sort, and lying so near the waterside as to be conveniently shipped, which gave it in this particular a manifest advantage over that discovered to the southward. Some specimens of this coal were brought up in the boat."

The city of Newcastle, now with a population of nearly 60,000, stands on the harbour in which Lieutenant Shortland discovered coal. The river which empties itself into the harbour was originally known as the Coal River, and, as a matter of fact, retained that name for many years, but soon after the discovery of coal it was officially named the Hunter River, in honour of the naval officer who then ruled the colony.

A small penal settlement was formed at the mouth of the river with a view to marketing the coal by shipping it to Sydney. It was also expected that ships on their way to China would ballast with the coal. "This," wrote the governor, "was done by one or two vessels, but the success of the speculation was not encouraging to them to take a greater quantity, and as the person I had put in command at that place had not conducted it so well as might have been done, and having no other person to place there, I was obliged to withdraw that settlement altogether." This remark of the governor illustrates the disadvantages under which the early rulers of Australia suffered.

Another settlement was founded at Newcastle by Governor King in 1804, it having been decided to send the "most turbulent and refractory characters" to the coal mines instead of to Norfolk Island. Lieutenant Menzies was appointed commandant of the settlement, which in the beginning consisted of fifteen officers and soldiers and thirty-four convicts. The convicts were chiefly employed at the outset in clearing the land and erecting wooden houses. Later, additional convicts were sent to the settlement, and, of course, the military guard was then increased. In March. 1806, there were 103 persons in the new settlement. Governor King named the district Newcastle; but for many years, indeed, until the twenties, the settlement was known as King's Town.

The task of Lieutenant Menzies and his successors in keeping the "turbulent and refractory" members of the settlement in order was no light one,

COAL AT THE DYKE, NEWCASTLE, AWAITING SHIPMENT and one can readily understand Governor King writing that the commandant of the little settlement was "certainly obliged to have recourse to severe measures with such a description of people as he is surrounded by." He then goes on to say that one convict has thrice left the settlement and was as often returned, and that several others had found their way to Broken Bay naked and starving. The greatest care was also exercised in regard to vessels visiting the new settlement, and the following regulations, which seem unnecessarily harsh, serve to show that the authorities were compelled to govern the country in the strictest sense of the word:—

"The coal and timber is the exclusive property of the Crown. No vessel to proceed thither without a license from the Governor's secretary. The owners to enter into recognisances, themselves of £100 and two sureties in £25 each, to observe as follows:—First, to take a regular clearance from the naval officer. Second, to procure cedar and coals as directed by the Commandant, and not to interfere with people at public labour; not to be troublesome or riotous, not to disregard any order issued by the Governor or Commandant on pain of penalty levied, and vessel ordered to depart; no person on arriving to leave the vessel until entered, and the Commandant's permission received to load; to use only one kind of basket, to contain one hundredweight of coals, for measuring in and out of the vessel by; to give a daily account to the Commandant of coals and timber received; not to sail without giving him two days' notice, and being provided with his certificate and letters for the Governor. Not to leave the harbour between dusk and daylight; to land at no other place than that pointed out by the Commandant; not to employ convicts without the Commandant's permission on pain of penalty being levied on the owners for each offence. Not to give spirits to prisoners, nor to land any without the Commandant's permit; not to take any person to or from that settlement without authority of the Governor or Commandant; and no excuse of the person's swimming or being secreted on board admitted."

Another order, issued in 1807, warned the masters and crews of vessels visiting Newcastle not to sleep on shore without the Commandant's written authority, and that they were expected to be on board by 8 P. M., "or when the bell rings."

In the early twenties free men were arriving in the colony in large numbers, and, as a result, Sir Thomas Brisbane, the Governor, in 1822 decided that Newcastle should no longer remain a penal settlement. The convicts were consequently removed to Port Macquarie, further north. Even in its later penal days Newcastle was not the most desirable residential place, for the rulers were extremely severe, though perhaps not unnecessarily so. H. M. S. *Satellite* visited the settlement in 1821, and Captain Currie's account of what he witnessed is most interesting:—

"King Lash," he says, "is master in the penal settlement at the mouth of the Coal River. * * * The Commandant argues that the men have to be flogged when they become unruly, or they would rise and cut the throats of every free man in the place. There are over a thousand convicts there, and of them 250 are women. Some of the latter are the most degraded creatures on God's earth. Whatever goodness there was in them when they were sentenced in England was lost on the voyage out. * * * One morning I saw thirty-two men tied to the triangles and flogged. One of them got fifty lashes, and the others received from twenty upwards. The floggers are all convicts who have got their tickets, and some of them appeared to be worse ruffians than the poor brutes they flogged. 'This is a light morning,' said the Commandant. 'Three months ago we would have the cat going all day, but the brutes are getting quietened.' He is a believer in the lash, this burly major, and he says that if there is more flogging in his settlement than at Parramatta, there is less hanging, for he has only executed seven men in three years."

The laying out of the city was begun

in 1823, and it was proposed to retain the name of King's Town. True, there is nothing in a name, but the residents did not take kindly to the selection, so the name of the town was changed to Newcastle, the similarity of the river to the Tyne influencing popular opinion. In the early days the industries of Newcastle were numerous, but many of them were afterward abandoned. Coal mining, however, remained, although it was unprofitably worked by the government for several years. The industry is now the mainstay of the district; in fact, it is one of the most important industries in New South Wales. The shipping trade of the port increased at length to such an extent that the government finally took steps to provide more suitable accommodations in the harbour.

The island spoken of by Collins as lying in the entrance to the port was at first known as Coal Island, but is now called the Nobby's. This island has the appearance of a fortress, and has been isolated from the coast through the action of marine denudation. It is composed of horizontally-bedded sandstones, shales and tuff, together with coal seams, and these beds have been intruded by a large delorite dyke. The dyke can be seen, at low tide, on the ocean side of the hill, where it intersects vertically the regularly banded coal measures.

The island was originally connected to the mainland by a submerged reef, but during Captain Wallis's term of command a large proportion of the male convicts began the construction of a breakwater. About that time a number of female convicts committed grave breaches of the regulations, and Nobby's Island was selected as an abode for the worst characters, the solitary confinement at the island very soon reducing them to tranquility. Several of them endeavoured to reach the mainland while still ironed, but were drowned in their foolhardy attempt to regain freedom. A splendid breakwater now connects Nobby's with the mainland, and a lighthouse, 115 feet above sea level, and showing a light visible 18 miles at sea, stands on the island.

A scheme, formulated about the year 1854, whereby Nobby's was to be blown up in order to enlarge the entrance to the harbour, was approved by the government of the day; but a great agitation arose against the proposed work, so that the scheme was ultimately abandoned and Nobby's was spared. Tunnels in which to place the explosives were actually driven into the island, and one of these may still be seen; it is shown in the accompanying illustration of the island. In the early days of Newcastle a coal fire beacon was lighted nightly near the city, and this was continued until the opening of the lighthouse on Nobby's in 1857.

The convicts had made good progress in opening up the coal seams found at the entrance to the harbour before the place was proclaimed a free settlement, and they had also begun improving the port, as well as constructing the breakwater. Soon after the convicts were removed, free settling began. The breakwater, left unfinished by the convicts, was continued after the abolition of the penal settlement, and Nobby's was thus connected to the mainland. A breakwater on the opposite side of the entrance was also begun, but the work did not answer the purpose for which it was being constructed, and the idea was abandoned. The southern breakwater within recent years has been continued from Nobby's seaward; this, together with numerous other harbour works, has considerably improved the navigation of the port. An immense quantity of sediment is brought down by the Hunter River, and powerful dredges have to be kept continually in operation. By this means the channels and wharf frontages are kept clear, so that vessels drawing 23 or 24 feet of water can safely be handled in the harbour.

Before passing to a review of the growth and the present magnitude of the coal industry, it is well to have an idea of the computed resources of New South Wales. It is estimated by the government geologist, Mr. E. F. Pittman, that the coal fields of the state cover an area of about 16,550 acres, and

VESSELS AWAITING COAL CARGOES AT THE DYKE, SEE PAGE 357

HETTON COLLIERY, NEWCASTLE

that there is a total quantity of 115,346,880,000 tons of fuel available after deducting one-third of the gross weight for loss in working, in impurities, etc.

The state is divided into three coal districts,—the northern, in which Newcastle is included, the southern, and the western. The northern district is the most important, and in it there are eight principal seams, which, in decreasing order of value, are as follows:—The Wallarah seam, about 11 feet thick; the Four Feet seam, 4 feet thick; the Catherine Hill Bay seam, about 14 feet thick; the Great Northern seam, about 20 feet thick; the Dirty seam, from 6 to 10 feet thick; the Yard seam, about 3 feet thick; and the Borehole seam, from 4 to 22 feet thick, but usually from 8 to 9 feet thick. The Borehole seam is the principal one, and from it is obtained the greater portion of the coal raised. Of the quality of the coal the government geologist says:—

"The excellence of the Borehole coal consists in its purity and the amount of gas it yields. It is an excellent household coal, and though not a true steam coal, is a free burning fuel, and adapted for steamers when steam is quickly required rather than when economy is the principal consideration. It will compare favourably with any known coal for general usefulness, but is more specially applicable to gas-making, household purposes, and the manufacture of coke."

The seams, as already stated, are of varying thickness, and one of the richest is at Greta, some distance from Newcastle; this contains an average thickness of 41 feet of clean coal, the quantity underlying each acre of land having been computed to be 63,700 tons. At Wingen, about eighty miles from Greta, is what is known as a "burning mountain"; this phenomenon is formed by a coal seam, supposed by geologists to be the Greta seam, which has been burning underground for many years. Comparative tests of the calorific value of the New South Wales coal show that while 1 pound of some of the best Welsh coals, such as Ocean Merthyr, converts 16.1 pounds of water into steam, 12.94 pounds of water are converted into steam by 1 pound of Borehole seam coal. A similar quantity of the southern or western coal will convert, respectively, 12.88 pounds and 11.98 pounds of water into steam, or by mixing the three kinds of coal together, 12.82 pounds of water can be converted into steam per 1 pound of the mixture.

Now as to the growth of the coal industry. The first shipment of coal was sent to Sydney in 1798, and in 1801 the foreign export trade began; the brig *Anna Joseph* was sent to the Cape of Good Hope in 1801 with a cargo which realised £6 per ton. The only mine opened at that time was the government colliery, situated in the vicinity of Nobby's, and in close proximity to the convict settlement. This was worked by convicts' labor until 1817. A drift made on the seashore was utilised for the purpose; this drift penetrated a seam of coal that was visible in the sandstone which abounded in that locality. Subsequently the colliery was worked by means of a perpendicular shaft 111 feet deep, the coal being then raised by a windlass.

For many years the coal was held by the government as the exclusive property of the Crown, and until 1826 the industry was worked by unskilled labour. In that year a monopoly was granted to the Australian Agricultural Company, a London syndicate having for its object the development of the mineral resources of Australia. This company was granted 1,000,000 acres of land, and the exclusive right to work the seams in the Newcastle district. They held this privilege for twenty years, and but comparatively little enterprise was shown. In 1847 the monopoly ceased, and the industry then began to show signs of prosperity. Various companies were launched, and new mines were opened, the result being an enormous increase in the output. In 1847, for instance, the district produced 40,732 tons of coal, valued at about £14,000, while in 1857 the output was 210,434 tons, valued at £148,158. In 1872 the output of New South Wales reached 1,000,000 tons, and of that

AN UNDERGROUND SCENE

quantity the Newcastle district produced more than half. Twenty years later, that is, in 1892, Newcastle produced 2,611,731 tons of coal, valued at £1,102,694, the total quantity raised in New South Wales during the same year being 3,780,968 tons, valued at £1,462,388. In 1902 the output from New South Wales was 5,942,011 tons, having a value of £2,206,598, the quantity raised in the Newcastle district being 3,900,297 tons, valued at £1,633,062. Last year there was a material increase in the production, the State producing 6,354,846 tons, valued at £2,319,660; of this quantity the output from Newcastle and district mines was 4,410,565 tons, valued at £1,783,408. These figures demonstrate the progress which is being made in the coal mining industry, particularly at Newcastle, where the output last year was 510,268 tons more than in 1902. Nearly the whole of this excess is due to the expansion of the foreign export trade.

Let us now see what becomes of the enormous quantity of coal thus produced. It may at once be stated that, as regards home consumption, Australia is self-producing. In the case of New South Wales, the export considerably exceeds the quantity required for local purposes. Of the coal produced in 1903, the quantity used locally was 2,368,652 tons, while the quantity exported amounted to 3,986,194 tons, valued at £1,704,993. Of that quantity 2,031,473 tons were exported to other Australian ports, and 1,954,721 tons to foreign ports. In ten years the quantity exported has increased 2,151,104 tons.

The part which Newcastle plays in the export trade is striking, for of the exports from New South Wales in 1903 the quantity obtained from the Newcastle district was 3,420,197 tons, leaving only 565,997 tons as representing the export from the other coal districts of the state. With the export of such a large quantity of coal, Newcastle is naturally a large shipping port. In 1903, 674 vessels, of which 373 were operated by steam and 301 were sail craft, having a total aggregate tonnage of 1,034,440 tons, entered the port of

Newcastle, while 1143 ships, of which 592 were operated by steam, and 551 were sail craft, having a total tonnage of 1,639,165 tons, left the port.

There are 103 coal and shale mines in New South Wales, 65 of which are within the northern, or Newcastle, district. The mining industry means a great deal to the inhabitants in the way of providing employment; 14,117 persons are employed either below or above ground in connection with the mines. To be exact, there are 11,048 persons employed below ground, and 3069 employed above ground. In the Newcastle district the mines provide employment for 10,000 persons, 8000 below ground and 2000 above ground.

With the development of the coal trade the facilities for shipping the mineral were also improved, and the apparatus for loading vessels is now very complete. Originally, the coal was shipped by means of wheelbarrows, and this very primitive method of transportation remained in vogue until 1864, when the shipping appliances were taken in hand by the Railway Department. Ten years later a wharf was erected at Bullock Island, once a series of mud banks, but now the populous municipality of Carrington, and hydraulic cranes were erected soon after the wharf was completed. This wharf, which is about 2580 yards long, is called the Dyke, and upon it are placed at intervals twelve hydraulic cranes and three steam cranes. Six of the hydraulic cranes are of 15 tons capacity, four are of 9 tons, and two are of 25 tons. The hydraulic machinery was built by Sir W. G. Armstrong & Co., Ltd., of Newcastle-on-Tyne, and is worked at a pressure of 700 pounds per square inch. A new wharf, 1300 feet long, has also been constructed in a new basin, and on it six hydraulic travelling cranes of 12 tons capacity, with high jibs and wide range, are being used. The cranes lift the loaded hoppers off their carriages, which latter carry between 6 and 7 tons each, and swing them round over the hatchways of the vessels where the bottoms of the hoppers are opened out.

The wharf is lighted by electricity, and this greatly facilitates the loading of coal at night. There are employed fifty large arc lamps, each of 5000 candle power capacity. On the town side of the harbour there is a continuous line of wharf, 3607 feet long, belonging to the government; of this length, 3130 feet is occupied as cargo berths for deep draught vessels, 500 feet is reserved for Sydney passenger steamers, and the remaining 977 feet is used as a general cargo wharf, in which is included a lumber wharf for loading vessels with timber. There are also several private shoots, and the expeditious manner in which vessels are now coaled is remarkable when compared with the methods employed by the "ancients" of this great coal city.

THE THERMO-CHEMISTRY OF IRON ORE REDUCTION AND STEEL MAKING

IN THE ELECTRICAL FURNACE

By Horace Allen, C. E.

OF the many applications of electricity to metallurgical purposes in the way of competing with the well-developed processes at present in vogue, probably the most striking is its employment in the commercial production of cast iron and steel. Recent developments have proved that electricity may be successfully employed in the manufacture of iron and steel in such a manner as to indicate that this method is likely to enter into the field of competition as regards certain classes of product at any rate.

When Mr. Albert Keller read his paper on " The Application of the Electric Furnace in Metallurgy " before the Iron and Steel Institute in May, 1903, the possibilities of electricity entering into competition with the usual methods of production of cast iron direct from its ores, and steel of such high class as that required for tools, was doubtless received with great incredulity. The rapid progress being made in this direction is, however, being forced upon our attention, and necessitates the consideration of the thermo-chemistry of the subject.

The chemical considerations entering into the reactions may remove the doubts which have occurred to the minds of those actively engaged in the production of iron and steel by the usual methods, and give good reasons explanatory of the possibilities in this direction. The object of this article is not so much to discuss the various methods at present being subjected to practical trial as to show the limits necessitated by the chemical reactions. To deal with the subject from a thermo-chemical point of view necessitates the employment of such factors as:—

1.—The specific heat of the materials.
2.—The heat of chemical combination.
3.—The reactions occurring in melting or reduction.
4.—The temperature attainable in the electric furnace.
5.—The temperatures of the molten products, etc.
6.—The latent heat of the products.

TABLE OF SPECIFIC HEATS

Iron	0.11379	(Regnault)
Carbon	0.02411	"
Magnetic oxide, $Fe_3 O_4$	0.154	
Sesquioxide of iron, $Fe_2 O_3$	0.171	
Cast iron	0.1124	(Bystrom)
Iron	0 10601 + 0.00014t ° C	(Tomlinson)
Steel	0.1217	
Carbon, graphite	0.1604	(Weber)
" Charcoal	0.1935	"
" Coke	0 1571	
Slag	0.148	
Manganese	0.1217	(Regnault)
Silicon, crystalline	0.1697	(Weber)

HEAT OF CHEMICAL COMBINATION

For 1 lb. of substance in British Thermal Units.

Fe	product,	$Fe_3 O_4$	2,880
Fe	"	$Fe_2 O_3$	3,650
C	"	CO_2	14,544
C	"	CO	4,451
CO	"	CO_2	4,350
Si	"	$Si O_2$	14,094
Mn	"	$Mn O_2$	3,803
The Board of Trade unit			3,410

CHEMICAL REACTIONS IN THE PRODUCTION OF IRON AND STEEL

$$Fe_3 O_4 + 4 C = 3 Fe + 4 CO$$
$$Fe_2 O_3 + 3 C = 2 Fe + 3 CO$$
$$Mn O_2 + 2 C = Mn + 2 CO$$

The temperature of the electric arc being about 5970° F., the temperatures resulting from the employment of the electric current can be made to range from comparatively low heats up to that of the simple arc. The temperature at the tuyeres of the blast furnace will be about 5166° F.

The melting points of the various products are about as follows:—

Pure iron	2,730 — 2,900 °F.	(Pouillet)
Grey cast iron	2,910 — 3,450 °F.	"
White cast iron	2,530 — 2,730 °F	
Steel	3,272 °F.	
Magnetic Oxide	2,370 °F.	

The latent heat of the substances may be taken as:—

Cast iron	233 (Clement)
Slag	249

In ordinary blast furnace practice it requires the application of about 1 ton of coke to produce 1 ton of pig iron, in high furnaces, with heated air blast. If the thermal value of the coke be taken as 13,000 B. T. U. per pound, then each pound of pig iron requires the application of 13,000 B. T. U. to be provided in the form of coke.

To produce one ton of steel in a Siemens furnace requires the application of 7 cwt. of coal to the gas producers; this, at 13,000 B. T. U. per pound, is equivalent to 4550 B. T. U. per pound of steel. As there is about 3 per cent. loss in the process, the above figure should be increased to 4690 B. T. U. to make the comparison on the basis of the iron employed.

When the product consists of an alloy of iron containing 20 per cent. of manganese, the weight of fuel in the form of coke amounts to 26.5 cwt. per ton of product, which, at 13,000 B. T. U. per pound of coke, is equivalent to 17,225 B. T. U. per pound of product.

When the product of the blast furnace is ferro-manganese, then 41.4 cwt. of coke are required per ton of product, and, on the same basis as considered above, the equivalent per pound of ferro-manganese is 26,910 B. T. U.

Crucible steel manufacture requires from 2½ to 3 tons of hard coke per ton of product, or from 32,500 to 39,000 B. T. U. per pound of steel.

Theoretically, 1 lb. × 0.1217 × 3272° + 233 = 631 B. T. U.

Mr. J. E. Stead's figure for this is 718 B. T. U.*

Melting pig iron in large cupolas requires about 4½ per cent. of hard coke, by weight, or, per pound of iron melted, 580 B. T. U.

Theoretically, 1 lb. × 0.1124 × 3000° + 233 = 570 B. T. U.

From this it appears that in melting iron in cupolas an efficiency of about 90 per cent. is obtained.

Mr. Albert Keller referred to an electric furnace which was capable of producing 1 ton of cast iron by the expenditure of $\frac{1 \text{ kilowatt year}}{4}$ + 771.4 lbs. of coke, for the reduction of the ore, which, expressed in B. T. U., is,—

For electric smelting	7,467,900	= per lb. 3,334
771.4 lbs. of coke to CO_2	3,433,500	= per lb. 1,532
Total B. T. U. to produce one ton	10,901,400	
Total B. T. U. to produce one lb		4,866

To compare this with blast furnace practice and coke at 16s. per ton,—

In the blast furnace 1 lb. of pig	= 0.085d.
Reduction in electric furnace coke at 16s. per ton.	
Electric current ¼d. per B. of T. Unit per lb. of pig	= 0.244
Coke for reduction per lb. of pig iron	= 0.010
	0.254d.

The ratio of cost is thus 1 to 3.

Where there is a cheap and ample water supply, as Mr. Keller refers to, for an installation in Brazil, the B. of T. unit being estimated to cost 0.03d., the figures are:—

Electric current at 0.03d per unit per lb. of pig	0.0293d.
Coke for reduction @ 16s. per ton	0.010
	0.0393d.

This gives a ratio of 1 to 0.5.

However, it must be noticed that the cost of coke in Brazil comes to 48s. per ton, which would give,—

Current	0.0293
Coke	0.03
	0.0593

in which case the balance is still in favour of the electric furnace.

In regard to the manufacture of steel by electric current, Mr. Keller states that about 0.1 kilowatt-year is necessary for melting and fining 1 ton of steel, by the fusion of scrap iron and steel.

To turn these figures to their equivalent in B. T. U., we have

0.1 KW-year = 2,728,000
or per lb. of steel 1,218 B. T. U.

As we have seen that, theoretically, 1 pound of steel requires for melting alone 631 B. T. U., the efficiency, without providing for the fining process, comes out as 52 per cent.

Comparing this with the figures given for crucible steel, we have

Per lb. of steel by electric furnace	1,218 B. T. U.
" " " crucibles and coke	32,500 B. T. U.

---

* Discussion on Mr. Albert Keller's paper.

Again, taking coke at 16s. per ton, and bringing the cost per B. of T. unit to an equivalent rate, we have:—

Coke for crucible steel per lb. of steel.......	0.21d.
Equivalent value of B. of T. Unit when the steel is produced electrically...............	0.59d.

or a little more than ½d., at which rate a large, suitably actuated and equipped generating station can readily supply it at a profit, even from steam.

Mr. Keller, referring to the electric steel furnace at Livet,* gives the figures at 2800 KW-years per ton of steel, equal to 4262 B. T. U. per pound of steel, or nearly four times the former figures; but this may refer to the combined process of electric blast furnace and electric fining furnace.

Mr. G. Ritchie (Glasgow), in describing the working of a Kjellin furnace at Gysinge, Sweden, in the correspondence on Mr. Keller's paper, gave some interesting particulars. The furnace is of the "transformer" type, consisting of a circular brick structure with a primary coil placed in the centre; around the primary coil, but in the brickwork, an annular groove, or chamber, forms the receptacle for the charge to be melted, constituting the secondary coil. The current is thus induced in the charge itself, and transformed from 3000 volts to 7 volts, there being no electrodes.

The power used amounts to the equivalent of 1449 to 1980 B. T. U. per pound of steel, or, compared with the figures given earlier in this article, the efficiency being $\frac{631}{1449} = 43$ per cent. to $\frac{631}{1980} = 32$ per cent., without taking the fining period into consideration.

However, the steel resulting is of high class, and has a fair sale for all classes of work, including tools, dies, scythes, surgical instruments, etc., and, therefore, the efficiency of the process should be compared with the crucible steel process.

Crucible steel by coke per lb........	32,500 B. T. U.
Electric steel per lb..............	1,449 B. T. U.

In the February, 1904, number of *Electrochemical Industry*, Mr. Marcus Ruthenberg, in an article on "The Smelting of Iron Ores and the Production of Steel in the Electric Furnace," refers to the following developments in this direction:—

Describing a plant situated at Niagara Falls, he says the operator, in discussing the smelting of iron ores electrically, proved, theoretically and practically, that it required the continuous expenditure of 200 H. P. to produce one ton of metallic iron in 24 hours, or 4800 H. P.-hours. Stasano, in Italy, claims to smelt a ton of finished product with 3000 H. P.-hours.

De Laval, in Sweden, required 3500 H. P.-hours, and Rossi, at Niagara Falls, 4800 H. P.-hours, and plants in France give results not differing much from those above mentioned.

The respective efficiency of these operators may approximately be stated as follows, compared with the figures following for magnetic oxide:—

Rossi	per lb. =	5,454	B.T.U.	Efficiency nearly	60%
De Lavel	" =	3,976	"	"	81
Stasano	" =	3,408	"	"	92
Blast furnace	=	13,000	"	"	25

This comparison is only approximate. Mr. Ruthenberg at this stage gave the result of his furnace as only requiring 500 KW-hours per ton of metal produced, or 716 B. T. U. per pound of metal.

The efficiency in this case would amount to about 51 per cent. compared with the smelting of $Fe_3 O_4$. He also states that the coke required in the blast furnace for the chemical action of reduction was but a little over 300 pounds per ton of metal, or 0.134 pounds of carbon per pound of iron produced, or 533 B. T. U. per pound of metal produced.

However, in connection with this it is necessary to compare the method adopted by Mr. Ruthenberg with that of previous operators. With earlier workers, the practice was to melt the ore and maintain it molten by making

---

* Mr. J. E. Stead has seen 1873.4 lbs. of steel, in the form of turnings melted in the electric furnace at Livet, in two hours, at the rate of 600 KW-hours per ton, which is equivalent to 913 B. T. U. per lb. of steel, as compared with 631 B. T. U., the theoretical amount before stated, the efficiency being, therefore, about 70 per cent. In this case the steel contained only 0.16 per cent. carbon.

the molten mass the resistance to the electric current, which, being low, necessitated a great expenditure of energy.

In the Ruthenberg furnace the only energy required is that necessary to bring the magnetic oxide to the molten condition, when the operation of reduction by carbon, or carbonic oxide, will proceed without the further application of external heat.

The furnace consists of two revolving barrels or rolls of bronze, water cooled, and placed over the poles by a horizontal horseshoe magnet.

The ores employed may be in a state of fine division, such as would not be available for use in the blast furnace; in fact, the finer, the better, provided that they are rich in quality, thus allowing of a previous magnetic concentration. It will be noticed that the rolls, which are covered with carbon, form the poles of the melting circuit, and as fast as the ore is fused, losing, as it does, its magnetic property, it falls into a receptacle below, where the final reduction is effected by carbon or carbonic oxide.

The Stassano method consists of reducing the metal direct from the ore by carbon, by the aid of an electric arc formed above the mass of mixed ore and carbon, a current of 2000 ampères at 170 volts being necessary.

The ore employed consisting of almost pure peroxide of iron, the chemical reaction is represented by the equation:—

$$\begin{array}{ccccc} Fe_2\,O_3 & +\,3\,C & =\,2\,Fe & +\,3\,CO \\ 56 \times 2 + 16 \times 3 & & & \\ 112 + 48 & 12 \times 3 & 56 \times 2 & 28 \times 3 \\ \hline 160 & 36 & 112 & 84 \end{array}$$

The heat to be supplied in reducing the ferric oxide being 3650 per pound of iron, 112 pounds = 408,800 B. T. U. One pound of carbon combining with oxygen to form carbonic oxide, liberates 4451 B. T. U., so that the 36 pounds of carbon would give 160,236 B. T. U., showing that the reaction requires the application of heat from some external source to the amount of 348,564 B. T. U. per 112 pounds.

However, it will be noticed that *CO* is given off to the extent of 84 pounds, which, on further combustion, give 84 × 4350 = 365,400 B. T. U., which, if applied to develop heat in the operation, shows that the quantity of electric current necessary would be greatly reduced, the heat balance of the reaction being theoretically almost perfect.

At one of the recent meetings of the American Electrochemical Society, Mr. Marcus Ruthenberg gave further particulars of results obtained by his furnace. Instead of requiring 500 KW-hours of energy to produce a ton of iron, he has succeeded in doing this with about 250 KW-hours, so that it will be interesting to consider the thermo-chemistry of the operation.

The material employed being magnetic oxide, almost pure, the application of the electric current has only to bring it to the point of fusion. Taking the fusing temperature as 2370° F., and the specific heat as 0.154, the thermal requirements are:—1 lb. × 0.154 × 2370° = 365 B. T. U.

To reduce the magnetic oxide to metallic iron and oxygen requires the further application of heat to the extent of 2880 B. T. U. per pound of iron. If carbon is employed for the reduction, the chemical equation is:—

$$\begin{array}{cccccc} Fe_3 & O_4 & +\;4\,C & =\,3\,Fe & +\;4\,CO \\ 56 \times 3 & 16 \times 4 & 12 \times 4 & & 12.16 \\ \hline 168 & 64 & 48 & & 28 \times 4 \\ \hline \multicolumn{2}{c}{232} & & & 112 \end{array}$$

168 × 2880 = 483,840, or, per pound, 2880 B. T. U.

The carbon combining with *O* to form *CO* = 48 × 4451 = 213,648 B. T. U., or, per pound of iron, 1271 B. T. U., showing in this case that unless the *CO* formed is applied to make up the deficiency, this must be derived from the electric current.

The *CO* would be capable of developing 112 × 4350 = 487,200 B. T. U., or, per pound of iron, 2900 B. T. U., which more than provide for the heat requirements.

However, if the reduction is to be by *CO* gas, the equation becomes:—

$$\begin{array}{ccccc} Fe_3 & O_4 & +\;4\,CO & =\,3\,Fe\,+\,4\,CO_2 \\ 56 \times 3 & 16 \times 4 & 12.16 & \\ \hline 168 & 64 & 28 \times 4 & \\ \hline & & 112 & \end{array}$$

In this case 112 pounds of *CO* will

supply $112 \times 4350 = 487,200$ B. T. U., or, per pound of iron, 2900 B. T. U., or sufficient heat, if loss could be prevented, to carry on the reaction continuously.

In Heroult's electric furnace for the production of steel from scrap iron as carried out in France and Sweden, the current passes from two vertical electrodes through the slag which covers the metal. With one furnace working 5-ton heats, the product is 15 tons in twenty-four hours, using 600 H. P. produced by a blast furnace gas engine. The quality of the steel is that of high-grade tool steel. This works out at 716.2 KW-H. per ton of steel, or about 2,444,240 B. T. U. per ton = 1090 B. T. U. per pound of steel.

Crucible steel by coke, per lb.	32,500 B. T. U.
" " by Heroult furnace	1,090 B. T. U.

The latter figure is only slightly higher than that required by theory, while the former is about 42 times that absolutely necessary when most effectively applied.

A study of the thermo-chemistry of the production of iron and steel by means of the electric current shows that when carried out on a system as nearly as possible in accordance with that required by theory, the capabilities of profitable application only require scientific treatment to prevent an excessive charge for electric current from turning the scale between profit and loss, even in the field of the blast furnace.

The calculations given are in the theoretical examples only approximate, but they will be of service to those who wish to consider the possibilities in the direction of the employment of the electric current as a factor in the manufacture of iron and steel.

/7

THE WIDENING USE OF SMALL ELECTRIC MOTORS

WITH SPECIAL REFERENCE TO AMERICAN PRACTICE

By Fred. M. Kimball

Concluded from the February Number

LAUNDRY machinery is largely operated by electric motors, and especially is this true of centrifugal dryers and mangles. An attempt has recently been made to operate family washing machines by motors, and the results which have attended the preliminary experiments have been highly gratifying. If durable and reliable machines for household purposes can be produced and put on the market at reasonable prices, which will enable dish washing to be simplified and adequately relieve the rather trying situation which usually develops during the Monday wash and Tuesday's ironing, inventors and manufacturers may be well assured that they will receive the unanimous thanks and liberal patronage of housekeepers in all civilised countries.

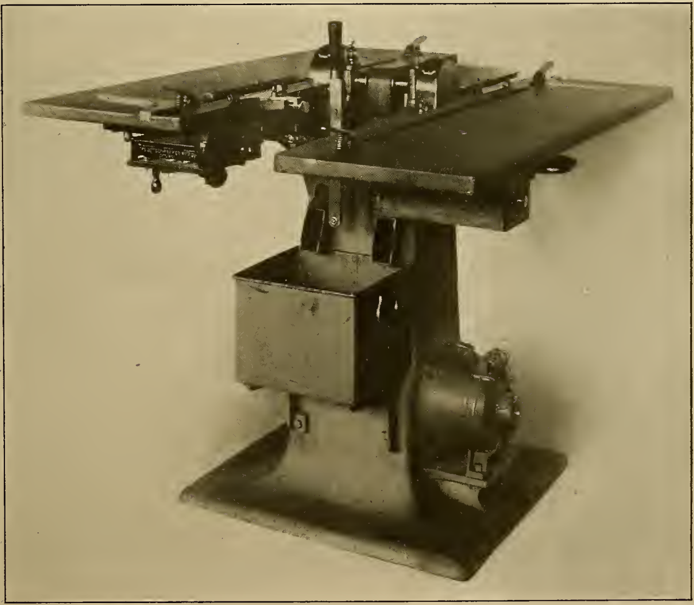


FIG. 17.—A BEVELING AND SQUARING MACHINE FOR ELECTROTYPERS' USE, DRIVEN BY A MOTOR MADE BY THE SPRAGUE ELECTRIC CO., NEW YORK

In the large hotels and restaurants motor-driven blowers, pumps, dumb-waiters, exhausters, knife cleaners and chopping and mixing machines are in evidence on every hand, while the number of electrically operated sewing machines in the homes of the country is increasing very rapidly.

FIG. 19.—THE FAIRY FLOSS CANDY MACHINE, MADE BY THE ELECTRIC CANDY MACHINE CO., NASHVILLE, TENNESSEE

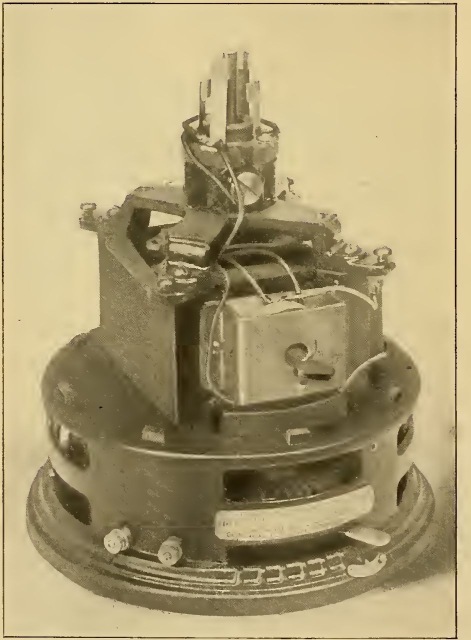


FIG. 18.—THE FAIRY FLOSS CANDY MACHINE MOTOR, WITH CASING REMOVED, MADE BY THE GENERAL ELECTRIC CO., SCHENECTADY, NEW YORK

Recently motor-driven polishers have been brought out for use in caring for the hardwood floors in large halls and public buildings; motor-driven sweepers, which are used in some of the large department stores for quickly sweeping the long aisles and wide open spaces; and also electrically operated carpet sweepers for domestic use. These last are said to perform marvellous work in removing dust and litter of all kinds from carpets and rugs. The peculiar stroke of the rapidly moving brush whips up the finest particles out of the pile of the carpet or rug and effectually prevents the lodgment of foreign matter in it.

One of the most recent applications of the electric motor is in the manufacture of candy. In a device known as the "Fairy Floss Spinner," —shown in Figs. 18, 19, and 21,—a small motor with vertical shaft is provided with what is technically known as a "spinner head." This spinner head consists essentially of two porcelainised plates between which is mounted a finely corrugated ribbon of metal. A current of electricity circulates through this ribbon when the machine is in motion. In the centre of the top disc is an aperture into which ordinary granulated sugar may be poured by means of a suitable funnel, and supported by the frame of the motor is a large porcelainised bowl to receive the finished product.

When the machine is put in operation and supplied with sugar, the centrifugal force imparted to the sugar by the very

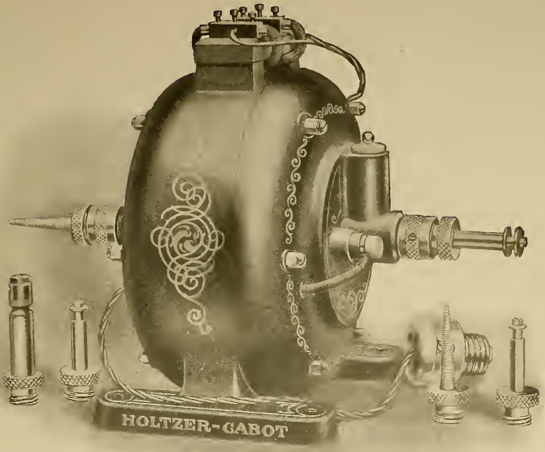


FIG. 20.—A MOTOR-DRIVEN JEWELERS' LATHE, MADE BY THE HOLTZER-CABOT ELECTRIC CO , BOSTON, MASS.

rapid motion of the spinner head causes it to be thrown outward against the ribbon, which, being hot, melts the sugar and allows the viscous mass to be spun out between the fine corrugations of the ribbon in the form of delicate threads, very much like raw silk. The large porcelainised bowl receives this skein of sugar fibre, which instantly cools, and the result is a coil of fluffy, saccharine thread of beautiful lustre and most appetising in appearance and odour.

During the spinning, flavouring extracts may be thrown on to the skein through an atomiser, and granulated nut meats or other similar additions may be made to the cooling candy. The success of these machines has been very great, and those shown at the recent St. Louis Exposition have not only been enormous money earners, but have been constantly surrounded by interested crowds of people.

The electric motor is also largely employed by the medical profession. Physicians find it of great value for operating atomisers, various special devices for massage purposes, and in connection with the many forms of apparatus which have been devised for effecting special exercises of the human body. Very in-

FIG. 21.—THE FAIRY FLOSS CANDY MACHINE MOTOR IN SERVICE FORM

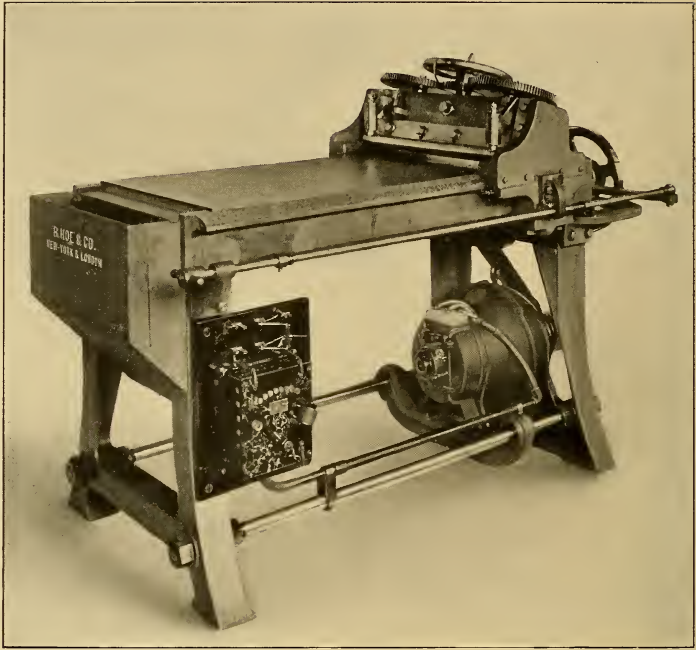


FIG. 22.—A STEREOTYPE PLANING AND SHAVING MACHINE, DRIVEN BY A MOTOR MADE BY THE SPRAGUE ELECTRIC CO., NEW YORK

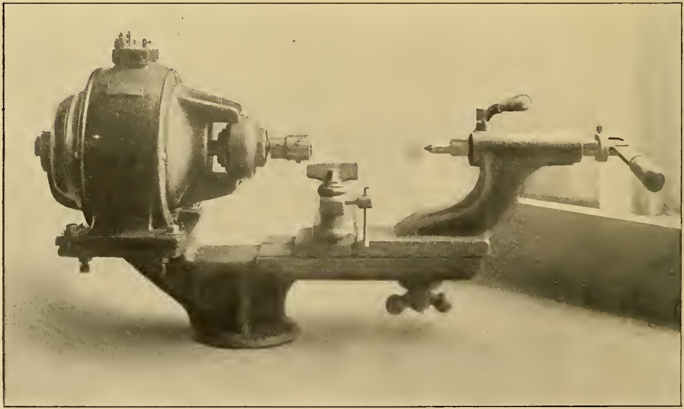


FIG. 23.—A BENCH LATHE MADE BY THE WESTERN ELECTRIC CO., CHICAGO, ILL.

genious gymnasium exercisers have been developed, such as those for exercising the muscles of the body, as in horseback riding, walking, running, and various exercises of the arms and shoulders.

The latest advancements in the art of dentistry require many mechanical appliances. Electric motors are used for running the dental engines, air pumps, lathes and buffs used in the mechanical departments of most dental offices. For these purposes the electric motor is unexcelled, its compactness, readiness and artistic appearance making it a particularly desirable adjunct to a dentist's office. Through its use in connection with the dental engine, the dentist is able to use both his feet for the firm support of his body, and to relieve himself of the laborious task of propelling a foot-wheel.

Modern printing offices, bookbinderies, and the allied trades, too, make extensive use of electric motors. Nearly every mechanical operation necessary in the preparation of a book may owe something to an electric motor. The author's manuscript was written on a motor-driven typewriter, and the matter was set up on a motor-driven linotype machine. Stereotype plates are trimmed, planed, sized and formed by motor-driven machinery. The press on which the book is printed may be driven by an electric motor, for which the ink may be ground in motor-driven mills, and, if the edition be a large one, it will probably be printed on a press provided with automatic motor-driven feeders. The sheets, as printed, are folded by a motor-driven folder.

In certain classes of book work the stitching is done by a motor-driven sewing machine. The trimming, embossing, and pressing are all done through the intermediary of the motor-drive, and if the printing house is thoroughly modern, the boxes in which the books are packed may be lowered or raised to

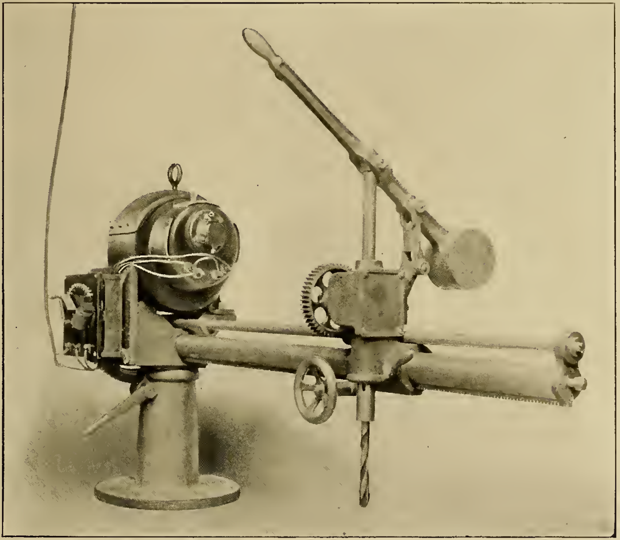


FIG. 24.—A PORTABLE ELECTRIC RADIAL DRILL, MADE BY THE STOW FLEXIBLE SHAFT CO., PHILADELPHIA, FITTED WITH GENERAL ELECTRIC 1-H. P. MOTOR

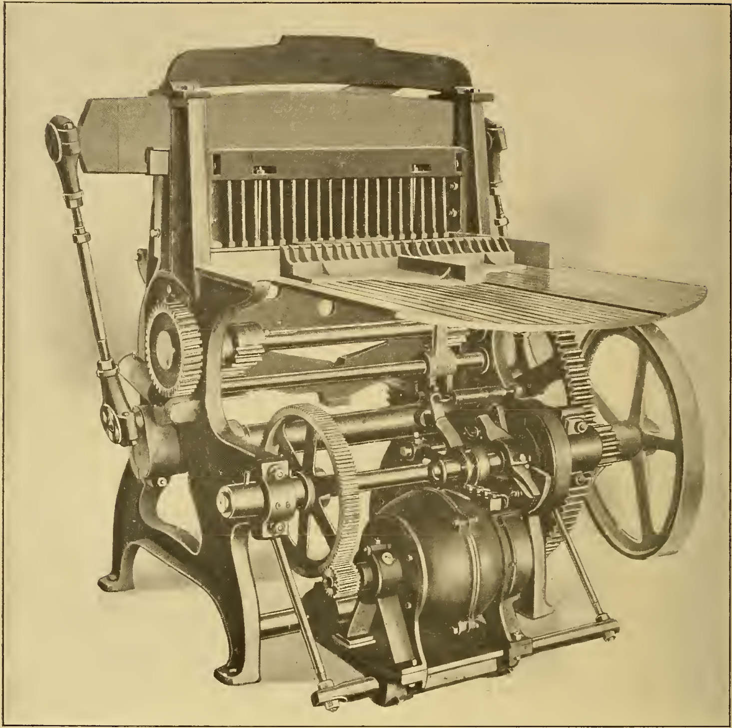


FIG. 25.—A HEAVY PAPER CUTTER EQUIPPED WITH A SPRAGUE ELECTRIC MOTOR

the street on an electrically operated elevator and taken to their destination by electrically driven automobiles. In case these books form part of the acquisition of one of the newer public libraries, they are transported from the book-stacks to the distribution desk by motor-driven conveyors, and finally are taken home by the borrowers in motor-driven street cars.

Electricity has played a very important part in the preparation of the high-grade cuts now used for the illustration of modern books. Nearly all of the photographic reproductions are made by the electric light, and this electric light is frequently provided by means of a motor-driven generator set taking current from the street mains of a central station, and transforming it for suitable service with the arc lamps employed. The mechanical pantograph, routers, stippling machines, and section shaders are practically all motor-driven, and the saving in labour and time to produce modern cuts has thus largely been accomplished through the instrumentality of the electric motor.

Many interesting, special and labour-saving electrically operated tools may now be found in manufacturing establishments. A portable drill, such as that shown in Fig. 24, is of the greatest utility where a number of holes are to be drilled in a piece of work which it is inconvenient, owing to its size or weight, to move to and around a stationary drill. The drill can be clamped onto or alongside of the work, and, by means of the travelling carriage and radial swinging arm, the drill mechanism may be brought to bear on, or operate in, the work within a comparatively large radius.

A bench lathe recently brought out by the Western Electric Company, of Chicago, shows a valuable and interesting application of small motors to the everyday requirements of a machine shop. The lathe is 10½ inches swing and driven by a 220 volt, ⅙-H. P., fully enclosed, shunt-wound motor, having a normal speed of 1800 revolutions per minute, which may be increased 50 per cent. by field control. This lathe is suitable for a great variety of special operations or miscellaneous work. It rests on a swivel base, so that it may be turned around on the bench through an arc of 360 degrees. This adds materially to its general utility. See Fig. 23.

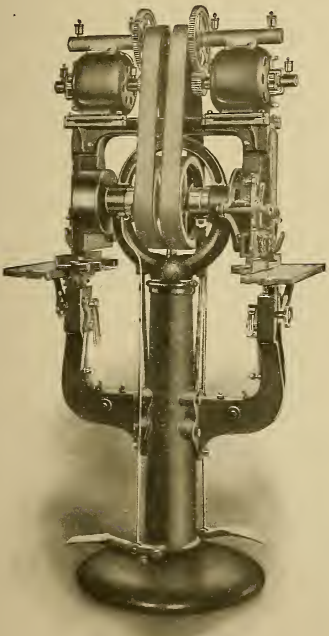


FIG. 26.—A WIRE STITCHING MACHINE FOR BOOKBINDERS' USE, DRIVEN BY TWO MOTORS MADE BY THE HOLTZER-CABOT CO., BOSTON, MASS.

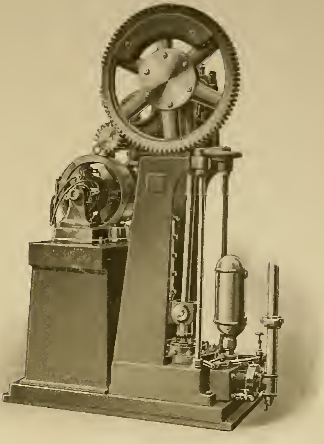


FIG. 27.—A DEEP-WELL PUMP DRIVEN BY A MOTOR MADE BY THE HOLTZER-CABOT ELECTRIC CO., BOSTON, MASS.

A novelty in breast drills is shown in Fig. 28. The tool is constructed to meet all the requirements of the ordinary breast drill, but, in addition, contains as an integral part a small motor of about 1-12 H. P. With such an equipment, the labour of drilling holes in work that cannot be taken to drilling machines is much facilitated.

A horizontal boring machine,—shown in Fig. 29,—affords an interesting illustration of special tool-drive. The boring machine is made by the Beaman & Smith Co., of Providence, R. I., and is driven by a Western Electric 5-H. P., constant-speed, 220-volt, semi-encased, shunt-wound motor. The motor is supplied with a self-starter, which is controlled by the push button on the base of the machine shown in the illustration.

No form of motive power is better

FIG. 28.—AN ELECTRICALLY DRIVEN BREAST DRILL

adapted for use with horseless carriages than the electric motor. Especially is this true when the requirements of fine pleasure carriages or heavy trucks and delivery waggons are considered. Many large business vehicles used in New York and other principal cities are operated by electric motors supplied from storage batteries contained within the vehicle itself. Among the many advantages attending the use of electric motors with horseless carriages are safety, smoothness of operation, simplicity of construction, wide range of control and reliability in service. The power derived from the electric motor, being delivered as a smooth and continuous rotary motion, is far preferable to that derived from prime movers delivering power in rectilinear lines, which must be transformed into rotary motion before it can serve its purpose.

In the western part of the United States and in Mexico the small electric

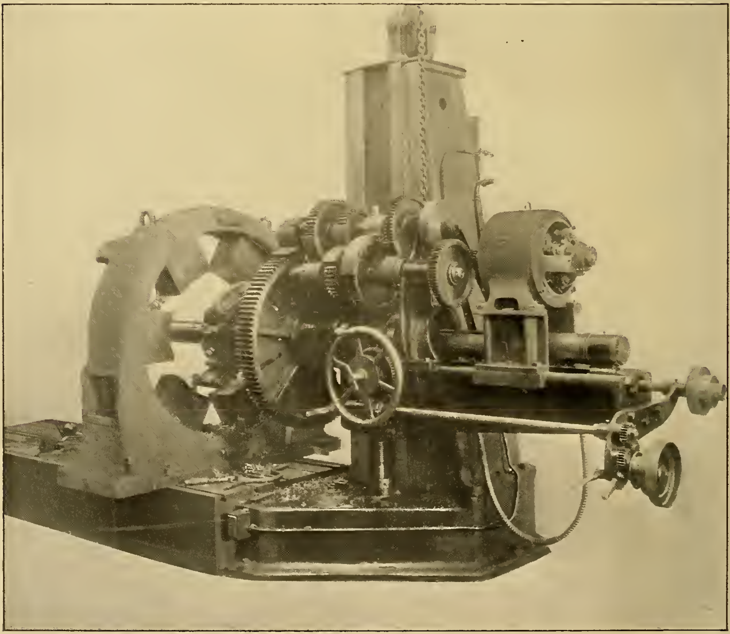


FIG. 29.—A HORIZONTAL BORING MACHINE, MADE BY THE BEAMAN & SMITH CO., PROVIDENCE, R. I., DRIVEN BY A 5-H. P. MOTOR MADE BY THE WESTERN ELECTRIC CO., CHICAGO, ILL.

motor is much used for operating pumps employed in distributing water for irrigating purposes in those sections where the rainfall is very scanty or entirely absent. Vast tracts of otherwise fertile land, capable of raising food stuffs to supply millions of people, have never been utilised owing to the scarcity of water. Many of these tracts are underlaid, at a depth of a few feet, by moisture-bearing strata or subterranean water courses. Small, direct-connected, motor-driven pumps, supplied with electric power from long-distance transmission lines, are now enabling the reclamation of thousands of acres of this land.

Mining engineers are adopting the motor-drive and electric distribution of power in much of the new developmental work now being undertaken, and the substitution of electricity for compressed air is making considerable advance in the re-equipment of some of the mines already in production. The distribution of electrc power through the shafts, tunnels, headings and stopes of a mine is not a matter of difficulty, special cables and wiring devices having been particularly designed for the work. Such an installation is much more flexible than an air or steam system. Incidentally, the electric light can be used, and in a well-lighted mine the efficiency of the men is far greater than it can be in mines lighted by more primitive methods. Pumping, hoisting, ventilating, haulage, and, recently, rock drilling, by means of electric motors illustrate how the power supply may be distributed not only more directly and compactly than by systems employing pipes, but also at materially decreased expense of direct attendance and losses of transmission.

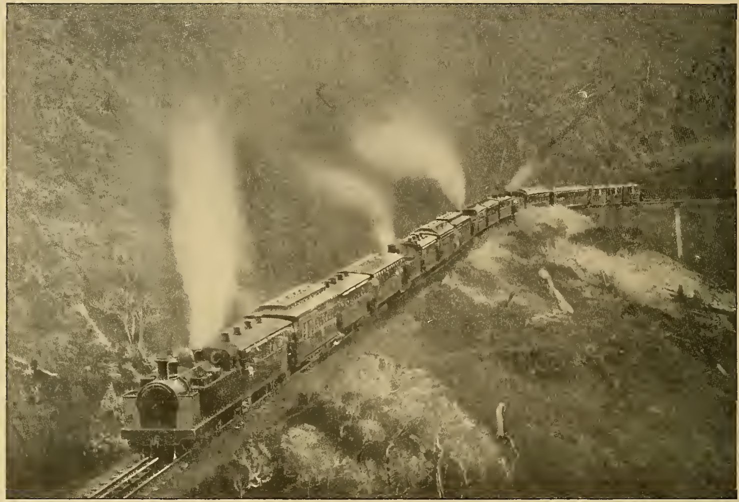


FIG. I.—AN EXCURSION TRAIN DRAWN BY FOUR FELL ENGINES ON THE RIMUTAKA INCLINE. GRADE, I IN 15; WEIGHT OF TRAIN, 174 TONS; LENGTH OF TRAIN, 648 FEET

LOCOMOTIVE PRACTICE ON THE NEW ZEALAND GOVERNMENT RAILWAYS

By Charles Rous-Marten

INTEREST of a somewhat special and multiplex character attaches to New Zealand locomotive engineering. In the first place, there is the non-technical phase. Of all British colonies, New Zealand is the most British. As regards a large proportion of its total area, a visit thither might be merely a step from one English county into another, so similar are most of the natural features, and still more markedly the characteristics of the population.

New Zealand is emphatically and more than merely figuratively "The Britain of the South," as it has so often been styled. But from the technical viewpoint the interest is infinitely greater, owing to the extraordinary variety of conditions under which railway work has to be carried on in that colony, these including such wide differences as those between the vast level stretch across the Canterbury Plains and the terrific climb on a grade of 1 in 15 over the Rimutaka Mountains, worked on the Fell system. There is also the excessive prevalence of steep gradients on the main lines,—long distances at 1 in 50, and some at even 1 in 40 and 1 in 35,—and inordinately sharp curves, numbers of these in the North Island having a radius of only 5 chains, and in the South Island of 7½ chains. Add the variety of local circumstances, and it will be seen that to devise locomotives that shall meet all these requirements

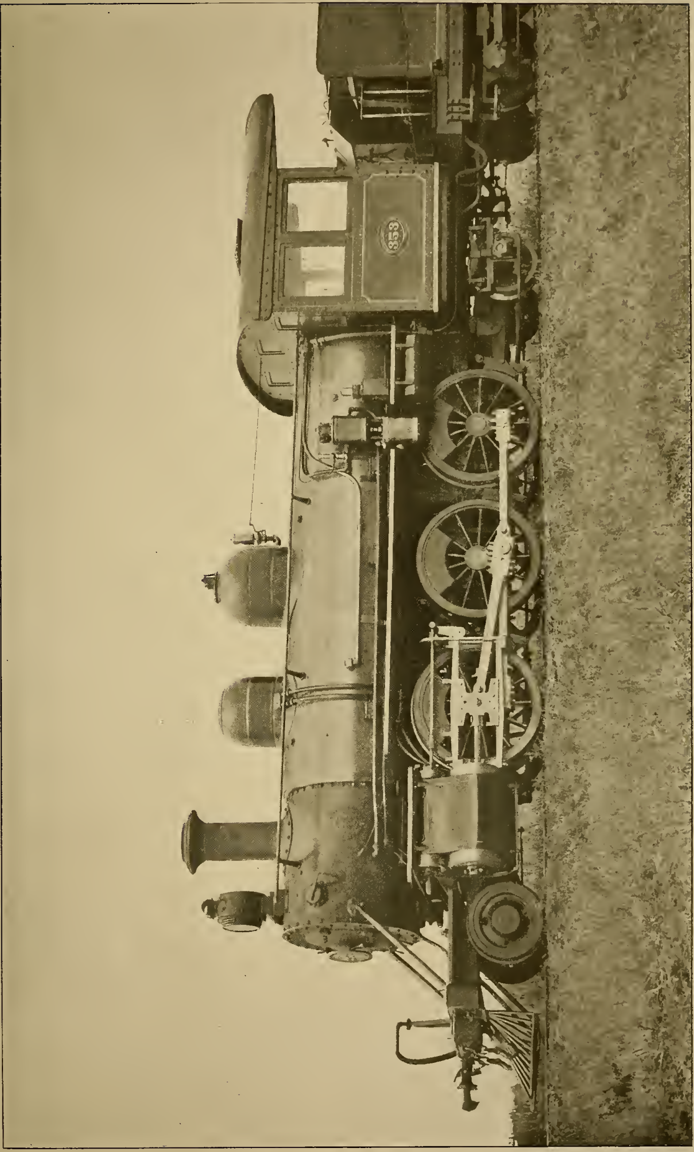
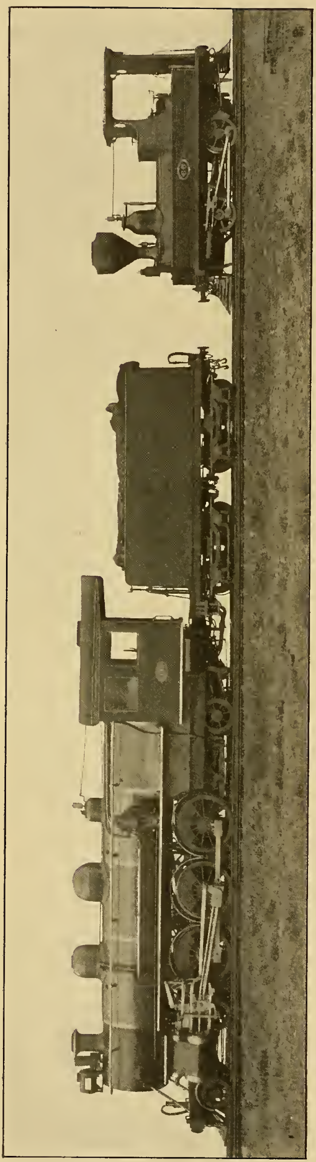


FIG. 2.—PASSENGER AND MIXED SERVICE LOCOMOTIVE, CLASS "N," BUILT BY THE BALDWIN LOCOMOTIVE WORKS, PHILADELPHIA, U. S. A. CYLINDERS, 15 IN.; STROKE, 20 IN.; DIAMETER OF DRIVING WHEELS, 4 FT. 1 IN.; TRACTIVE POWER, 13,775 LBS.; TOTAL WEIGHT IN WORKING TRIM, 53½ TONS



1904.—CLASS "Q."

Cylinders, 16 in. by 22 in.; driving wheels, 49 in.; tractive power (at 75 per cent. boiler pressure), 17,240 lbs.; boiler pressure, 200 lbs. Weight in working order, 69 tons.

1874.—CLASS "A."

Cylinders, 8 in. by 15 in.; driving wheels, 30 in.; tractive power (at 75 per cent. boiler pressure), 2856 lbs.; boiler pressure, 120 lbs. Weight in working order, 11¼ tons.

FIG. 3.—EVOLUTION OF THE LOCOMOTIVE ON THE NEW ZEALAND GOVERNMENT RAILWAYS. GAUGE, 3 FT. 6 IN.

has been no ordinary or facile task.

Another feature of special interest in New Zealand's railway history is the fact that in its initial stage it saw no fewer than three different gauges at work, all within a distance of less than 400 miles. The three southern provinces of the South Island were in those days *quasi* independent states, and each, in starting railway making, chose the gauge it deemed best constituted to local requirements, utterly irrespective and regardless of the difficulties that would accrue in the future when it should become necessary to link together these three detachments of a whole railway system. Thus Southland went in for the British standard gauge of 4 feet 8½ inches, Canterbury preferred the Irish gauge of 5 feet 3 inches, and between these two provinces came Otago, with 3 feet 6 inches. However, that period is one of ancient history, and my present purpose is to deal with New Zealand locomotive practice of to-day, merely referring to that of the past so far as may be necessary to elucidate the gradual development of the present. I shall, therefore, take up my story from the initiation by New Zealand of her national scheme of government railways, which may be roughly stated to date back about thirty years.

Somewhat regrettably, as it has always seemed to me, the Otago gauge of 3 feet 6 inches was the one finally selected as the standard for the whole colony, the lengths previously constructed on the 5-foot 3-inch and 4-foot 8½-inch gauges, respectively, being altered to that standard. The unavoidable consequence has been that the carrying powers of the lines are seriously limited, and ingenuity has been exhausted in devising

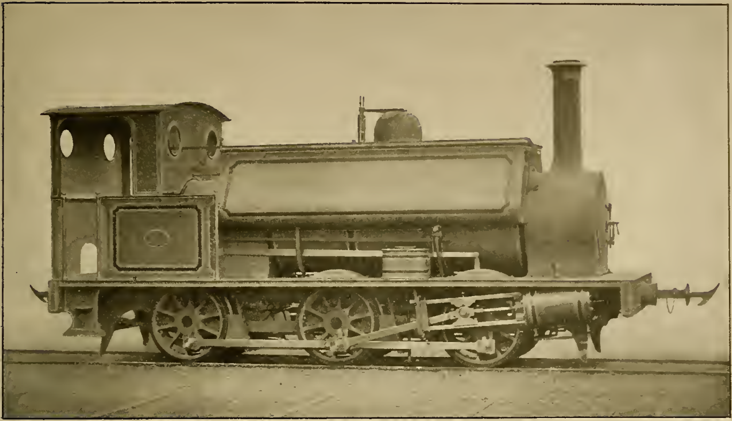


FIG. 4.—NEW ZEALAND ENGINE, CLASS "F." THE MOST NUMEROUS IN THE COLONY. CYLINDERS, 10½ × 18 IN.; WHEELS, 3 FT.

such means of increasing the locomotive power as shall enable these unduly narrow roads to do the work for which the British standard gauge would be infinitely more suitable.

Unfortunately, also, the pioneers in the construction of the New Zealand Government Railways contented themselves with a road which, in other respects than that of gauge, fell deplorably short of what most certainly would be necessary if any material amount of traffic should have to be carried. The idea, of course, was that, by economising the original outlay, the money available for railway construction would be used over a larger area than if the mode of construction were more costly. Thus, iron rails weighing 40 pounds to the yard were laid down, while at the same time excessively steep grades with sharp curves were adopted, and as a necessary consequence it was feasible to use engines of only very small weight and tractive power. Manifestly such locomotives were quite inadequate to haul heavy loads upon such grades as 1 in 50 to 1 in 35 round curves of 7 to 5 chains radius. As a result, excessive piloting and train-duplication had to be resorted to, and so the usual experience that low prime cost means high working expenses was the experience of New Zealand, as of other localities where this ill-advised experiment has been tried.

For more than a quarter of a century there has been a continuous effort to remedy this initial mistake, and I cannot illustrate more forcibly the distance which had to be travelled between the two terminal points of this effort than by showing in one illustration on a uniform scale the type of engine with which the New Zealand Government Railways of 3 feet 6-inch gauge practically started, and the type at which it has now arrived. .

The contrast speaks for itself and tells volumes about the planning and devising that must have gone on during the intervening quarter of a century in order to enable railways which, at the beginning, could be worked by such a toy as that shown,—known as the "A" class,—to develop into the sort of road which at the present day is worked by the larger engine and by others of modern times, which I shall illustrate in due course. To give a rough idea of the difference between the giant and dwarf which I show in Fig. 3, it is only necessary that I should refer my readers to

FIG. 5.—PASSENGER AND MIXED SERVICE LOCOMOTIVE BUILT AT THE BALDWIN LOCOMOTIVE WORKS, PHILADELPHIA. CYLINDERS, 16 IN.; STROKE, 22 IN.; DIAMETER OF DRIVING WHEELS, 49 IN.; TRACTIVE POWER, 17,240 LBS.; TOTAL WEIGHT IN WORKING ORDER, 69 TONS; AREA OF FIRE GRATE, 40 SQUARE FEET

FIG. 6.—EXPRESS PASSENGER LOCOMOTIVE, CLASS "U," BUILT IN THE NEW ZEALAND RAILWAY WORKSHOPS. CYLINDERS, 16 IN.; STROKE, 20 IN.; DIAMETER OF DRIVING WHEELS, 4 FT. 6 IN.; DIAMETER OF BOGIE WHEELS, 2 FT. 6 IN.; TRACTIVE POWER, 12,400 LBS.; TOTAL WEIGHT IN WORKING TRIM, 61 TONS

the respective dimensions which accompany the picture.

But those dwarfs of the "A" class, although for their size and power they did remarkable work, were soon found to be utterly inadequate for anything more than the light traffic of branch lines or for shunting at stations. Two classes, indicated, respectively, by the letters "C" and "D," therefore speedily came out, and the engines of the latter class were multiplied until, in the end, they became among the most numerous of any class in New Zealand. They were well-designed and handy little engines built by the best British makers, such as Messrs. Neilson, Messrs. Dubs, and others, and, within their limitations, they have always proved, and still are found, admirably efficient. The "C's" had saddle-tanks, four wheels, 2 feet 6 inches in diameter, coupled in front, to which a pair of trailing wheels was subsequently added, and cylinders 9½ x 18 inches. These were used mostly on goods trains. The "D's" had cylinders of the same size, but driving wheels 6 inches larger, namely, 3 feet in diameter, coupled behind, and the front end of the engine was carried on a two-wheeled Bissell bogie. These were the passenger engines.

Both types proved very useful. The "D's" often ran light passenger trains at a speed which seems almost incredible. I have several times known them to attain a rate of 40 miles an hour and even more. What this meant in the way of piston speed and also of wear and tear with 18-inch leading wheels, I need not indicate; but it was not infrequently done. On the other hand, the sturdy little "C's" used to walk away readily with goods trains that one would have imagined such midgets could scarcely even move.

Next came a mixed-traffic type known as "F" (Fig. 4), which soon became the most numerous of all. It had saddle-tanks, cylinders 10½" x 18", and six 3-foot coupled wheels. These "F" engines were genuine "servants of all work," and ran "expresses,"—such as they were in those days,—heavy goods, or mixed trains. They could attain 40 miles an hour on falling grades, and take thirteen loaded goods waggons

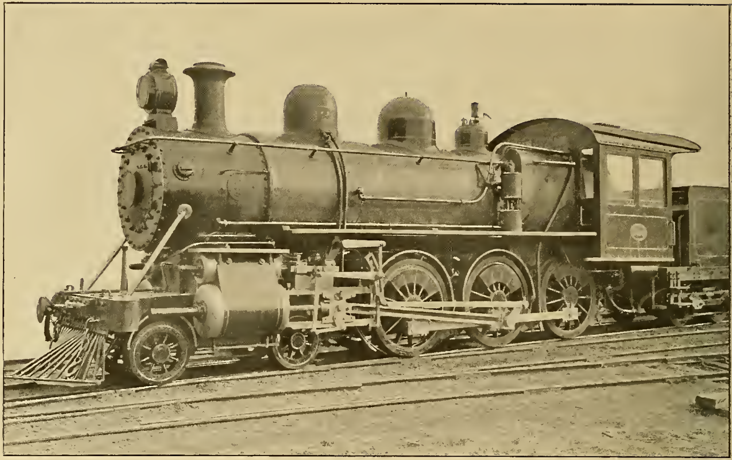


FIG. 7.—PASSENGER AND MIXED SERVICE LOCOMOTIVE, CLASS "Ub," BUILT AT THE BALDWIN LOCOMOTIVE WORKS, PHILADELPHIA, U. S. A. CYLINDERS, 16 IN.; STROKE, 20 IN.; DIAMETER OF DRIVING WHEELS, 4 FT. 1 IN.; TRACTIVE POWER, 15,673 LBS.; TOTAL WEIGHT IN WORKING TRIM, 58 TONS

up long banks at 1 in 50 with 7-chain curves.

However, as the main lines became extended and the traffic increased, tender engines that could carry a larger supply of fuel and water became imperatively necessary, so a number of very excellent ones came out and were classed "J." They were of the "Mogul" design, *i. e.*, with six coupled drivers and leading pony truck or Bissell bogie. The cylinders were 14″ × 20″; the coupled wheels, 3 feet 6 inches. These engines, too, proved valuable all-round workers, hauling seventy waggons of wheat,—no trifle of a load,—and attaining 45 miles an hour, when required, on light passenger trains. But when regular expresses between the chief centres of population became needful, it was decided to adopt larger driving wheels, four-coupled, and at this stage America made her entrance as a provider. Eight engines, with 12″ × 20″ cylinders, 4-foot coupled wheels, and leading and trailing pony-trucks, were procured and classed as "K." For some years they ran the Christchurch - Dunedin expresses in highly creditable style, while shortly afterward the "Consolidation" (or "T") type of goods engine made its appearance, six of these being imported from the United States. They had eight-coupled 3-foot wheels, leading pony-truck, and cylinders 15″ × 18″.

Almost simultaneously was introduced the British-built single-boiler Fairlie type (Class "R") with six-coupled 3-foot wheels, cylinders 12¼″ × 16″, and trailing four-wheel bogie. These, too, were useful in their way; but a series of trials showed that while the "F" engines could take only thirteen loaded waggons up 1 in 50, and the single-boiler Fairlies eighteen, the "Consolidation" engines could take twenty-seven. The superiority of the more powerful locomotives was thus strongly indicated, and important developments followed. This virtually brings us to the present day.

Two new standard types were designed, the passenger engine of the 2-6-2 order, with six-coupled 4-foot wheels and leading and trailing pony-truck; and the goods engine of the "Consolidation" class, with eight-coupled 3-foot to 3-foot 6-inch wheels

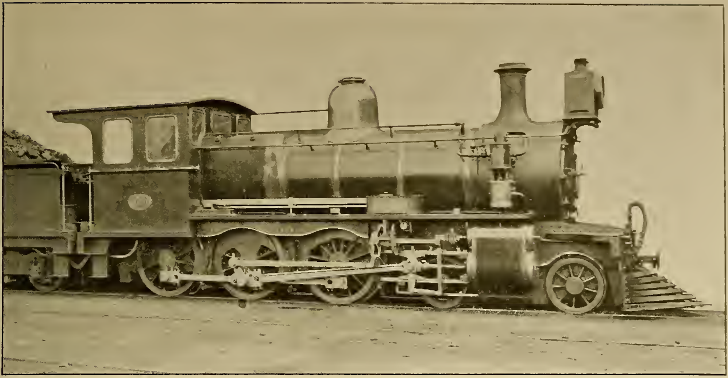


FIG. 8.—PASSENGER AND MIXED SERVICE LOCOMOTIVE, CLASS "UC," BUILT AT SHARP, STEWART & CO.'S WORKS, GLASGOW. CYLINDERS, 16 IN.; STROKE, 22 IN; DIAMETER OF DRIVING WHEELS, 4 FT. 1 IN.; TRACTIVE POWER, 17 240 LBS.; TOTAL WEIGHT IN WORKING TRIM, 61¼ TONS

and leading pony truck, both classes having cylinders 15″ × 20″. Some of each were built in Britain and some in America. The passenger engines were classed "N" and "V," respectively, according to the birthplace being American or British; the new goods engines were similarly differentiated by the letters "O" and "P."

It will be observed that the "N" and "V" engines were of what is termed in America the "Prairie" type, *i. e.*, having six-coupled driving wheels in the middle, with a two-wheeled truck at each end (Fig. 2). This design has given very satisfactory results, alike in speed and in haulage. I have been on the foot-plate on one of the American-built "N's" when a speed of 60 miles an hour was maintained continuously on the level for a distance of 15 miles, a maximum of 64.2 miles an hour being attained, and on another when a goods train of eighty-one waggons, loaded with wheat, was taken at 25 miles an hour on the level.

It was suggested at a recent meeting of the Institution of Civil Engineers by Mr. G. J. Churchward, the chief mechanical engineer of the Great Western Railway, that this 2-6-2, or so-called "Prairie," type might yet come into use in Great Britain for express duty. It certainly has the great advantage of a midway position for the driving wheels and of the most advantageous disposition of the adhesion-weight. But I doubt whether the four-wheeled leading bogie, with its manifest convenience, will be readily dispensed with, and I should rather anticipate preference being given to a still later New Zealand type which I shall mention shortly.

Even in New Zealand, the British possession in which the 2-6-2 type first made its appearance, it has long been abandoned, so far as new locomotives are concerned, in favour of the more ordinary 4-6-0 arrangement, in which the six-coupled wheels are preceded by a four-wheeled leading bogie, as in the case of the English Great Western's Nos. 98, 100 and 171; of the North-Eastern's "2001" and "2111" classes, and of the Great Central's "195" and "196." In the case of the first of these, which were constructed locally at the Addington Works, near Christchurch, 4-foot 6 inch coupled wheels and 16-inch cylinders with 20-inch piston stroke were employed for the first time on the New Zealand State Railways, but only nine of these were built

(Fig. 6). In the passenger engines subsequently constructed by the American Baldwin Company (Fig. 5), the 15 × 20-inch cylinder was retained; but the former standard size of driving wheel, 4 feet, was reverted to, and this is still the practice, which has its latest and largest development in the case of the huge engine shown in the first illustration, as contrasted with the old "A" class, and also separately (Figs. 3 and 5). The newest class is lettered "Q," and is, as will be observed, of the 4-6-0 (or "U") type, plus a pair of trailing carrying-wheels, thus becoming a so-called "Pacific" or 4-6-2 type engine.

With its 16-inch cylinders, 22-inch piston stroke, 4-foot 1-inch wheels, six-coupled, and 200 pounds steam pressure, this locomotive can exert as much as 17,240 pounds of tractive power, taking the effective pressure on the pistons in the cylinders at 75 per cent. of the full boiler pressure. It has also a fire-box of the extra wide order, giving no less than 40 square feet of fire-grate area, and consequently special freedom of fuel consumption. It is, in short, a thoroughly useful and well-planned locomotive in all respects, and capable either of running a very heavy express at the highest speeds permissible on the 3-foot 6-inch gauge, or of hauling unassisted at low speed the heaviest goods trains that can be accommodated on the New Zealand lines. Here, then, a climax may be said to have been reached as regards main-line engines. It is hardly probable that there can be any great advance on this new "Q" type so long as the New Zealand State Railways maintain their present character and their existing dimensional limitations.

But the classes which most closely preceded this *quasi* ultimatum, and, in fact, led up to it, deserve passing attention. I have already related how the 2-6-2 or "N" class,—of which I illustrate No. 353,—had been succeeded by the 4-6-0 style, and I illustrate the pioneer of this build, "U" class, No. 274, which was built in the New Zealand Railway workshops. It will be observed that it has, among other novelties, a fire-box of the Belpaire design. But the 4-foot 6-inch driving wheel was not perpetuated, the 4 feet being reverted to in the next two batches of passenger and mixed traffic engines imported. One lot of these came from the Baldwin Works, America, and had 4-foot 1-inch coupled wheels with cylinders 16 × 20 inches; that is to say, the dimensions were very similar to those of the latest of the 2-6-2 set, but the cylinders received an additional inch of diameter with proportionately enlarged boiler power and consequently augmented weight.

The Belpaire fire-box also is used, as

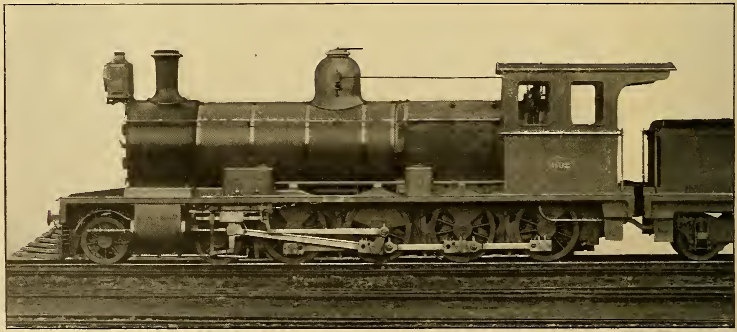


FIG. 9.—"MASTODON" LOCOMOTIVE, CLASS "B," BUILT IN THE NEW ZEALAND RAILWAY WORKSHOPS. CYLINDERS, 16 IN.; STROKE, 22 IN.; DIAMETER OF DRIVING WHEELS, 3 FT. 6¼ IN.; TRACTIVE POWER, 17,495 LBS.; TOTAL WEIGHT IN WORKING TRIM, 65 TONS

FIG. 10.—GOODS TANK LOCOMOTIVE FOR HEAVY GRADIENTS, CLASS "wa," BUILT IN THE NEW ZEALAND RAILWAY WORKSHOPS. CYLINDERS, 14 IN.; STROKE, 20 IN.; DIAMETER OF DRIVING WHEELS, 3 FT. 3¾ IN.; TRACTIVE POWER, 11,833 LBS.; TOTAL WEIGHT IN WORKING TRIM, 37¼ TONS

in all recent New Zealand tender engines. Fig. 7 shows No. 329 of this class. The batch of British-built engines of the 4-6-0 class came from the works of Messrs. Sharp, Stewart & Co., Glasgow, and I illustrate one of them, No. 369 (Fig. 8). It will be seen that the external design is more of the British model than is that to which I have just been referring; that is to say, it has a neater aspect to the British eye. The safety valves are placed in the steam dome, and the sand box is on the side frame instead of being mounted on the top of the boiler casing, with the appearance of a second dome.

But the chief difference between the two classes of engines,—both of which are in the "U" division, the one being differentiated as "Ub" and the other

FIG. 11.—GOODS TANK LOCOMOTIVE FOR HEAVY GRADIENTS, CLASS "wd," BUILT AT THE BALDWIN LOCOMOTIVE WORKS, PHILADELPHIA, U. S. A. CYLINDERS, 14 IN ; STROKE, 20 IN.; DIAMETER OF DRIVING WHEELS, 3 FT. 3¾ IN.; TRACTIVE POWER, 14 790 LBS.; TOTAL WEIGHT IN WORKING TRIM, 43¾ TONS

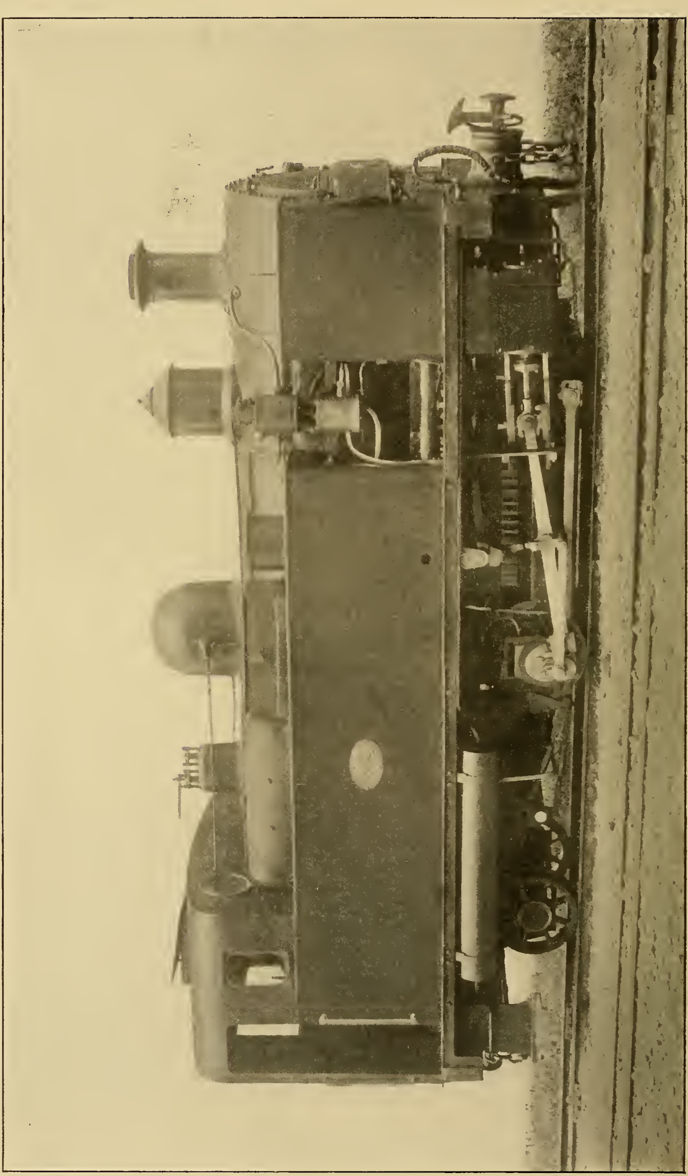


FIG. 12.—FELL ENGINE, CLASS "H," FOR THE RIMUTAKA INCLINE. BUILT BY MESSRS. NEILSON & CO., GLASGOW. GRADE, 1 IN 15; CURVES, 5 CHAINS RADIUS. CYLINDERS (OUTSIDE), 14 IN. DIAMETER × 16 IN. STROKE; CYLINDERS (INSIDE), 12 IN. DIAMETER × 14 IN. STROKE; DIAMETER OF COUPLED WHEELS, 2 FT. 8 IN.; DIAMETER OF TRAILING WHEELS (RADIAL), 2 FT. 6 IN.; TRACTIVE POWER, 19,250 LBS; TOTAL WEIGHT IN WORKING TRIM, 39 TONS

as "Ua,"—consists in the piston stroke being lengthened by 2 inches in the latter case, thus becoming 22 inches, and giving a material augmentation of tractive force, viz., to 115 pounds for every pound of effective steam pressure in the cylinders. It will readily be perceived how the latest, or "Q," type has naturally and almost automatically developed itself out of this series of these gradually expanding designs. The "Q" engine certainly ought to fulfill all New Zealand's main-line requirements for some years to come.

As regards the locomotives of the purely "goods" type, for main-line service, their advance may be said to have been along one single line of rails. The "O" and "T" classes of American engine, with 15" × 18" cylinders and eight-coupled, 3-foot wheels and a pony-truck, and the British "P" class, with 15" × 20" cylinders and eight-coupled, 3-foot 5-inch wheels, have combined to evolve the newest "B" class, which is of the order known in America as the "Mastodon," or 4-8-0, which has eight-coupled wheels and a four-wheeled leading bogie, differing in this latter respect from the "Consolidation," or 2-8-0, order, which has four pairs of coupled wheels, but only a two-wheeled leading truck.

The New Zealand "Mastodons," Fig. 9, have 3-foot 6½-inch coupled wheels (eight), and cylinders 16" × 22". The eight at present in use have been built in the New Zealand Railway workshops, but more will probably be ordered when required, from abroad. It must be understood, however, that in New Zealand there is not, as a rule, the definite discrimination between passenger and goods traffic, so far as the locomotive working is concerned, that one finds in older communities. Many important main-line trains are "mixed," and those are usually worked by six-coupled engines, either of the 4-6-0 or of the 2-6-2 style. But as main-line traffic develops, the tendency is to allot the passenger services to the six-coupled, and the goods to the eight-coupled classes.

I come now to a curious group of classes, some of which have no exact analogy in Britain. In sketching the earlier features of the New Zealand Government Railways I mentioned the large use that was made of a six-coupled, saddle-tank type classed as "F" (Fig. 3), which for many years proved most efficient and satisfactory. But after a while they, with their 10½" × 18" cylinders, were outclassed by the expanding traffic, as were, in their turn, the later single-boiler Fairlies, which also had 3-foot coupled wheels, but 13" × 16" cylinders. In some cases this led to the use of the more powerful tender engines, but in others that method was inadmissible. So the New Zealand locomotive department set about designing a new order of tank engines that should fulfill the requirements newly created and should also be capable of expansion for particular service that might need special provision.

In this way the "W" class came to be produced some years ago, the pioneer of which I illustrate. It bears the number "67" (Fig. 10). These engines, it will be observed, possess the disposition of wheels which has come into prominent favour on several British lines, notably the North-Eastern, Great Western, Great Central, and Lancashire & Yorkshire, viz., having the three pairs of coupled wheels placed in the middle, with a pair of carrying wheels at each end.

The earliest-built of these tanks, classed "Wa," have cylinders 14" × 20", and 3-foot 3¾-inch coupled wheels. Of the other subdivision of the "W" class, while "Wa" and "Wb" followed the original design with fair closeness and differed only in minor details, "Wd," "We" and "Wf" exhibited important departures from the prototype of the order. Thus, "'Wd" (Fig. 11), which was built in America from the New Zealand design, was fitted with a four-wheeled trailing bogie instead of a two-wheeled pony-truck, and so became a twelve-wheeled engine of the 2-6-4 plan, while "Wf" (Fig. 13), constructed in New Zealand, has not only the trailing four-wheel bogie, but also a 22-inch piston stroke and 5¼

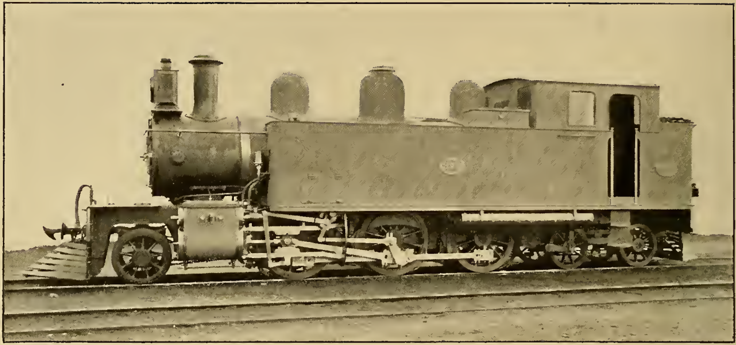


FIG. 13.—SUBURBAN TANK LOCOMOTIVE, CLASS "Wf," BUILT IN THE NEW ZEALAND GOVERNMENT RAILWAY WORKSHOPS. CYLINDERS, 14 IN.; STROKE, 22 IN.; DIAMETER OF DRIVING WHEELS, 3 FT. 9 IN.; TRACTIVE POWER (AT 75 PER CENT. BOILER PRESSURE), 14,370 LBS.; BOILER PRESSURE, 200 LBS.; TOTAL WEIGHT IN WORKING TRIM, 43½ TONS; GAUGE, 3 FT. 6 IN.

inches extra driving wheel diameter, the coupled wheel being 3 feet 9 inches, while the boiler pressure was raised to 200 pounds per square inch. This species was expressly built for suburban passenger duty. One of these is illustrated in the present article.

Class "We" (Fig. 14) must be considered in association with another locomotive type, "H," that was specially constructed for working the steep incline by which the Rimutaka Mountains are ascended from the northern side, and which, for three miles, has the exceptional grade of 1 in 15 continuously, with reverse curves of only 5 chains radius, about fifty of which occur in that short distance. The engine shown (No. 204) is on the Fell system (Fig. 12). It has four coupled wheels, 2 feet 8 inches in diameter, driven by outside cylinders, 14″ × 16″. There are also two pairs of horizontal coupled driving wheels which, worked by inside cylinders, are pressed by powerful springs against the raised middle rail and so obtain, by means of that direct grip, a large increment of tractive power. The radial trailing wheels are 2 feet 6 inches in diameter. These Fell engines, six in number, work constantly between the Rimutaka summit and the foot of the incline; but with the heavy trains that are constantly encountered nowadays three engines are quite commonly used, and four not seldom have to be employed, these being placed at intervals along the train so as to avoid undue strain on the respective draw-bars.

It was with the view of minimising this tripling and quadrupling of the Fell engines that the new variety of the "W" class has lately been introduced as "We," specially to assist both up the Rimutaka incline itself and also on the severe grades of 1 in 40, etc., which occur just below the Fell incline, but are worked by ordinary locomotives. The "We" engines can go up the 1 in 15 quite readily without the aid of any gripping apparatus on the mid-rail, but they are fitted with powerful gripping brakes working on the third or middle rail, and so can exercise all the brake power required for the descent of the incline by heavy trains.

Last among the new engines comes one of a very remarkable character, which was designed for similar duty to that just described in the case of Class "We," but of a still more arduous nature. This type, bearing the letter "E," is mainly for use in assisting on the steep grades immediately below the Rimutaka incline. It can also work up the incline if required, and, with that end in view, has been equipped with very powerful middle-rail gripping brakes. The cylinders are those of some Vauclain compounds imported some years ago, but not used. In order to utilise them they have been worked in for this articulated Class "E" engine, and on account of the existing smoke-box saddles on the cylinder castings it was necessary to place them at opposite ends of the engine, instead of having one set of cylinders immediately under the fire-box. There is a special type of boiler with a corrugated, cylindrical fire-box. For slow speeds and heavy work this engine should give good results. There can be few locomotives of the 3-foot 6-inch gauge more powerful than this one; but, of course, the cylinder arrangement is not what it would have been had the cylinder castings been made specially for this purpose. Nevertheless, the type is a very powerful one, which ought to prove exceedingly efficient.

From the side elevation of this engine (Fig. 19), it will be seen that the boiler is of the extended waggon-top type, while the carrying portion of the engine is articulated in two divisions of six wheels each. Each set of six-coupled wheels is driven by two pairs of cylinders, the high-pressure cylinders being 9½" × 18", and the low-pressure cylinders, superposed upon the high, 16" × 18". The front end of the engine is carried on a two-wheel pony truck. On each pair of coupled wheels a weight of exactly 10 tons is imposed, while the pony truck carries 5 tons.

The total weight of the engine in working order is, therefore, 65 tons, while its normal tractive power is 29,000 pounds on the basis of 75 per cent. of the boiler pressure, 200 pounds per square inch being exercised effectively upon the high-pressure pistons. The boiler is very large, giving a total heating surface of 1540 square feet, while the grate area is 26 square feet. The recital of these principal dimensions will suffice to show what a vast and potent machine it is, especially in proportion to the narrowness of the gauge upon which it has to work.

Before closing this paper a few lines ought to be devoted to two other productions of the New Zealand Railways workshops, which, although of the nature of conversions and rebuildings, nevertheless will long constitute a substantial numerical proportion of New Zealand's locomotive stock. Early in the course of this paper I mentioned the

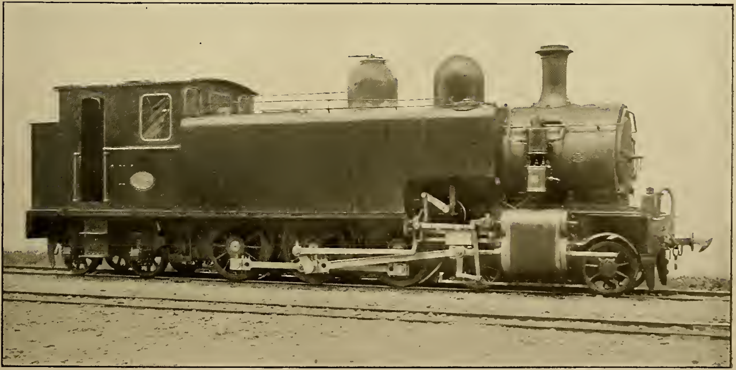


FIG. 14.—TANK ENGINE, CLASS "WE," FOR THE RIMUTAKA INCLINE. LENGTH OF "INCLINE," 3 MILES; GRADE, 1 IN 15; CURVES, 5 CHAINS RADIUS. CYLINDERS, 16 IN.; STROKE, 22 IN.; DIAMETER OF DRIVING WHEELS, 3 FT. 6¼ IN.; TRACTIVE POWER, 18,000 LBS.; TOTAL WEIGHT IN WORKING TRIM, 54½ TONS

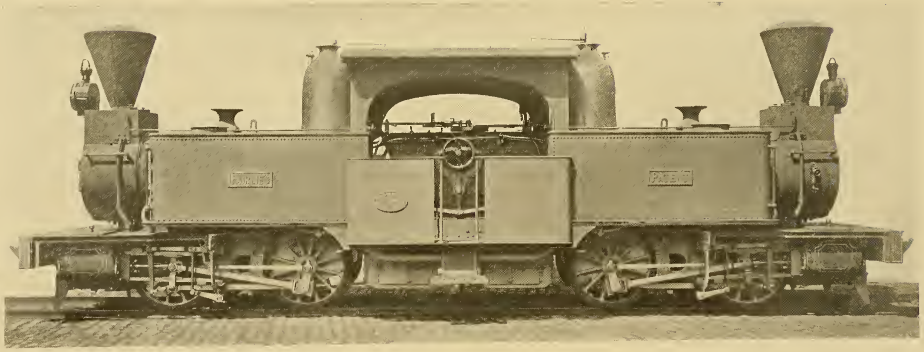


FIG. 15.—THE UPPER ILLUSTRATION,—CLASS "E," DOUBLE FAIRLIE ENGINE, ONCE MUCH USED IN NEW ZEALAND. CYLINDERS, 10 IN. × 16 IN.; WHEELS, 3 FT. 3 IN.

FIG. 16.—THE LOWER ONE,—SINGLE-BOILER FAIRLIE, CLASS "R." CYLINDERS, 12¼ IN. × 16 IN.; WHEELS, 3 FT. ONE OF THESE ATTAINED SPEED OF 53 MILES AN HOUR

very numerous Class "F" of the "old times" of New Zealand railways, and it may be recollected that they were six-coupled saddle-tanks, with cylinders 10½" × 18" and 3-foot wheels. These are being converted at the railway workshops into wing-tanks, with 12-inch cylinders and with trailing pony trucks added, their weight being simultaneously augmented by about 10 tons. As thus altered, they are proving extremely useful little machines, as, indeed, they always were even in their "unconverted days." They are shown in both phases, Figs. 4 and 17.

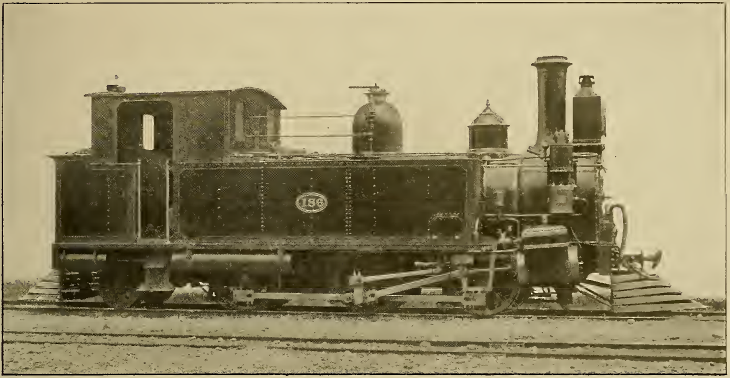


FIG. 17.—TANK LOCOMOTIVE, CLASS "Fb," BUILT IN THE NEW ZEALAND RAILWAY WORKSHOPS. CYLINDERS, 12 IN.; STROKE, 18 IN; DIAMETER OF DRIVING WHEELS, 3 FT. ½ IN.; DIAMETER OF BOGIE WHEELS, 2 FT. ¼ IN; TRACTIVE POWER, 8521 LBS; TOTAL WEIGHT IN WORKING TRIM, 28¾ TONS

In the other case, engines of the "L" class,—a slight enlargement of the "D's" described before, with 3-foot wheels, four-coupled, 10½" × 18" cylinders, and radial leading axle,—are being rebuilt with 3-foot 6½-inch wheels, *i. e.*, 6½ inches larger than before, and 12-inch cylinders, *i. e.*, 1½ inches larger; also with a leading four-wheeled bogie instead of a single pair of carrying wheels with radial axles, and also with a pair of trailing carrying wheels, the weight, moreover, being increased by 12 tons, viz., to 31½ tons in working order (Fig. 18). These two rebuilt classes have done, and are doing, excellent service on general local traffic.

The total number of locomotives which were at work on the New Zealand Government Railways up to March 31 of last year, when the latest returns were made up, was 377. A good many of the engines earliest in use have been sold to contractors and others, and some, of course, have been condemned and broken up. Thus, only four of the "A" class still remain and six of "C," while all of the double Fairlies (Fig. 15), which originally numbered eight, have long since been condemned. They were useful engines in their day, but generally laboured under the disadvantage that full loads could not be given them, the result being that they were extravagant in fuel consumption, while they were regarded as costly in respect of repairs.

On the other hand, it is only fair to bear in mind that the double Fairlies were never favourites in New Zealand, and, as everyone knows who has had much to do with locomotives, unpopular engines seldom have the chance of showing themselves at their best. Personally, I may say that while the double Fairlies were never favourites of mine, I have seen them do some very good work, and I have often thought that they might have been used to better advantage. However, they are all gone now, and it is in the highest degree improbable that the type will ever again be seen on the New Zealand railways.

The single-boiler Fairlies (Fig. 16) have always performed respectably, but there seems no reason to think that they have derived any advantage through their somewhat complex and troublesome steam bogie. I have seen a great deal of their work in New Zealand, and have never been able to convince myself that they would not have done just as well with rigid framing for the six-coupled wheels, seeing that they had a four-wheeled bogie in the rear. I imagine, therefore, that this locomotive type will not be multiplied in the future, and that the twenty two now remaining will be replaced by engines of the ordinary build when they shall have worked out their time. Should they be found worth rebuilding, I anticipate that they will be converted on the normal lines of construction.

As showing how even in the newest countries, where the opportunity has been afforded of beginning absolutely from the beginning, unhampered with disadvantageous legacies of the past, the tendency will creep in to multiply the number of different classes, it is noteworthy that the three hundred and seventy-seven engines employed on the New Zealand Government Railways are divided into no fewer than thirty-one classes. This fact, however, does not imply any fault on the part of the successive mechanical engineers. Each separate type, as it came, was devised for the requirements of a particular service or to comply with certain local conditions, as, for example, the Fell engines, which had to be built for the work of the Rimutaka incline of 1 in 15.

FIG. 18.—TANK LOCOMOTIVE, CLASS "L," BUILT IN THE NEW ZEALAND RAILWAY WORKSHOPS. CYLINDERS, 12 IN.; STROKE, 18 IN.; DIAMETER OF DRIVING WHEELS, 3 FT. 6¼ IN.; DIAMETER OF BOGIE WHEELS, 2 FT. 2½ IN.; TRACTIVE POWER, 7361 LBS.; TOTAL WEIGHT IN WORKING TRIM, 31½ TONS

Similarly the most recently introduced types of the tank order, such as the articulated, four-cylinder compound Class "E," described before, and also the "We" class, likewise described, have been evolved with the special object of securing the more economical and efficient working of that 1-in-15 incline and other severe, though less steep, grades by which the crossing of the Rimutaka range of mountains is effected. Thus, also, the urgent public demand for

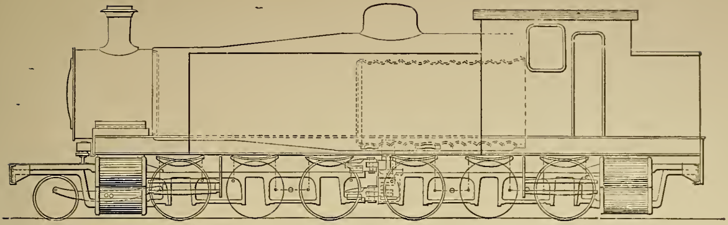


FIG. 19. - COMPOUND LOCOMOTIVE, CLASS "E," BUILT IN THE NEW ZEALAND RAILWAY WORKSHOPS. LOW-PRESSURE CYLINDER, 16 IN. × 18 IN.; HIGH-PRESSURE CYLINDER, 9½ IN. × 18 IN.; DIAMETER OF DRIVING WHEELS, 36½ IN.; TRACTIVE POWER, 29,000 LBS.; TOTAL WEIGHT IN WORKING TRIM, 65 TONS

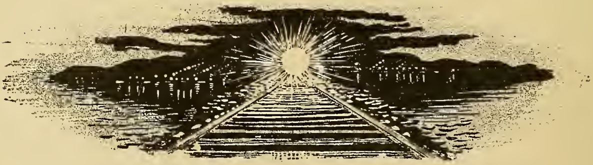
faster express services suggested the idea of building the larger-wheeled engines of the first "U" class.

Three of the earliest classes of New Zealand locomotives, those lettered "B," "E," and "N," all double Fairlies of varying dimensions, have long been totally abolished; but already new locomotive types were waiting to receive the disused letters, and each has been allotted to one of the newer classes, while at the same time, some of the original letters have had to be used to indicate a group of several builds differing from one another in material respects, although usually, but not invariably, agreeing as regards their main features, such as the number and disposition of their wheels. This multiplicity of types is necessarily a drawback, yet it is not so easy to see either how it could have been originally avoided, or how, even in the light of modern experience, it can be entirely remedied. All that can be done in this direction is being done by the present able chief mechanical engineer, Mr. A. L. Beattie, and doubtless the process will steadily continue until most of the older classes have been either condemned or rebuilt into a more modern and uniform design.

Reviewing the New Zealand Government locomotives as a whole, it may be observed that certain features prevail. All, for instance, have steam domes; all have outside cylinders. This latter arrangement is virtually compulsory, through the narrowness of the gauge, which would not afford space between the frames for cylinders of anything like a useful size. It is true that the horizontal wheels of the Fell engines, which obtain traction by strong pressure against the raised third or middle rail, are driven by inside cylinders; but it need hardly be explained that, as they drive horizontal wheels, there is no analogy between them and the inside cylinders of the normal locomotive. It may be remarked here that traction on the Rimutaka incline has proved in practice feasible to a much larger extent by means of more adhesion weight than had been thought at all feasible when the incline was planned. I have known the Fell engines to take fair loads up the incline by means of their vertical wheels only, without calling in the aid of the horizontal gripping gear, and it is believed that the new double-six-coupled "E" engine will prove to have very considerable capabilities in this direction. But by whatever means it may be worked, the Rimutaka incline must always prove a serious stumbling-block in the way of the speedy and facile transmission of traffic between the capital city, Wellington, and the large and important district that lies north of the Rimutaka ranges, apart from the fact that railway communication is ultimately intended to be completed by that route between Wellington and the more northern city, Auckland.

In order to avoid any risk of misconception, I may mention here, although the fact ought to be sufficiently plain from what I have said before, that all I have stated in this article applies solely to the New Zealand Government Railways, which constitute an overwhelming majority in mileage of the entire railway system of New Zealand. Practically the only private line in that colony is the Wellington and Manawatu Railway, which comprises but 84 miles, as compared with the 2300 miles of the Government lines. The locomotive practice of the Wellington and Manawatu line possesses undoubtedly a considerable interest of its own, but confusion would be apt to result if I dealt with it at the same time as that of the Government Railways. Possibly a future opportunity may offer to touch upon that subject.

My notes upon the locomotive practice of the New Zealand Government Railways would be in some degree incomplete if I wholly omitted to notice the personal element in the history. But I must content myself with brief mention of a few names that stand out with principal prominence in this connection. They include those of Mr. W. Conyers, the first chief mechanical engineer of the earliest New Zealand railway, subsequently chief railway commissioner, *i. e.*, general manager, for all the Government Railways of the Southern Island; Mr. Allison Smith, who long filled the post of chief mechanical engineer to the same extensive railway system, who designed and built the Addington workshops,—the most important in the colony,—and who subsequently held the post of locomotive superintendent to the Government Railways of Victoria; and Mr. A. L. Beattie, who for some time past has most worthily occupied the position of mechanical engineer-in-chief of all the Government Railways in both the main islands of New Zealand. To his courtesy and that of the general manager, Mr. T. Ronayne, I am indebted for the admirable photographs and for some of the valuable figures and details which I have used in this article.



SPECIAL FORMS OF CRANES

By Joseph Horner

Concluded from the February Number

A SPECIAL form of coal transporter is built on the gantry crane model. The gantry runs alongside the wharf, and serves a gas works on the other side. In place of the usual crane, a steam transporter is mounted on the gantry, the carriage way or beam being sloped at an angle of 60 degrees with the vertical. The block carriage with its bucket is lowest on the water side, whence it lifts the coal to the skips on the higher level on the gas works side. The carriage is drawn up by wire rope, and coiled round a hoisting drum actuated directly by the engines alongside the boiler. Slewing and travelling are both done by hand.

For many years the Fairbairn crane was a fixture. The swinging jib, as in the old standard design, carried down into a deep pit, fitting in a footstep at the bottom, and swivelling therein and on a race of rollers at the ground line. The immense sweep of the jib and its mass,—being solidly plated,—would seem to render the idea of slewing it on the truck of a travelling crane absurd.

FIG. 11.—A 2½-TON STEAM CRANE, ON THE HAMBURG DOCKS, BUILT BY MESSRS. MOHR & FEDERHAFF, MANNHEIM, GERMANY

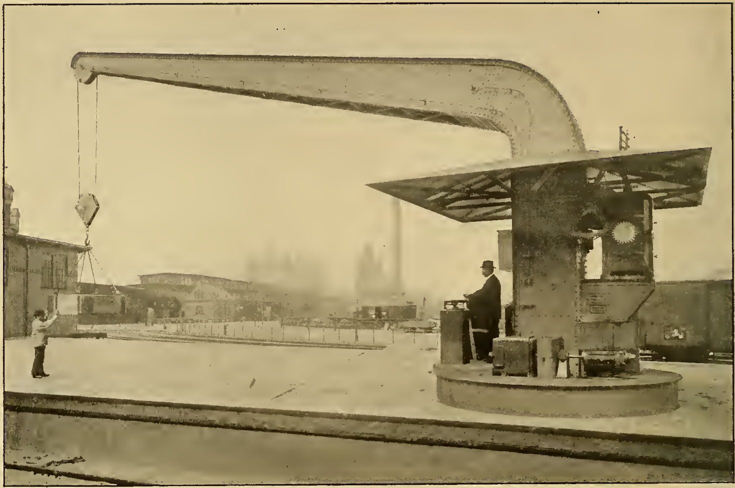


FIG. 12.—AN ELECTRIC 2½-TON TWO-MOTOR REVOLVING CRANE BUILT BY MESSRS. MOHR & FEDERHAFF, MANNHEIM, GERMANY

Hence, when jibs of long radius are used on portable cranes they are nearly always lattice braced, and if they are bent they are not self-sustaining, as a rule, but are supported with tie rods at about the centre of their length, leaving only the portion beyond self supporting.

It is, however, quite practicable to use Fairbairn jibs on portable cranes, and they will lift across the rails if rail clips or blocking girders are employed. There are examples of their being fitted thus to steam cranes. The foot of the jib rests on the revolving bed at the front, and on a pillar a few feet up, while the boiler and engines go on the back of the bed. Used thus, they should be excellent cranes for quay walls and wharves, owing to the bulky packages which can be admitted under the jib. Fig. 11 shows a portable steam crane with Fairbairn jib, one of fourteen supplied for a railway serving Hamburg. It is of 2½ tons power, and has a radius of 32 feet 2 inches. This is by Mohr & Federhaff, of Mannheim, Germany, and represents a favourite form of this crane for dealing with goods. Figs. 12, 13, and 14 are other examples of this type of crane.

Almost invariably steam balance cranes rotate directly on the truck, the advantages of which are that the best stability is secured, because the centre of gravity is kept low, and the attendant can see all over and around the crane. The one disadvantage is that the swing of the tail with its counterbalance requires a clear room of several feet on each side of the rails. In one German type this is avoided, but at the sacrifice of stability. Here the engines and boiler stand directly on the truck and do not slew. The jib, with its counterweight, is pivoted above these, clearing the top of the boiler and swinging with the post. An electric crane of this type is shown in Fig. 15.

If the superstructure of a revolving crane be mounted on a high tower built of lattice-braced legs, we have an imposing type which is adapted for shipyards and wharves. A 75-ton crane of this kind, made by the Düsseldorfer Krahnbaugesellschaft Liebe - Harkort m. b. H., is shown in Fig. 17 with a derricking jib.

The modern type of "Titan" crane is a machine which has been evolved by the trying conditions of very heavy service on exposed sea fronts. There are some cases of "Titan" cranes having been blown over into the sea in spite of their immense mass. In daily service the strains on the various members are most severe. To move such heavy cranes, weighing from 200 to 300 tons, along a pair of rails with a load of thirty, forty or fifty tons hanging out 50 feet or more from a cantilever jib, and to slew such a load around with perfect stability and safety and also to rack the load along the jib with smoothness of motion, are problems not easy of solution. There is no aid to stabilty derived from the rail clips or blocking girders of the light cranes.

FIG. 13.—A 25-TON ELECTRIC REVOLVING WHARF CRANE, 44 FEET RADIUS, BUILT BY THE NAGEL & KAEMP IRONWORKS CO., HAMBURG, GERMANY

The easy travelling of such a mass is only possible by distributing the load over a number of wheels, from twelve to sixteen, and by taking the thrust of the axles on springs. None of the early "Titans" had springs, and the result was sometimes that wheels broke, and the rails bent and sunk locally in places where the load became concentrated. Volute springs are used, either two or four to each journal, or the leaf springs seen in Figs. 17 and 18. The strain on the forward wheels is terrific at the moment of taking the load, the end of the jib dropping several inches, and the effect on the permanent way would be

FIG. 14.—A 5-TON ELECTRIC REVOLVING CRANE BUILT BY THE DUESSELDORFER KRAHNBAU-GESELLSCHAFT LIEBE-HARKORT, M. B. H., DUESSELDORF-OBERKASSEL, GERMANY

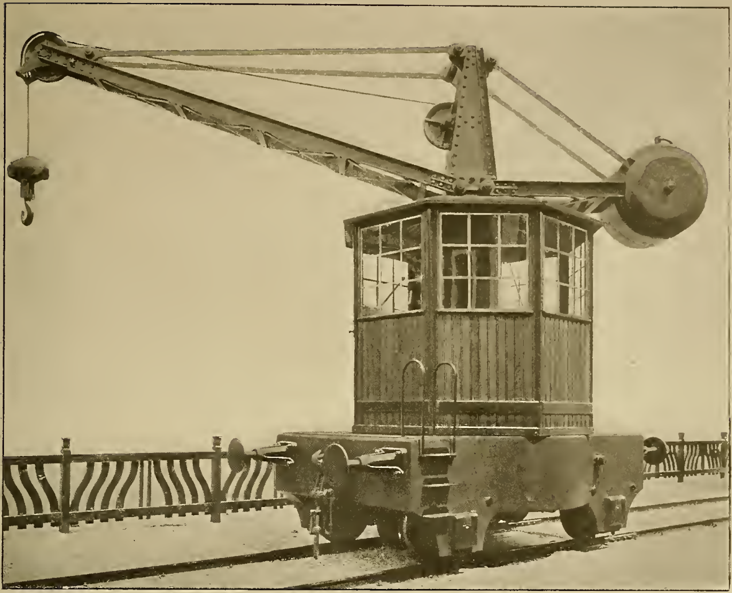


FIG. 15.—A 5-TON ELECTRIC LOCOMOTIVE REVOLVING CRANE, 16 FEET RADIUS, BUILT BY THE BEURATHER MASCHINENFABRIK, BEURATH, GERMANY

to cause depressions in it but for the practice of mounting the wheel bearings against springs. When a "Titan" has to take quick curves, bogies are used.

Steady rotation of the jib is ensured by the large diameter of the wheel race,—30 to 35 feet,—and the distribution of the load over two to three dozen turned rollers running between turned roller paths. The very large diameter of the roller race is a noticeable feature of this type. This, together with the fact that the boiler, engine and gears are placed behind or within the circle of the race, and that supplementary ballast is also placed behind, ensures the stability of the crane under maximum loads at maximum radii.

The tall framing, made high to clear the block trucks, is subject to severe oscillatory stresses when the loaded crane is travelling. The plating is, therefore, made very deep, and supported with massive angle brackets and braced in all directions with broad channels.

The travelling of these huge masses, weighing from 200 to 300 tons, is accomplished in one of two ways, either through pitch chains or bevel wheels. This operation, like those of racking, lifting, and slewing, is performed from a single set of double-cylinder engines. The pitch chains, being long, sag and operate the travelling wheels in a rather jerky manner, causing reversal to become a nuisance, and they also stretch with service. The bevel gears, on the other hand, are liable to fracture, so that it is necessary to carry their shaft bearings in stiff brackets well tied together, and to see that the plating to which the brackets are bolted is well stiffened with diaphragms or stiffening ribs. Both systems of driving are adopted, as they are in "Goliaths."

FIG. 16.—A 33-TON STEAM "TITAN" CRANE BUILT BY MESSRS. RANSOMES & RAPIER, LTD., LONDON

A "Titan" crane possesses a certain amount of similarity to a portal crane, because space is left underneath between the frames or uprights for the rows of block trucks as the crane runs over them. It is much quicker to work in this way than to slew the crane each time a block is fitted and deposited. Most of them have racking jennys, as well as capacity for longitudinal travel.

FIG. 17.—A 75-TON ELECTRIC REVOLVING CRANE BUILT BY THE DUESSELDORFER KRAHNBAUGESELLSCHAFT LIEBE-HARKORT, M. B. H.

The workmanship in these machines has always been, and necessarily so, of high quality. The joints are plated in the girder work, and as the mechanism has to be shipped in sections, this means that these sections have to be bolted together temporarily during erection and for testing. Punched holes are never allowed here, but the holes are either reamered or drilled, and turned bolts have to be inserted. The gears, though cast, are mostly machine moulded. The large slewing ring is cast in sections and held down with turned bolts in reamered holes. Wire rope is generally used in preference to chains for lifting.

The functions of these cranes are not quite restricted to the work for which they were originally designed. Besides handling the concrete blocks, they are used for grabbing, for lowering diving bells and for depositing concrete in bags. Fig. 16 shows two of these functions in a crane built by Ransomes & Rapier. The grab is operated by a special fixture at the end of the jib. It is used in preparing the ground at the sea front for the reception of the bags of concrete in the drop-bottom skips, one of which is suspended and another upside down on trestles.

Generally a " Titan " is built for one special contract of harbour work and is seldom used for any other. It is, therefore, hardly ever made in duplicate, though certain portions may remain standard for cranes varying in other particulars. This question of specialisation, however, lies outside the subject of the present article.

There are only two rivals to the " Titan,"—the " Goliath " and the derrick. The last-named is only so in a slight degree, but the " Goliath " is more serviceable than the " Titan " on long and wide piers and breakwaters. An object lesson of this kind is afforded by the Ransomes & Rapier " Goliaths " at Dover in the block yards and on the breakwaters. A " Titan " here would be wasteful of time, because of the great extent of the works. Blocks are being stacked and others are being deposited simultaneously by different " Goliaths," while at the same time the grabs are dredging, and the divers are being lowered in the bells.

The cranes span the entire width over

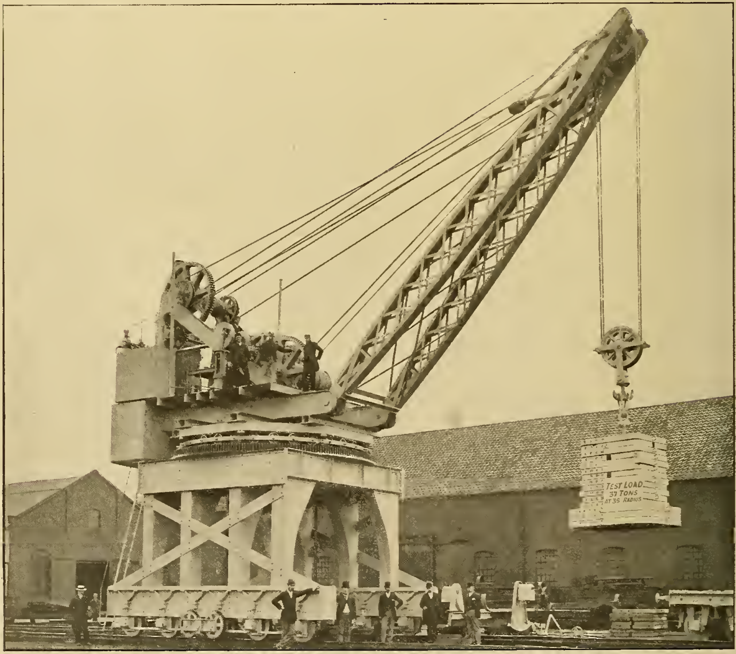


FIG. 18.—A 30-TON STEAM TRAVELLING CRANE BUILT BY MESSRS. RANSOMES & RAPIER, LTD., LONDON

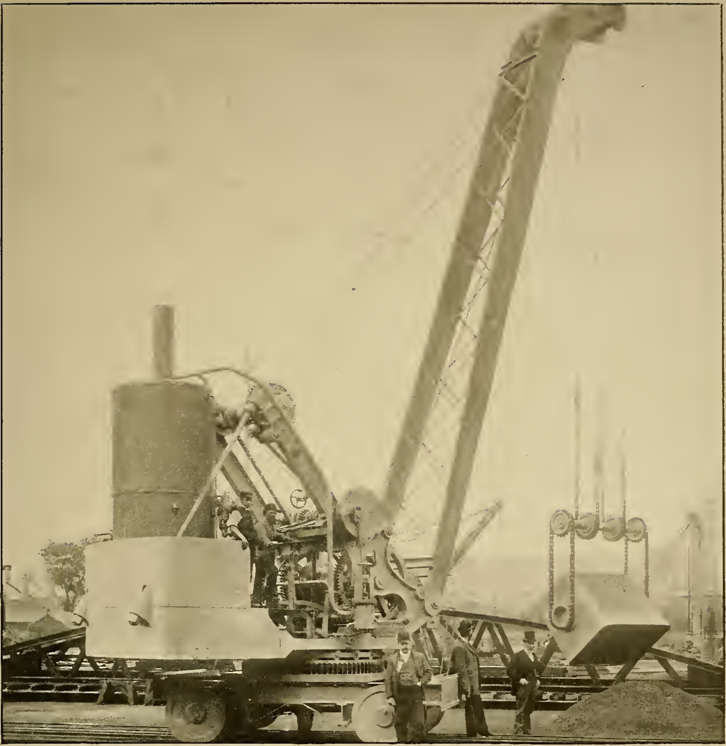


FIG. 19.—THE STONEY PATENT TIPPING CRANE MADE BY MESSRS. RANSOMES & RAPIER, LTD., WATERSIDE IRONWORKS, IPSWICH

which work is going on, running on temporary stagings which a big derrick is building out at the sea front. A "Titan" would be quite unable to cope with such an extensive work.

Fig. 18 shows a special form of travelling steam crane made by Ransomes & Rapier, its most obvious feature being the height, which is unusual in this class of crane. This was embodied for a similar reason to that of building the "Titans" at a good elevation, to permit of the passage of trucks underneath, —in this case railway trucks at Parkeston. It is, therefore, in this sense a big portal crane of very powerful build, lifting 30 tons at a maximum radius of 36 feet, a load which it will hoist to a height of 50 feet. For lesser radii the jib is moved nearer the vertical. Here we note the great mass of 120 tons carried on twelve wheels with leaf springs. All the motions, including the travelling, are made through toothed wheels driven from the pair of engines on the revolving superstructure. The mass of the jib is lessened by adopting the double parabolic and lattice-braced design. Wire ropes are used for lifting and raising or lowering the jib. The superstructure is rendered stable in all positions of the jib by the large diameter of

FIG. 20.—A LONG-RADIUS 2-TON STEAM CRANE BUILT BY MOHR & FEDERHAFF, MANNHEIM, GERMANY

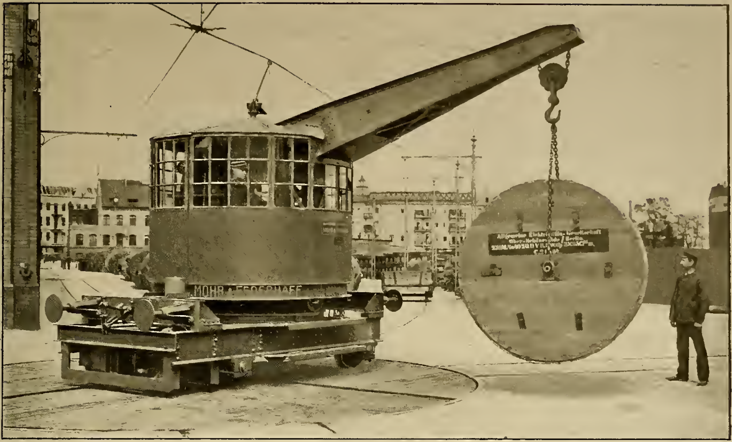


FIG. 21.—A 4½-TON ELECTRIC LOCOMOTIVE CRANE. THERE ARE THREE ELECTRIC MOTORS, ALL TAKING CURRENT FROM AN OVERHEAD TROLLEY SYSTEM. BUILT BY MESSRS. MOHR & FEDERHAFF, MANNHEIM

the roller race and the dispositions of the boiler, heavy gears and ballast.

Fig. 19 shows a design of crane for a special duty. It is the Stoney patent tipping crane, built by Ransomes & Rapier for handling spoil from a dredger, small coal, or other similar duty. The principal feature here is the perfect control that is exercised over the tipping action, the amount of which can be regulated to a nicety from the engines. The advantage of this is that the water dredged up with the spoil can be emptied out before the gravel, sand or mud is tipped into the trucks. In the case of coal, the advantage is that the steadiness of movement lessens the liability of the coal to break up, which occurs when it is thrown down from an ordinary skip.

The boxes are suspended by two sprocket chains, carried by wheels on the lifting bar, and the latter is turned by chains and wheels on the same bar, in connection with four steel wire ropes used for lifting, and wound in pairs on two barrels. These can be made to revolve in the same, or in opposite directions, to cause the box to lift or tip in either direction. The tipping can be done at any height within the range of lift of the crane, and at any angle. Nine of these cranes have been at work for several years on the Manchester Ship Canal, where 312 boxes, each containing six tons of material, have been lifted 25 feet from barges, swung around and tipped in barges by one crane in a working day of nine hours.

Fig. 20 shows a very special crane by Mohr & Federhaff, of Mannheim, which was built for unloading ore for an iron and steel works. The enormous length of the jib is the most striking feature, reminding one of a "Titan" arm. The loads, however, do not exceed two tons. The radius is 67 feet 3 inches, lifted across a gauge of 11 feet 9⅜ inches, with no blocking girders or rail clips; the gauge, the roller path,—as large as the railway gauge,—and the heavy balance weights behind ensuring stability. A racking carriage drawn with chains takes charge of the traverse of the load, which is lifted by wire rope.

A feature common to many of the recent types of cranes is the lightly-braced jibs. The older, heavy jib in compression, sustained by light tie rods in tension, is giving place to a light-braced structure in which there is very little difference in the sections of the two classes of members, but they are stiffened by bracing and by their spread from sheave to base. The two thrust members and the two tension members occupy four corners of a rectangle, and the bracing is disposed to make in effect a solid structure, as may be seen in Figs. 21 and 22. The contrast is very marked between these and the solid plated Fairbairn jib. The design seems to be a reflection of the braced gantry frames and legs in the cranes of large span. It lessens the tipping moment of the crane by reducing the mass of the overhanging jib, and, while given good workmanship, nothing is sacrificed.

Among special designs which are not confined to any one class of crane we notice the growing practice of building up skeleton frames mainly of channel sections and H sections, to the displacement of cheeks of cast iron and steel-plated work. These are noticeable in many steam cranes of horizontal and vertical types. The shaft bearings are bolted on the edges or faces of the sections. The same thing is done in many electric cranes.

These designs are cheaper than the ones for which they are substituted. They are also favourable to the examination and repair of worn or broken parts; but they take away mass from the place where it is wanted most, that is, over the centre of the crane. This is a matter of less importance in cranes of long radius than in those having long jibs. It is opposed to the best designs, in which the aim is to lessen the balance at the tail and abandon the use of rail clips or blocking girders by making

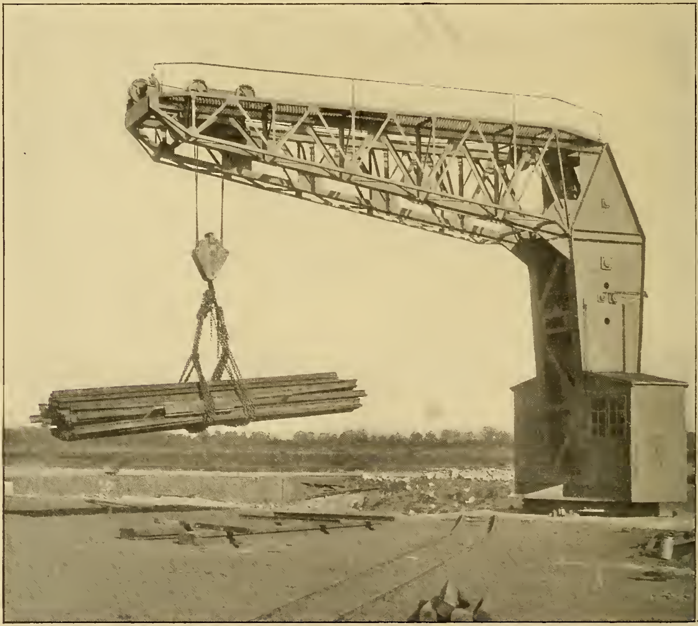


FIG. 22.—A 15-TON REVOLVING CRANE, WITH TROLLEY RACKING ON CANTILEVER JIB, BUILT BY THE BEURATHER MASCHINENFABRIK, BEURATH, GERMANY, AND LONDON

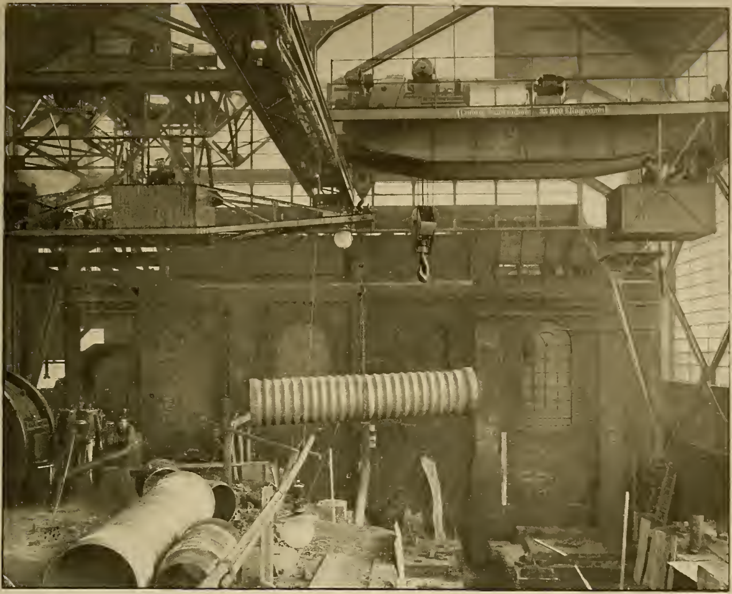


FIG. 23.—TRAVELLING CRANES, IN THE SCHULZ KNAUDT ROLLING MILLS AT ESSEN, BUILT BY LUDWIG STUCKENHOLZ, WETTER, A. D. RUHR, GERMANY. THE CRANE AT THE RIGHT IS OF 35 TONS CAPACITY AND 27 FEET SPAN, AND HAS AN AUXILIARY 6-TON HOIST. THE 6-TON CRANE AT THE LEFT IS OF THE SAME SPAN, AND HAS A SUSPENDED REVOLVING OUTRIGGER ARRANGEMENT, GIVING IT AN EXTENDED RADIUS OF ACTION

cranes stable, though lifting maximum loads across the rails.

According to present indications, we may anticipate that the big cranes of the future will consist of skeleton structures, in which the various members will be reduced to a minimum consistent with safety. Skeleton frames and jibs or gantries and legs will contain no solid plating and no heavy castings, but the latter will be reserved for the bases of balance cranes. The cost of building cranes will thus be cheapened, while the dead weight will be lessened materially.

As mentioned previously, electricity will have the effect of rendering possible the design of all kinds of unique types of cranes, as it has already done to a remarkable extent, and many old types will fall into oblivion accordingly, superseded by better kinds, accomplishing the same service in a more efficient and rapid manner.

Crane progress is already so rapid that the novelties of to-day will shortly become commonplace, and new forms will arise, to be in turn superseded by others.

COLD-FLOWED STEEL JOINTS

A NEW DEVELOPMENT IN THE ART OF EXPANDING TUBES

By Robert S. Riley

COLD-FLOWED steel joints, as described in the following pages, are a development in the art of expanding tubes, which opens up new possibilities in the connection of pipes by means of flanges. Expanded joints have heretofore been confined to boiler tubes in tube sheets and other such plain work which it was thought impossible to do in any other way. Nothing but the plain expanding was attempted, and that was done with crude portable expanders worked either by hand or by power. The work was satisfactory enough in most cases, and no need was felt for any further development of the art of roller expanding.

That pipe expanding by this method was done after the right principle is proven by its survival and further development. Other methods have been tried, notably that of internal pressure, by which the pipe is swelled out into recesses provided for the purpose. The weakness of this method lies in the fact that the internal pressure, although it exceeds the elastic limit and causes a permanent set in the tube, does not leave it pressed tightly enough against the containing body. In other words, the pipe contracts slightly on the removal of the pressure, and so invites a leak.

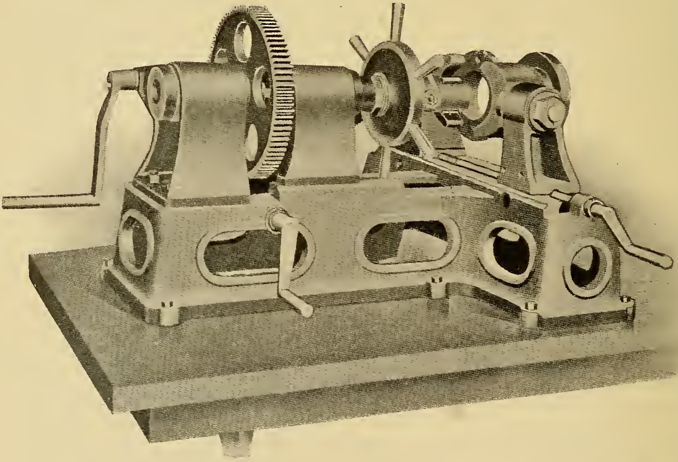


FIG. 1.—THE FIRST MACHINE BUILT FOR EXPANDING PIPES INTO FLANGES

The rolling principle, on the other hand, actually rolls out and lengthens the circumference of the tube so as to leave it in a state of compression by the flange or other containing body. The joint thus made is dependent on the pressure which tends to keep the surfaces in intimate contact, and this pressure is limited only by the ability of the tube to resist collapse or of the flange to resist bursting.

The action of the rolls on the tube is that of peening it out, just as a coppersmith peens out a soft copper pipe to fill a flange before he brazes it, or it may be compared more properly to the action of the rolls in a rolling mill. The metal in the pipe is compressed between the surface of the flange containing it on the one side and the revolving roller on the other side. Thus every part of the circumference of the pipe is subject to a squeezing or extrusion process which causes the metal to flow into tool marks or any crevice left in the interior of the flange. A slight expansion takes place in a longitudinal direction, but this is insignificant and not to be compared with the circumferential expansion. The beading or peening effect of the rolls in a circumferential direction is due to the concentrated pressure at one point, and this causes a flow of metal away from that point.

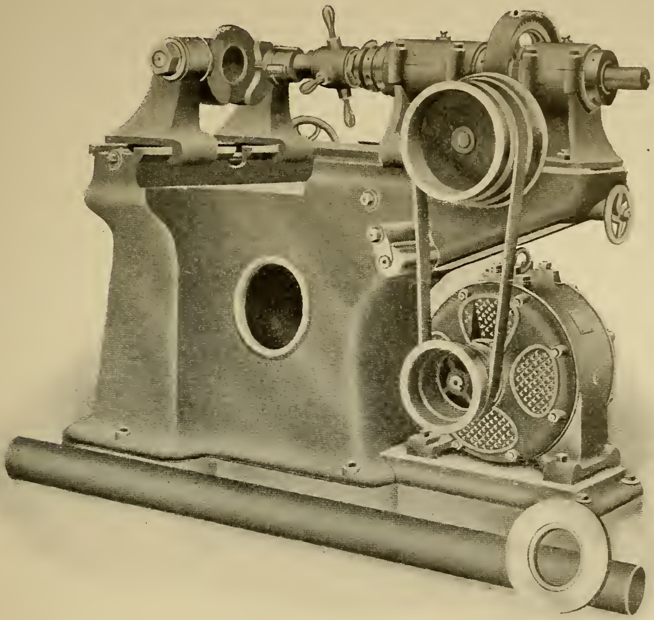


FIG. 2.—TYPE OF EXPANDING MACHINE WITH MOTOR AS USED FOR JOINTS UP TO 7½ INCHES DIAMETER

It is the purpose of the present article to give some idea of the extent to which this principle can be utilised for the purpose of connecting flanges to steel pipes, and of the machinery requisite for such work. The pioneer in this field of work is Luther D. Lovekin, of Philadelphia, chief engineer of the New York Shipbuilding Co., of Camden, New Jersey, who began experimenting in 1889 with the small machine shown in Fig. 1. Since then Mr. Lovekin and his associates have developed a series of strong

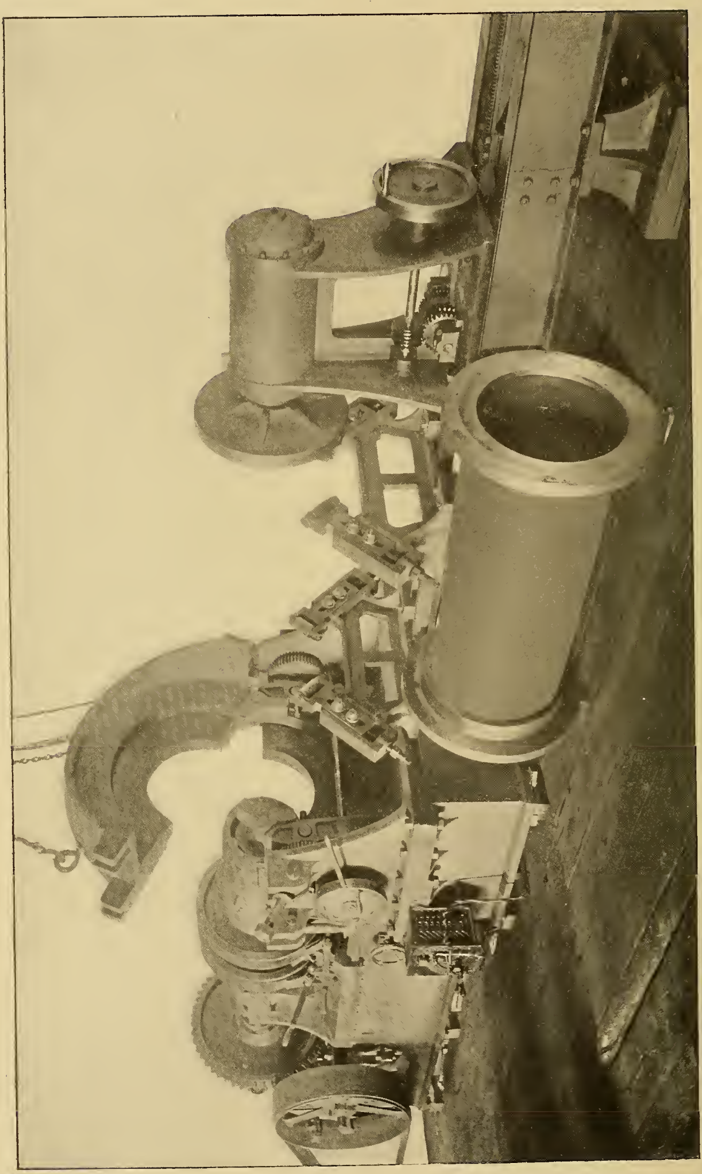


FIG. 4.—A LARGE EXPANDING MACHINE FOR STEEL PIPES UP TO 26 INCHES IN DIAMETER, SHOWING A 20-INCH PIPE ALONGSIDE WHICH HAD BOTH FLANGES EXPANDED, FLARED AND FACED COMPLETE IN ONE HOUR

and efficient machines capable of expanding pipes from 2 inches in diameter up to 48 inches, or, in fact, any size that it is possible to handle. For his invention and researches in this direction Mr. Lovekin has been recommended for the award of the Elliot Cresson gold medal by the Franklin Institute, of Philadelphia.

A general idea of the machines may be gathered from the illustrations accompanying this article. In their design many difficult problems have been solved, and the details worked out are interesting. The expanding tool proper is similar in appearance to the usual type of extending tool used for boiler tubes. Primarily it consists of three or more tapered steel rollers which revolve around a central roll or mandrel. The latter is tapered to correct the taper of the revolving rollers, and has a feeding mechanism by which it may be advanced or withdrawn while in operation.

It will be seen that the feeding device consists of a pin or key passing through the central mandrel, and threaded on its ends so that it engages with the threaded interior of the feed wheel. The rotation of this feed wheel relative to the tool then advances or withdraws the central mandrel. The central tapered roll is attached to this mandrel, but is left free to revolve independently of it by means of the friction thrust rings shown. The driving power on the rollers is applied through the shell or casing. This gives great strength and leaves the central roll free to adjust itself to allow for irregularities in the pipe.

The expanding machine for the smaller sizes is somewhat similar in appearance to a threading machine, as will be seen from Fig. 2, which represents a small machine for expanding pipes from 2 inches to 7 inches in diameter. The expanding tool of the required size is attached to the main spindle. This spindle rotates in a movable head, which can be run back and forth on the ways to engage with the pipe as desired. The driving power is transmitted to this spindle by means of a splined shaft, which slides in the worm-wheel, as shown. This worm-wheel receives its motion from the worm revolved by the attached motor or any other convenient source of power.

The pipe and flange are held by a pair of sliding heads which have their

FIG. 3.—AN EXAMPLE OF COLD-FLOWED STEEL JOINT. A SECTION OF THIS FLANGE HAS BEEN CUT AWAY TO SHOW HOW THE METAL HAS FLOWN INTO THE RECESSES

motion perpendicular to the spindle of the machine. They form a combination of faces and clamps for securing the flange in proper position, together with a pair of toothed jaws which act as a pipe vise for holding the pipe in position. The pipe has to be secured thus until it is expanded sufficiently to be held by the flange. The combination forms a very convenient arrangement for quickly clamping the pipe and flange in position for operation. Then the head is brought forward until the tool enters the pipe the required distance. The feed wheel is now held so that the motion of the spindle causes a relative rotation. This advances the tapered mandrel and spreads the small rollers until they engage with the pipe. The operation of expanding now begins. It is regulated by retarding the feed wheel relatively to the revolving spindle as desired. As the rotation is slow, this is very conveniently done by hand. The expanding mandrel can be withdrawn in a similar manner by accelerating the rotation of the feed wheel relatively to the spindle.

It is found in practice that the operation of expanding by cold rolling cannot be hurried to advantage. A rolling speed of from 15 to 20 feet per minute is all that is advisable. At a higher speed than this the metal of the pipe flakes off and appears to be abraded by the rapid motion of the rolls. It seems that the metal in the process of changing its form has to be allowed time to flow into the recesses provided for it. Fig. 3, representing a 5-inch pipe and flange with a section of flange removed, shows how completely the metal of the pipe has filled every crevice in the interior of the flange. Every tool mark in the flange is imprinted in the pipe, and the special recesses are completely filled by the extruded metal.

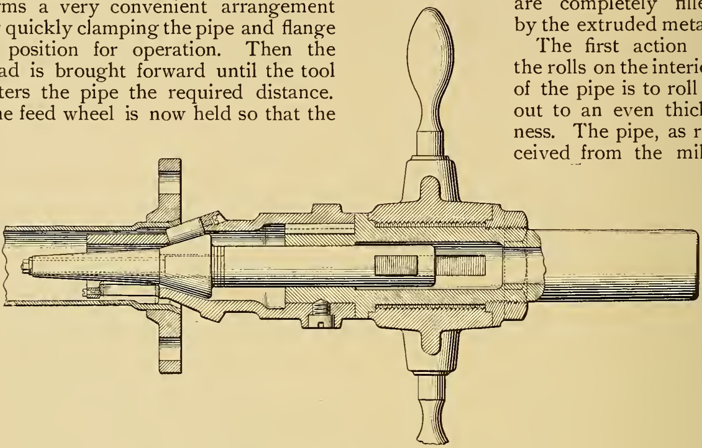


FIG. 5.—SECTIONAL VIEW OF A 4-INCH EXPANDING TOOL

The first action of the rolls on the interior of the pipe is to roll it out to an even thickness. The pipe, as received from the mill, frequently has ridges and a noticeable seam at the weld in the case of welded pipes. But such irregularities are soon rolled out under the action of the rolls, and the uniform extension of the circumference begins. The thickness of the pipe is thus reduced to some extent, depending upon the amount of rolling needed to make a complete fit in the flange. Actual tests show that this cold rolling strengthens the pipe per unit of cross-section, so that the expanded portion is left stronger than the original section.

After the expanding is completed the rollers used for expanding are collapsed by withdrawing the central mandrel by which they were distended, and the head of the machine is moved in further so as to bring the flaring rollers into action. These are distended by the same feeding device that operate the expanding

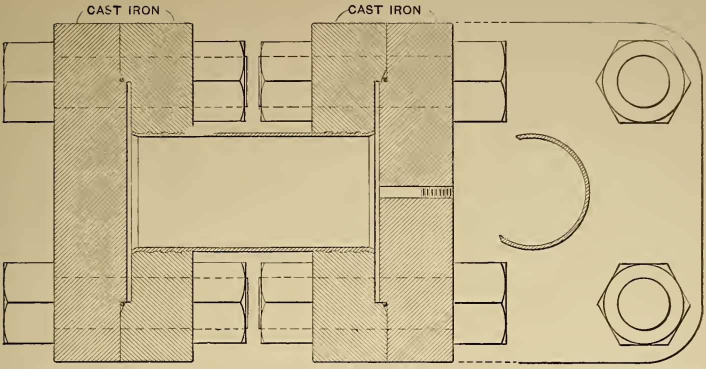


FIG. 6.—ARRANGEMENT OF A COLD-FLOWED STEEL JOINT WHICH WAS TESTED UP TO 5900 LBS. PER SQUARE INCH

mandrel. This action is clearly shown in Fig. 5, which represents a sectional view of a 4-inch tool.

The flaring is much more quickly done than the expanding. The rolls, acting on the end of the pipe, cause it to expand and flare out with an ease and quickness that would astonish one not accustomed to such work. It was supposed at first that there would be a tendency to split the ends of the pipes in the process of flaring them out cold, as described; but it is found in practice that no such thing happens. The greatest amount of work is expended on the pipe in the process of expanding to fill the flange, and this leaves it so perfectly filled out at the end that the flaring may be considered as merely a continuation of the expanding, but confined only to that portion of the pipe. This is borne out by a consideration of the method of operating the flaring rollers. They are not forced into the pipe along its axis, but are first inserted and then distended, just as they would be for expanding. The result is that the flared part of the pipe is very readily forced out to fill the flaring recess, and the continued rolling extends the circumference so that it fits just as tightly in the flaring recess as the rest of the pipe does inside the

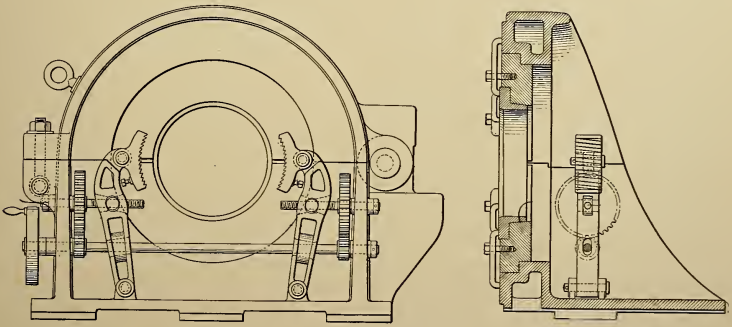


FIG. 7.—HEADS FOR HOLDING PIPE AND FLANGE DURING EXPANDING PROCESS WITH LARGE SIZES.

flange proper. After the flaring is completed, a facing-off tool is inserted in the slot at the end of the expander tool. This very quickly cuts off any fin or surplus metal left by the flaring and leaves it perfectly smooth and true and ready to be jointed up in place.

Thus, the whole process of expanding the pipe into the flange, flaring it over and facing it off true is all performed in one setting in the machine, and when the job is done, nothing describes it except the word "perfection." The interior is smooth and even, the flaring is uniform and neat, and the facing-off is true with the surface of the flange. Altogether, it is a remarkable achievement in the art of joining flanges to pipes.

This is further emphasised by the results of hydraulic tests made to determine the pressure which these joints would stand. Two short lengths of pipe, as shown in Fig. 6, were expanded into this special type of flange so that the liquid under pressure had free access to the ends of the pipe and hence had a good chance to begin a leak. The tests showed that a pressure of 5900 pounds per square inch was required before the pipe sprung away from the flange. The failure then occurred by the shearing of the ridges formed on the pipe where it had filled in the recesses of the flange. Such results show that, for all purposes within a reasonable range, the cold-flowed joint is absolutely secure and water-tight. This applies to all steam pressures used in the present era of steam engineering and any subsequent development that is likely to occur.

This type of expanded joint has a wide range of application. It does all that a threaded joint can do, and in some cases it has a marked advantage, which is most noticeable where the pipes are exposed to corrosion. For instance, in the ballast systems of modern ships, both merchant and naval, the salt water begins corrosion at the root of the thread cut in the pipe. About 30 per cent. of the pipe is cut away thus, so that the life of the pipe is really shortened in that proportion. This applies also to exposed pipes ashore, in many instances that will occur to the reader, such as

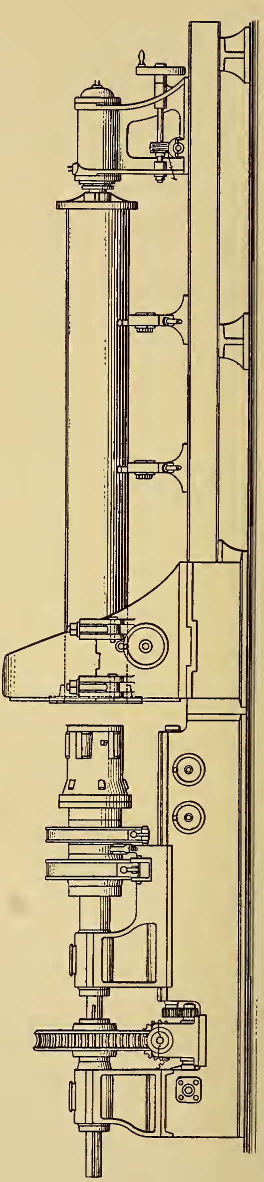


FIG. 8.—TYPE OF EXPANDING AND FLARING MACHINE FOR PUTTING FLANGES ON PIPES UP TO 26 INCHES DIAMETER WEIGHT, 25 TONS

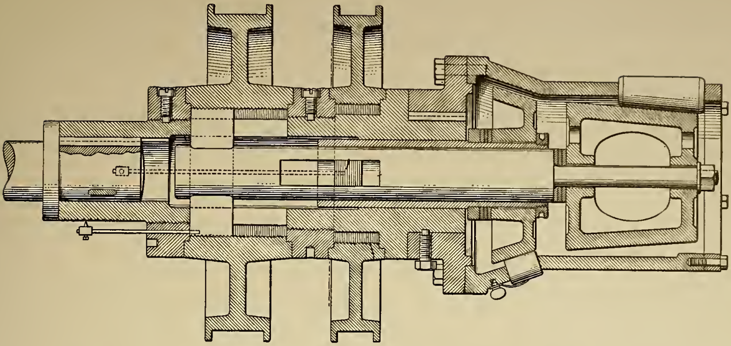


FIG. 9.—SECTIONAL VIEW OF 20-INCH TOOL FOR EXPANDING AND FLARING, SHOWING INDEPENDENT FEED FOR EXPANDING AND FLARING MANDRELS

acid water and drainage systems in mines.

This type of joint is expanded by hand after a fashion. It is done laboriously by peening out the interior of the pipe as far as can be reached by a hammer. But of course it cannot be "cold flowed" in the same sense that it is in the machine. The two jobs compared show up the hand work to great disadvantage. It is rough and uneven to the eye, and a test discloses the fact that the hand work is not capable of uniting the pipe and the flange in any way satisfactorily.

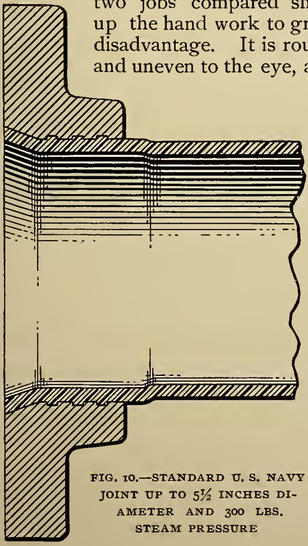


FIG. 10.—STANDARD U. S. NAVY JOINT UP TO 5½ INCHES DIAMETER AND 300 LBS. STEAM PRESSURE

A number of the machines have been installed in shops where the pipes are required to be fitted in this manner, and the difference in the quality and the quantity of the work turned out is remarkable. One man can do more on the machine than ten could formerly accomplish by the hand process, even by the most strenuous labour. In the tests required of the pipe it is found that no leak ever develops in the machine-made joint, whereas the hand-made joint leaks very frequently, and a second course of peening and calking has to be resorted to. These comparisons between hand and machine work in expanding have been applied particularly to iron and steel pipes in this article. It will readily be seen that they apply equally well to copper or any other material, though this is outside of the present discussion.

LARGE PIPES

Perhaps the most remarkable feature of the cold-rolled joint is in its application to the larger sized pipes. A machine is illustrated in Figs. 4 and 8 which expands pipes up to 26 inches in diameter with the same ease that the smaller machine will handle 2-inch diameters. The principle used is exactly the same. The tool is simply a larger size of the same type, though it has a separate feeding device for feeding the expanding and flaring mandrels which enables each to be operated independently of the other. Fig. 8 is a sectional view of a 20-inch tool. Many other modifications and special features have been designed to facilitate the operation of such large and heavy pipes. The flanges have to be handled by a crane, and are held by a powerful clamping head, which not only holds the face of the flange true, but provides a backing to reinforce the flange against the great pressure to which it is subjected during the process of rolling. This head is shown in Fig. 7. This backing is very necessary when it is considered how great a force is required to roll out a pipe ½ inch thick in such a manner as to fill out the recesses of the flange as described.

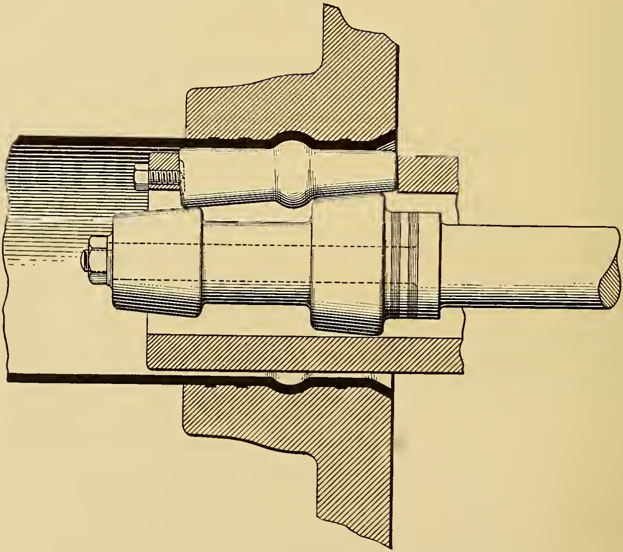


FIG. 11.—A SPECIAL JOINT

The pipe, after being brought to the machine by a crane, is pushed into the flange by a hydraulic ram, which is part of the machine. The head-stock is operated very conveniently by hand or by power through a system of friction clutches connected with the motor. The feed wheels for expanding and flaring are also operated automatically by friction bands under the control of the operator. Altogether, it is a very complete and powerful labour-saving machine which is destined to work a revolution in the method of connecting such large pipes.

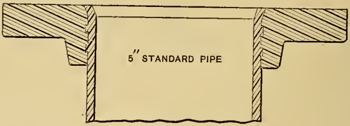


FIG. 12.—JOINT WITH DOVETAILED RECESSES

To those engaged in the manufacture and installation of systems of large piping the commercial possibilities of the expanded joints will appeal strongly. For effectiveness it stands second only to a welded flange, while the cost is far below that of any other known method. No size of pipe is too large, for machines may be designed to take in any diameter that can be manufactured. In fact, it would seem that the use of threads for connecting the larger sizes of pipes and flanges must shortly give way to this new method of cold flowing the metal of the pipe into the recesses of the flange. The excellence of the method for small pipe is very marked, although for such pipes threaded joints serve very well. On the larger pipes, however, say, 10 inches and over, the threading is expensive and the tightness is doubtful. For work over 16 inches it is necessary to do such threading in a lathe, and leaks are frequent even with moderate pressures. With the new method of cold flowing the work can be done at a greatly reduced cost, as compared to that of lathe work, and the nature of the joint is such that a leak is simply impossible, for the flange becomes an integral part of the pipe.

The sectional views of the types of joint possible under this method, and the other views of the work actually done, show to what an extent this art has been developed, and will suggest to engineers its great possibilities for the future.

The makers of the machinery here described are Messrs. Dienelt & Eisenhardt, Inc., of Philadelphia, while the Scully Steel & Iron Company, of Chicago, are the selling agents. The International Engineering Company, of Philadelphia, control the business in other countries.

THE DESTRUCTION OF NIAGARA FALLS

By Alton D. Adams

NIAGARA FALLS are doomed. Children already born may yet walk dry-shod from the main land of the New York State Reservation to Goat Island, across the present bed of the Niagara River. Certain economic, industrial and political forces are working strongly toward this result, and their course can be stayed only by the strong hand of the government.

In order to appreciate the nature and extent of these forces a general view of the geographical situation of the great cataract is desirable. Niagara River is the only natural outlet of the chain of four great lakes that discharge through it. Lakes Superior, Huron, Erie and Ontario lie between the United States and Canada, and the chain of lakes borders on eight of the American States. These States stretch from the Atlantic Ocean to the Mississippi River, and the beds of streams in some of them are from one hundred to several hundred feet below the water levels of the higher lakes. In Canada, Lake Huron and Lake Erie are so near to Lake Ontario that the development of great water powers by the construction of canals between either of the two former and the latter is practicable. Lake Superior has a surface elevation 601 feet above sea-level, and discharges into Lake Huron with a fall of about 20 feet.

Lake Michigan also discharges into Lake Huron, though with only a slight fall, and the water from all three of these lakes then goes to Lake Erie, where the mean surface elevation is 573 feet above tide water. A great difference in levels is the next feature, for the Niagara River, in crossing the strip of land, about twenty-seven miles wide, separating Lake Erie from Lake Ontario, drops 327 feet. At one point in its course it makes a perpendicular descent of 161 feet, and thus forms Niagara Falls, which the development of water power in both the United States and Canada is tending to destroy.

The falls owe their beauty and grandeur mainly to their great volume of water rather than to extraordinary height. Inasmuch as any diversion of the water of the Great Lakes reduces by just so much the amount that goes over the cataract, it matters little as to this result, whether water is taken from the lakes at Chicago or whether it is diverted from Niagara River near the upper rapids and then discharged into the gorge below the falls by means of canals, pipe lines or tunnels. Either process will dry up the falls if it be allowed to progress sufficiently far.

The possibilities of electrical transmission of energy have given great impetus to the development of water powers, and the many centres of population that may be reached by electric lines from the Great Lakes are a constant temptation to utilise their resources.

The greatest menace to Niagara Falls is the construction and operation of nearby power plants on either side of the river. At present two such plants are operating on the New York side, and the construction of three more on the Ontario side is well advanced; besides these, a smaller plant is already at work there. Each of these plants diverts water within 1¼ miles above, and discharges it a little below Niagara Falls. In view of the relatively small expense at which water power can be developed by plants located as these are, it seems probable that strong efforts will be made to increase indefinitely their number and capacity as the years roll on. These efforts must be resisted if Niagara Falls are to be saved.

Popular ideas as to a practically unlimited supply of water at Niagara Falls, based on the area of the Great Lakes and the width of the upper river, are incorrect. Great as is the area of the lakes, it is only their discharge of water that maintains the falls and is available for the development of power. When standing on the bank of Niagara River a mile or more above the falls, where the river is from six to seven thousand feet wide, one is impressed by the apparently inexhaustible volume of water; a trip of several miles down stream to the Whirlpool Rapids, however, where the width of the river shrinks to only 300 feet, does much to change this impression. Of course, the explanation of this differnce is that in the upper river the current is comparatively slow, while in the gorge it is very rapid.

According to the measurements of the United States engineers in the years 1899 and 1900, the normal discharge of the Niagara River for mean level in Lake Erie is 222,000 cubic feet per second, but this sinks at times to as little as 165,340 cubic feet per second. Great as is this amount, it is not beyond the capacity of water power developments like those now in progress about Niagara Falls to seriously diminish or even dry up the cataract. On a clear day, when the rising mist is blown up stream, a person near the centre of the new suspension bridge over the Niagara River, or at Inspiration Point, on the Canadian side, can readily see the American and Horse Shoe Falls. The former, with its straight crest and silvery curtain, is the fall of beauty; but the latter, with its great mass of dark-green water, seemingly rushing to the central point, its hidden foot, its loud explosion, and its fountain of spray, rising like white smoke high above all, is the fall of grandeur. Walk out on the rocks at the upper end of Goat Island where the water just up stream seems ever threatening to rush upon and wash away the adventurer, and the reasons for the differences between the falls below are evident.

On the right, toward the Canadian shore, are three-quarters of a mile of river with that dark, unbroken surface that indicates deep water. To the left, between the island and the New York bank, there is a channel only 400 feet wide whose rugged bottom raises the first line of breakers and carries all of the water that passes over the American Fall. How little of the river discharge passes on the New York side and how much on the Ontario side of Goat Island, perhaps no one can tell, though the former is estimated as low as 10 per cent. of the total; but certain it is that the American Fall now receives a comparatively small percentage of Niagara River water.

The international boundary, as defined by the treaty of Ghent, lies a full quarter of a mile toward the Ontario bank from the upper end of Goat Island, and yet it is estimated that at least three-fourths of the river discharge pass over the Canadian bed of the stream. It is reported that, in past years, when strong east winds have lowered the level of Lake Erie at Buffalo, the discharge of Niagara River has been so reduced that the channel between Goat Island and the New York bank has been dried up, and the American Fall has disappeared for hours at a time.

From these conditions it is evident that any large decrease in the discharge of Niagara River, either by diversion of water from the Great Lakes to the Mississippi River or to other rivers, or the creation of other channels for the flow from Lake Erie to Lake Ontario, or the construction of canals, pipe lines or tunnels between the upper river and the gorge below, must have a much greater tendency to destroy the American than the Canadian Fall.

It may be suggested, however, that the quantity of water already diverted, or likely to be diverted, from the Great Lakes or from Niagara River, is too small to make any notable change in the volume of water at either the Canadian or the American Cataract. This matter may be determined by comparing the volume of water already diverted, or likely to be diverted, with the total discharge of the river.

On the New York side of Niagara Falls the discharge tunnel of two of the power plants is said to have a capacity of 8600 cubic feet of water per second, and the open canal of the third plant has a capacity of 7700 cubic feet during the same time.

Across the river, in Queen Victoria Park, the hydraulic plants now under construction will divert as much as 32,100 cubic feet of water per second from Niagara River above the falls when they are in operation at full load. This estimate allows 12,000 cubic feet per second for one of these plants, 11,200 cubic feet per second for another, and 8900 cubic feet per second for the third plant. In the same park the power house of an electric railway and the pumping plant for town water are estimated to draw as much as 400 cubic feet per second from the river. The total capacity of the power plants, either operating or under construction on both sides of the falls, is thus about 48,800 cubic feet of water per second. As the minimum discharge of the river is 165,000 cubic feet per second, the power plants just named will divert over 29 per cent. of this flow when operating at full load.

But this is not the only drain on the water supply of the upper Niagara River. A few miles west of Buffalo the Welland Canal turns toward the Canadian shore of Lake Erie and runs about thirty miles to Lake Ontario, with a drop of about 327 feet. As all the water traffic between Lake Erie and the St. Lawrence River passes through this canal, its consumption of water for purposes of navigation alone must be considerable, but in addition to this a rather large amount is used for the development of power. Some of this power is used in factories along the line of the canal, but one large electric system with its generating station near St. Catharines is operated also with water from the canal. In this power house, which has only recently been completed, the wheels will pass about 1400 cubic feet of water per second when operating under full load.

If the new barge canal follows the line of the present Erie Canal from Buffalo to Savannah, a distance of 138.6 miles, this length of the new canal will be supplied with water from Lake Erie, as the corresponding length of the old canal is now, and it is estimated that the amount of water required for this purpose will reach 1237 cubic feet per second. The Chicago drainage canal is said to require as much as

6000 cubic feet of water per second. Under the so-called Love charter from the State of New York, work has been started on a canal that is to run from La Salle to the Devil's Hole, in the gorge below the Whirlpool Rapids; this canal will develop 150,000 horse-power. As the total head of water available between these points is about 300 feet, the quantity of water necessary to develop 150,000 horse-power of electricity will reach 7400 cubic feet of water per second. It is also understood that the company now operating with one tunnel at Niagara Falls has the right to construct and use a second tunnel similar to the one now in operation, so that the two together will give a discharge capacity of 17,200 cubic feet per second.

From the foregoing it appears that the total diversion of water from the Great Lakes above Niagara Falls, for navigation, drainage and power purposes, will reach as much as 67,400 cubic feet per second when all of the works now operating, or under construction, are carried out to their full, authorized capacity. Even this volume of water, which is 41 per cent. of the minimum discharge rate of Niagara River, does not include the water taken by the Welland Canal for purposes of navigation and for the development of power by local manufacturing plants along its banks.

In 1899, when the minimum rate of 165,340 cubic feet per second was recorded for Niagara River by the United States engineers, the capacity of canals and power plants was probably not sufficient to divert from the river and lakes above the falls more than 10,000 cubic feet per second, instead of the 67,400 cubic feet of water previously mentioned. It is evident, therefore, that the completion and operation of works now under way must reduce the discharge of Niagara River over the falls by nearly 60,000 cubic feet per second, or about 36 per cent. of the minimum discharge. Whether the channel between Goat Island and the New York bank of the river carries 10 or 25 per cent. of the total discharge, it cannot be doubted that the further diversion of nearly 60,000 cubic feet per second from the upper river and lakes will very materially reduce the flow over the American Fall.

The diversion of this great volume of water, even at the expense of some of the scenic attractions of the falls, is no doubt warranted by the great economic and industrial advantages that result from cheap power. It does not necessarily follow, however, that this process of water diversion should be extended until the values of existing power plants are depreciated by lack of water, the American Fall is dried up, and the Horse Shoe Falls are robbed of most of their grandeur.

Yet this is the tendency of the industrial and political forces now at work. Private enterprise cannot be expected to stay its progress so long as there is a profit to be made by the diversion of Niagara water, and legislatures continue to give away franchises or peddle them out for trifling considerations.

For those who wish to see a fair share of the beauty and grandeur of Niagara Falls preserved, and even for those who wish to protect the great investments that have been and are being made there for power development, the unfortunate feature of the situation is that several of the immediately adjoining states have power to authorise the diversion of water from the upper lakes and Niagara River. The diversion of this water thus becomes a matter of competition, not only between persons seeking their own profits, but also between different governments that wish to build up their respective territories or increase their revenues. Further complication arises from the fact that the American states have no power, under the Constitution, to enter individually into any treaty for the preservation of Niagara Falls, or for the regulation of the diversion of water from the upper river or the Great Lakes, because the treaty-making power is vested entirely in the Federal Government.

That the competition of legislatures to develop power with Niagara River is a very active force may be gathered from the fact that within recent years at least six companies have been granted franchises by the State of New York to divert water from the river, and that the government of Ontario has authorised the diversion of as much as 33,000 cubic feet of water per second from the upper river within four years. More than this, the Ontario authorities have employed an expert hydraulic engineer to investigate the possibility of locating more power plants that will take water from the upper river, and he has reported that an additional 30,000 cubic feet per second can easily be diverted at and near Queen Victoria Park.

Other territory besides that of New York and Ontario offers opportunities for the development of power with water from the Great Lakes. The Illinois River at Joliet, only about 25 miles from Lake Michigan, has a surface elevation of 531 feet, and after flowing 325 miles across the State of Illinois, drops to 405 feet at its mouth in the Mississippi River. It is thus possible, by diverting water from Lake Michigan and discharging it into the upper bed of the Illinois or Des Plaines River, to develop a great local power, and also to increase any water power that may be developed along this river in its course across the State. A large diversion of lake water has already been made by the Chicago drainage canal in the way just indicated, and the power station near Joliet is to have a main equipment of 24,000 horsepower. If franchises can be obtained from the Legislature of Illinois, there seems to be no good reason to prevent further diversions of lake water and the development of other great powers on the river named.

In Indiana, the Kankakee River, a branch of the Illinois River, lies only thirty miles south of Lake Michigan, and much power could be developed by diverting water from the lake and discharging it into this stream. With Lake Erie on the north, the Ohio River on the South, and numerous rivers crossing the State between them, Ohio would offer an attractive field for the development of power from lake water, were it not for the fact that a ridge of land, several hundred feet above the level of Lake Erie, crosses the State from east to west.

The part of Pennsylvania that borders on Lake Erie is so elevated that there seems to be no opportunity to divert its waters through that State. At numerous points along the seventeen miles of river front between Niagara Falls and the foot of Lake Erie, however, canals and pipe lines might be led off to the Niagara escarpment where the land surface drops nearly to the level of Lake Ontario; in this way water heads of about 300 feet might be obtained.

In Canada abundant opportunity exists for the development of great water powers by means of canals running from lake to lake. Georgian Bay, an arm of Lake Huron, lies at Toronto, within sixty miles of Lake Ontario, and even this distance might be reduced by a course through Lake Simcoe.

The surface of Georgian Bay has an elevation of 582 feet above tide water, or 336 feet above that of Lake Ontario. A canal from this bay to the lower lake would not only shorten the water route between Chicago and Duluth on the west and Montreal on the east by several hundred miles, but could be made to develop a water power limited only by the discharge of the three upper lakes,—Superior, Michigan and Huron.

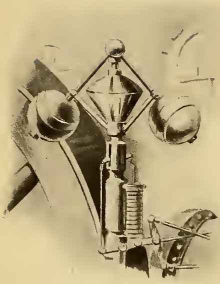
The strip of Canadian territory, about forty miles long and twenty-seven miles wide, between Lake Erie and Lake Ontario, might be crossed by any desired number of canals, substantially parallel with the Welland Canal and Niagara River, to utilise for power purposes the water head of 327 feet between these lakes. Even the Welland Canal may in the future be used to draw a far greater volume of water from Lake Erie for power purposes than it does at present.

From a consideration of the foregoing facts, it seems evident that the diversion of water from the upper lakes and Niagara River will be continued until the destruction of the American Fall, and possibly that of the Canadian Fall, result. Apparently the only hope lies in the intervention of the sovereign powers concerned.

THE MODERN HORIZONTAL STEAM ENGINE

AS EXEMPLIFIED IN BRITISH PRACTICE

By Leo H. Jackson



A VERY marked advance in the character of British-built horizontal steam engines has been discernible during recent years, and a review of the productions of some of the more prominent manufacturers will, it is believed, show practically uniform excellence of design. In almost every department of British engineering industry a similar movement is observable, as, for example, the typical express locomotive of to-day, as compared with the engines used for similar purposes ten years ago.

As an inspection of British steam engines will show, the demand for electric traction engines has resulted in effecting almost a revolution in the types of prime movers for actual station work. We find bigger, stronger, and heavier frames, adapted to withstand stresses and shocks previously unknown; very greatly increased wearing surfaces; the use of steam of far higher pressures, often with superheating; piston speeds beyond all precedent, and generally an all-round striving after the highest efficiency.

And it is well that it is so. America, Germany, Switzerland and France are fully up to date in their methods, and it behooves British builders to see that they are not behind them, even though handicapped by the inability of their workmen to grasp the fact that they are running a neck and-neck race with foreign producers.

With a view of taking stock, as it were, of the current types of British stationary steam engines, I shall give in the following pages illustrated descriptions of various designs regularly manufactured as standard types by leading British makers. To these I am greatly indebted for their ready response in the shape of photographs, drawings, specifications and information in general.

It is undoubtedly in the fixed or structural parts of the engine that the greatest advance has been made. The old-fashioned flat bedplate is as extinct for power purposes as the beam engine, and its successor, the tubular trunk bed, originally supported only by a foot under the main bearing and another under the cylinder, has been so strengthened and reinforced in various ways that it retains but little resemblance to its former self.

The essential element in an engine frame is rigidity. It is not sufficient that the metal should be disposed in a straight line between the cylinder and the bearing and carried by the feet at some distance above the foundation. The momentum of heavy reciprocating parts, rushing back and forth at six or seven hundred feet per minute, and the sudden shocks occasioned by the instantaneous throwing on and off of full load, as in direct-coupled generators, have demonstrated that the frame itself must have in it the element of weight, that it must lie low, and that it must also be in solid contact with the masonry foundation for very nearly its entire length. In being thus rigidly united to the massive stone and concrete foundation by numerous holding-down bolts passing through to the bottom of the masonry, the whole structure is solidly

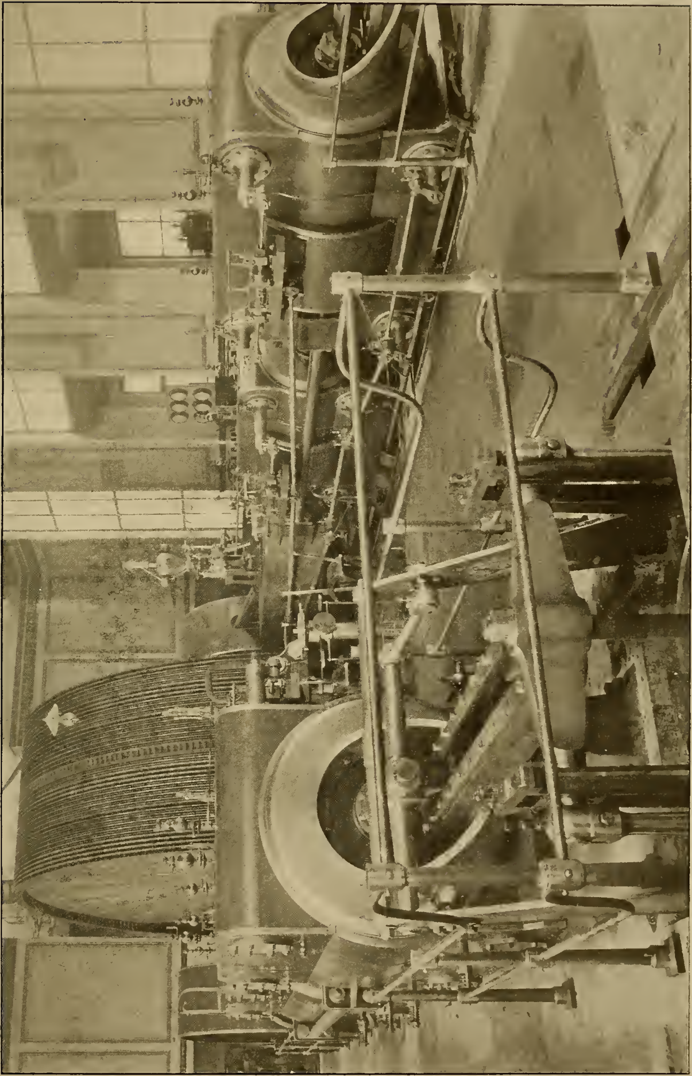


FIG. 1.—FOUR-CYLINDER TRIPLE-EXPANSION ENGINE BUILT BY MESSRS. YATES & THOM, BLACKBURN, LANCASHIRE

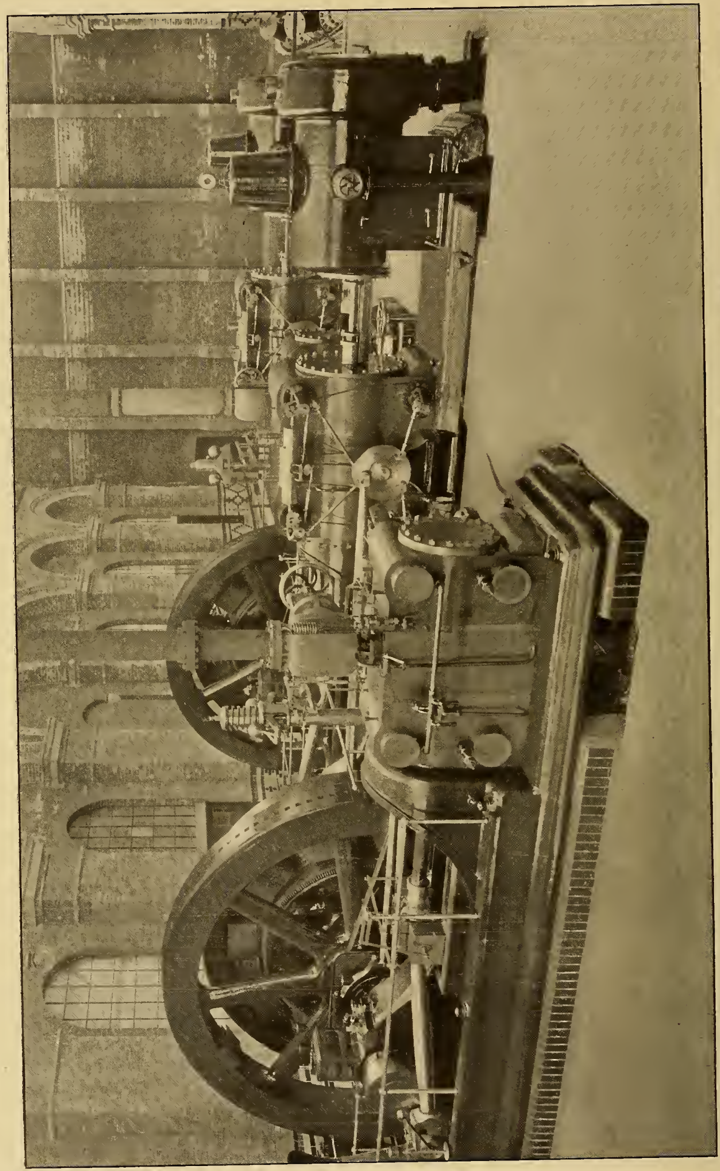


FIG. 2.—INTERIOR OF SOUTHAMPTON POWER HOUSE, SHOWING TWO 1000-H. P. CROSS-COMPOUND ENGINES, BUILT BY MESSRS. POLLIT & WIGZELL, LTD., SOWERBY BRIDGE, YORKSHIRE

FIG. 3.—INTERIOR OF THE FORMBY POWER HOUSE OF THE LIVERPOOL & SOUTHPORT ELECTRIC RAILWAY, SHOWING CROSS-COMPOUND ENGINES BUILT BY MESSRS. YATES & THOM, BLACKBURN, LANCASHIRE

bound into one mass, deep and strong and heavy enough to absorb all the shocks and jars incidental to the heaviest duty which can be imposed upon a steam engine, such as rolling mill or electric traction work. It will be understood, however, that reference is here made to the necessities imposed by severe conditions of stress, for it by no means follows that engines intended for the more peaceful pursuits of ordinary factory driving purposes should embody the massive proportions just described.

Many firms, indeed, make a point of specially adapting their engines to the work actually required of them, and the factory owner may go in full confidence to makers of railway or tramway generating sets, knowing that in the light of their experience a suitably designed engine will be furnished him. Examples of both these classes of engines were sent to the writer by a number of firms, in response to his request for representative types of each.

In every horizontal engine a wide and deep gap, forming the jaws for the reception of the main bearing, breaks the continuity of the frame. The importance of strength at this point is fully recognised, not only in the proportions of the massive " cap " which spans and embraces the jaws, but by the great spread of the base, which in large engines reaches several feet beyond the centre line of the shaft, the vertical part of the frame extending in a long slope downwards from the cap to the extremity of the flat base. Ample support is thus secured for the heavy weights, and the fore-and-aft stresses for which provision must be made. The strength and weight of the cap is, in fact, out of all proportion if its uses were simply confined to keeping the brasses together. Its principal function, however, is to keep the joints together. Indeed, so important is the need of making good the gaps in the frames that main bearing caps of cast or forged steel are coming into use.

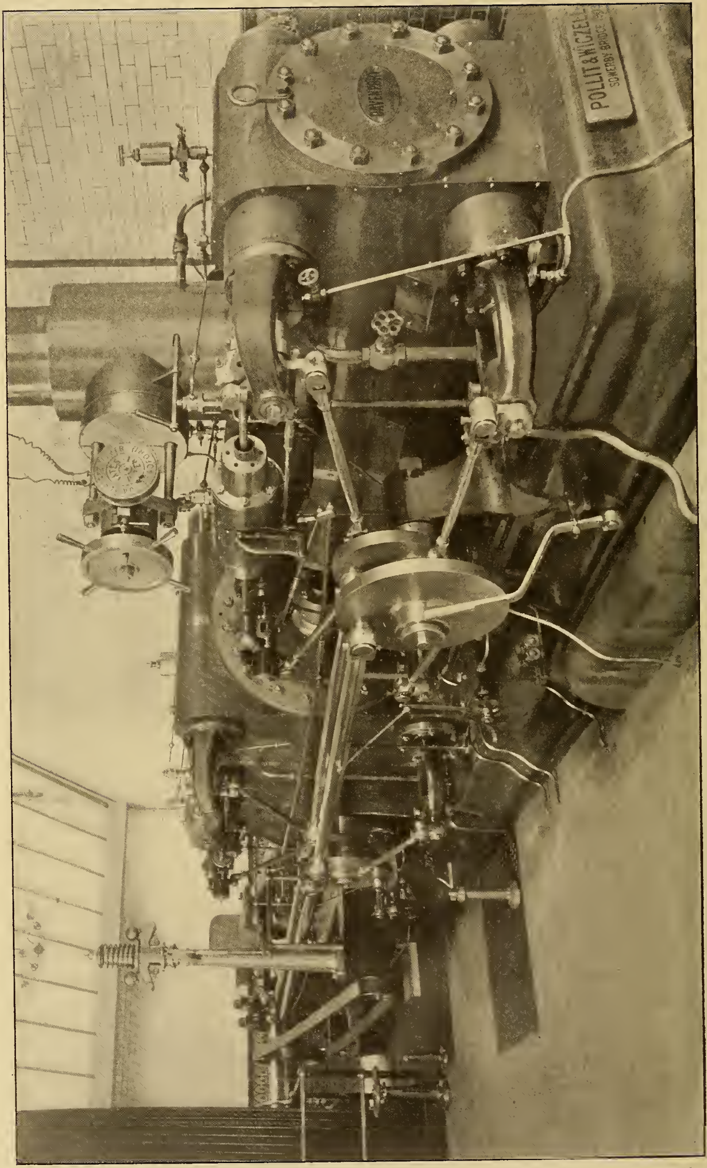


FIG. 5.—TANDEM MILL ENGINE OF 700 I. H. P. BUILT BY MESSRS. POLLIT & WIGZELL, LTD., SOWERBY BRIDGE, YORKSHIRE

The tubular trunk guide, which forms the connection between the bed proper and the cylinder, is usually of *C*-section, but sometimes both sides are open for convenience of access to the crosshead. In the latter case, when the engine runs continuously in the " outwards " direction, it is good practice to support the trunk at the centre of its length by a foot, bolted to the foundation, while for the heavier work this foot extends the whole length of the trunk. In a winding engine, or in other engines where the crosshead pressure is alternately upwards and downwards, the upper and lower guides must each be strengthened by a deep and heavy rib, care being taken that the minimum cross-section of metal in the trunk is adequate to resist the longitudinal stresses. The guide surfaces are invariably cylindrical, and their diametrical distance apart is governed by the ratio of connecting-rod to crank. In the best modern engines the end flange of the trunk does not make a steam-joint with the cylinder, a separate cover being either inserted between trunk and cylinder, or, in large sizes, fitted within the trunk, an internal flange being cast in the cylinder end for that purpose. Structurally speaking, the cylinder forms a continuation of the trunk, supported either by a foot under its whole length, or, in the case of cylinders fitted with Corliss valves, by a foot under each end.

So much for the frame. Let us now turn our attention to a matter on which there is not such a consensus of opinion,—the methods of admitting steam to, and exhausting it from, the cylinder. Virtually, the choice lies between two systems, the semi-rotating or Corliss valve, and the lifting or drop valve. The ordinary slide valve is out of the question for engines making any pretensions to high efficiency, for reasons which we need not discuss here.

The merest glance through the illustrations in this article will reveal the curious fact that locality exercises an important influence upon the choice of valve gear. In the north of England the Corliss type is strictly adhered to, with many variations in its manner of movement and release, while in the eastern counties of Lincolnshire and Essex there is a decided preference for the more modern system of drop-valves in the highest classes of engines. All of them, however, I believe, are prepared to supply the Corliss engine when required.

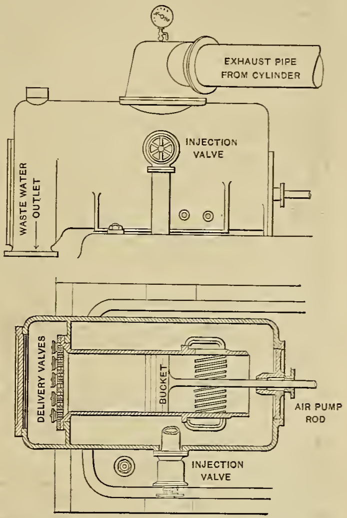


FIG. 4.—ELEVATION AND PLAN OF LONG-STROKE AIR PUMP MADE BY MESSRS. POLLIT & WIGZELL, LTD.

There is much to be said in favour of the semi-rotating slide valve, for that is what the Corliss valve really is; its wide and sustained opening of the port, its lightning rapidity of cut-off, the absolute simplicity of the valve itself, its large wearing surfaces, its compactness, and its small clearance spaces,—all these have for fifty years and more popularised it in every part of the world where steam engines are made or used. But it no longer holds undisputed possession of the field. On the Continent of Europe the drop valve has completely ousted it, and in British practice the use of this is rapidly extending. Sliding surfaces are not well adapted for use with superheated steam, but the latter appears to have

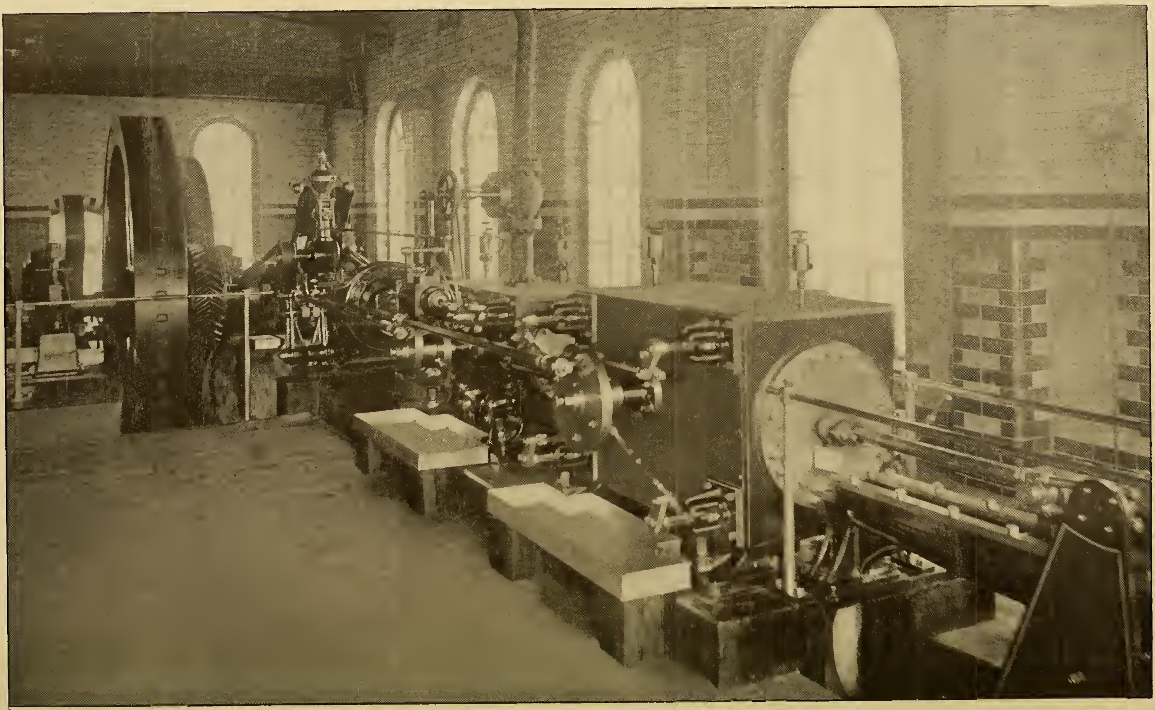


FIG. 6.—THE YORKSHIRE TYPE OF MILL ENGINE AS BUILT BY MESSRS. FOWLER & CO., LTD., LEEDS

little effect upon the narrow surfaces of the double-seated, conical drop valve. This is probably the prevailing cause for the preference now given to the latter system, although there are other reasons. For example, there is the striking simplicity and comparative silence of the lifting and releasing motions, as compared with the mechanism of the Corliss valve. The possibilities in the way of reducing the wasteful effects of clearance by skillful designing in the drop-valve system have hardly yet been reached, but already it has outclassed the Corliss in this respect.

It is in these two particulars, the frame or bed of the engine and the steam distributing mechanism, that the progress of the last few years is most apparent. For the rest, it seems that a careful examination of the various types here illustrated will show what a striking amount of care and thought has been expended in all details tending to ensure the running of the engines for long periods without a stop. Of these details may be mentioned the continuous lubrication automatically supplied to the more important working parts, by circulating a certain quantity of oil through the bearings by reciprocating or rotary pumps; also the general use of metallic packing for piston rods and valve spindles.

In Fig. 3 is shown the power plant in the Formby generating station of the Liverpool & Southport Electric Railway. Here may be seen four sets of engines built by Messrs. Yates & Thom, of Blackburn, Lancashire. These are cross-compound Corliss engines direct connected to 1500 KW generators making 75 revolutions per minute. The cylinders are 32 and 64 inches in diameter, with a stroke of 54 inches. Each engine is capable of giving out nearly 2900 horse-power continuously if required, the normal output being 2310 horse-power. The cylinders are built up, with separate ends containing the valve boxes for the double-ported Corliss valves. The trunk beds are so arranged that they bear continuously upon the foundation, and are separate from, but securely attached to, the main bearings. The pistons are of cast iron, fitted with Ramsbottom rings, the low-pressure piston being banded with white metal to reduce the wear and friction to a minimum. The weight of the pistons is largely carried by the crossheads and tail-rod guides.

Each engine is fitted with two Edwards air pumps driven from the low-pressure tail-rod, working a jet condenser with diverting valve, so that the exhaust can be instantly turned direct to atmosphere when desired. A complete service of continuous lubrication is provided, and every care which experience can suggest has been taken to ensure uninterrupted running for long periods.

It is worthy of note that the whole of this plant, together with sixteen Lancashire boilers, each 8 feet 6 inches in diameter and 32 feet long, were designed, built and erected within twelve months by Messrs. Yates & Thom,—a very convincing proof of the capabilities of this enterprising firm.

Messrs. Yates & Thom were also the builders of the remarkably fine horizontal, triple-expansion engine shown in Fig. 1. In this there are four cylinders, arranged in double tandem order. The high-pressure cylinder is 23 inches in diameter, the intermediate cylinder is 34 inches in diameter, and the two low-pressure cylinders are each 42½ inches in diameter, the stroke being 66 inches. The boiler pressure is 180 pounds, and the economical load is 1700 I. H. P., although upwards of 2000 I. H. P. is easily obtained. The high and intermediate cylinders are steam-jacketed, and there is a reheating receiver fitted between them. It will be noticed that the cylinders are very handsomely finished off by planished steel lagging with polished corners and mouldings, and that the whole engine bears the unmistakable stamp of good design and construction.

The engine frames are of the cylindrical trunk pattern, the material being so disposed that all the stresses are taken up within the bed itself independently of the foundations, which, nevertheless, are of the most massive character. The two low-pressure cylinders are directly

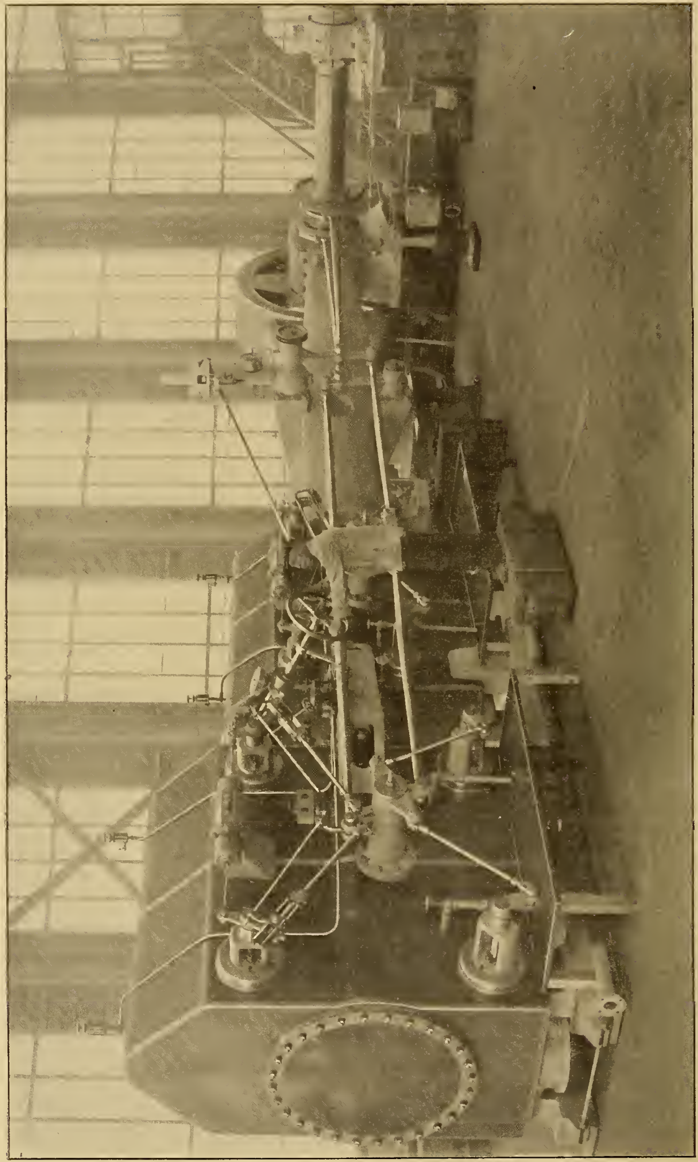


FIG. 7.—THE VALVE GEAR SIDE OF THE ENGINE SHOWN IN FIG 8.

connected to the trunk frames by steel tie rods passing on each side of the smaller cylinders in front of them, thereby relieving the latter of all the low pressure stresses, and permitting independent and free expansion and contraction in both pairs.

The bearing surfaces in the shaft, crank-pins and piston-rod guides are designed throughout on the most liberal scale, and, as forced lubrication is adopted, it may be taken for granted that the wear of these important working parts will be inappreciable for many years to come. The vertical air pumps, situated behind the low-pressure cylinders, are worked by bell crank levers from the tail-rods, the air pump rod having a crosshead and guides with side connecting-rods leading downwards to the bell cranks. By this means the pumps are brought nearly up to floor level while retaining the advantages of long connecting links.

All the valves controlling the engine are brought together, and in cases of emergency or accident the engine can be stopped from any part of the mill. The governor is of the Porter pattern, and is very quick and sensitive in action. The valve gear is of the improved "Dobson" type, and actuates Corliss valves. It will be observed that there is no wrist-plate, the exhaust valves being worked directly from a continuous line of eccentric rods. The admission valves are actuated and tripped through the medium of a long cast iron slipper moved by the eccentric rod and carrying the trip motion with it until released by the action of the governor.

A very important detail of this engine is the "knock-off appliance"; this becomes active and stops the engine in the event of any accident occurring to the governor, which might cause it to lose control of the engine.

This engine represents the standard practice of Messrs. Yates & Thom, and is a very fine example of the highest class of Lancashire engine builders' work.

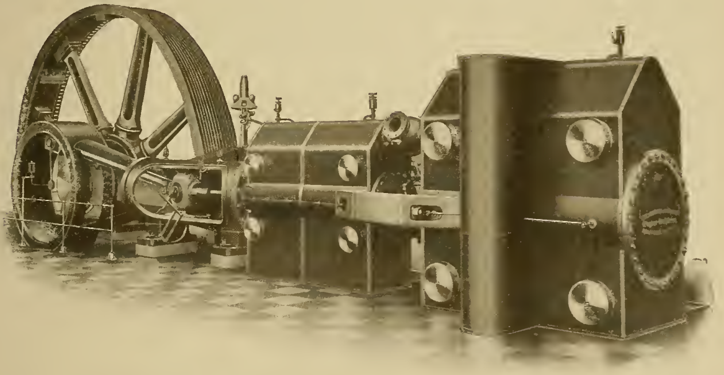


FIG. 8.—TANDEM COMPOUND STAMP MILL ENGINE BUILT BY MESSRS. COLE, MARCHENT & MORLEY, LTD., BRADFORD, YORKSHIRE

Messrs. Pollit & Wigzell, Ltd., of Sowerby Bridge, Yorkshire, are the makers of the two 1000 horse-power, cross-compound horizontal engines shown in Fig. 2. This illustration shows the interior of the power house for one section of the Southampton Corporation Tramways.

The frames of these engines are an interestng departure from the almost universal trunk-bed style, being somewhat on the lines of the familar gas-engine bed, with the addition of a pair of flat planed slides on which the cross-

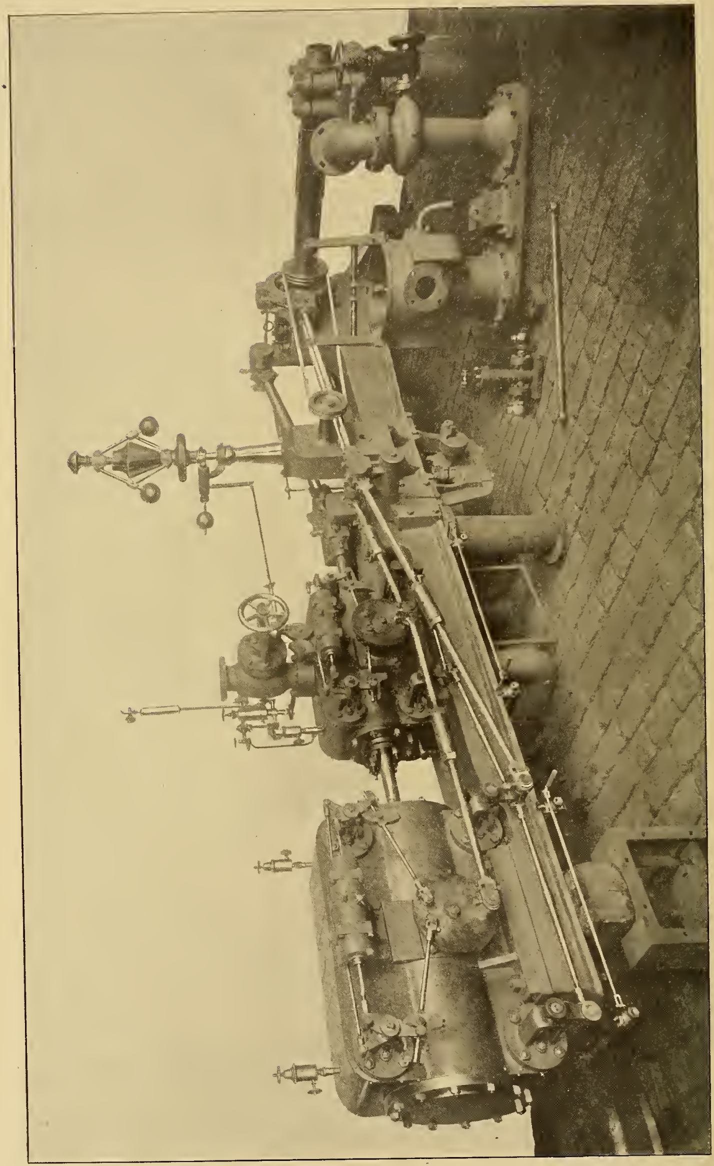


FIG. 9.—CORLISS ENGINE BUILT BY MESSRS. WOOD BROTHERS, SOWERBY BRIDGE, YORKSHIRE

head blocks work. The strength and solidity of the design is noticeable, particularly in the shape of the casting on each side of the main bearing, the jaws being obviously strong enough to dispense with the usual overhanging cap spanning the plummer block and acting as a tie. The cylinders, which are fitted with Messrs. Pollit & Wigzell's trip gear of the Corliss valves, are 19 and 39 inches in diameter, with a stroke of 42 inches. The fly-wheels are each 14 feet in diameter, weigh 20 tons, and make 100 revolutions per minute. The steam pressure is 180 pounds per square inch, superheated, and all the piston rods and Corliss valve spindles are, therefore, fitted with metallic packing. The engine nearest the spectator is provided with the Whitehead governor, and the further one with the Hartnell governor, with a view of testing one against the other under identical working conditions.

The single-acting air pumps with which these engines are fitted were illustrated in CASSIER'S MAGAZINE for November, 1904; but it may here be well to briefly describe this very successful arrangement, which is shown in Fig. 4. Its special peculiarity consists in there being no inlet valves. During the greater part of the outstroke the bucket creates a vacuum in the barrel, into which, the moment the diagonal inlet slots are uncovered by the passage of the bucket, rush the condensed water and its accompanying air, which are rejected upon the return stroke. In the engines just described the bucket travels 700 feet per minute, and yet the condenser works without noise or shock.

Engines of the design illustrated in Fig. 2 are made by Messrs. Pollit & Wigzell in sizes from 100 to 2000 indicated horse-power. They have just supplied to the Halifax Corporation for tramway purposes two similar engines of 1600 I. H. P. each.

In Fig. 5 is also shown a 700 I. H. P. tandem mill engine built by the same firm. The low-pressure cylinder is mounted near to the crank and the high-pressure cylinder behind, with central piston rod. Both cylinders are fitted with patent trip gear to the Corliss valves, the high-pressure gear being controlled by the Whitehead governor, and the low-pressure gear regulated by hand. The diameters of the cylinders are 17 inches and 34 inches, with a 5-foot stroke. The fly-wheel is 20 feet in diameter, and is grooved for eighteen 1⅝-inch ropes; it runs at 70 revolutions per minute, and weighs nearly 25 tons.

The steam pressure is 160 pounds per square inch. All the stuffing-boxes, both for piston rods and Corliss valve spindles, are supplied with metallic packings, and the engine is fitted throughout with continuous lubrication, so that no stoppage from one week's end to another is necessary. The air pump is of the vertical, single-acting type placed beneath the engine bed, and is actuated through bell crank levers from the main crosshead. Messrs. Pollit & Wigzell state that they have made many such engines of all sizes up to 1050 I. H. P.

The 1000 I. H. P. tandem compound engine shown in Figs. 7 and 8 was built by Messrs. Cole, Marchent & Morley, Ltd., of Bradford, Yorkshire, to the order of the Witwatersrand Deep Mining Company, in South Africa, for driving a stamp mill continuously day and night. The cylinders are 21 and 42 inches in diameter, and have a 60-inch stroke. The fly-wheel is 22 feet in diameter, makes 65 revolutions per minute, and is grooved for twelve 2-inch ropes, although the power is actually taken off through a line shaft directly coupled to the crankshaft of the engine. This arrangement for duplicate methods of driving is to enable the engine to occasionally take the place of an adjacent engine by putting on the driving ropes, which are always kept in readiness.

An independent surface condensing plant, not shown in the illustrations, but also made by Messrs. Cole, Marchent & Morley, is used in connection with this engine. It should also be mentioned that a double-cylinder barring engine is installed for turning the main engine when out of steam, or when putting on the driving ropes. Thus it will be seen that the installation is a very complete one. The normal load is 855 I. H. P., with a maximum of 1000 I. H. P. when condensing. The working pressure is 140 pounds. The steam is moderately superheated.

From Figs. 7 and 8 both sides of the engine may be seen and a fair idea obtained of its construction and details. The frame is of the trunk type, well supported by feet at both ends of the guides. The cylinders have the Corliss valve seats cast in one with them; this is done to avoid steam joints at the cylinder ends, as well as for ease of examination and good drainage. To obviate unequal expansion in the metal of the cylinders owing to the superheated steam, the cylinders are, as far as possible, plain cylindrical castings, with the steam and exhaust connections made separately and bolted on.

Turning to the details of the engine, the Corliss valve gear is of Messrs. Cole, Marchent & Morley's improved Spencer-Inglis pattern, controlled by a Hartnell governor. All the rods, from the main connecting-rod to the valve gear links, are of the solid-end type, with wedge and screw adjustments. The engine is fitted throughout with automatic lubricating arrangements, there being a continuous flow and return of oil through the principal bearings, and positive mechanical oil-feeds are fitted to the cylinders so that under ordinary circumstances the engine will run for weeks at a time without stoppage.

Messrs. John Fowler & Co., Ltd., of Leeds, are, perhaps, best known as manufacturers of winding and hauling engines, including all sizes up to the very largest. Nevertheless, they make also Corliss cross-compound and tandem mill engines up to any size required, and in Fig. 6 is shown one of the latter class of their standard construction, fitted with a surface condenser worked by a rocking arm from the tail-rod. The engine drives, as shown, through helical open gearing, and, while calling for no special remarks, is a thoroughly good example of what may be called the Yorkshire type of mill engine.

Before taking leave of north country steam engine practice, the firm of Wood Brothers, at Sowerby Bridge, Yorkshire, must not be overlooked, as they have for years made a specialty of Corliss engines in sizes up to 3000 horse-power, and have made many improvements in the cylinders and valve gear which ensure the best economy and reliability in working. Fig. 9 illustrates the general design of one of their products.

One special feature in Messrs. Wood's trip gear for Corliss engines is that all the working blocks are capable of being reversed, thus giving a double life to the parts usually subject to the greatest amount of wear. Messrs. Wood have constructed some of the largest mill engines in use, and have a reputation for first-class workmanship and the highest economy in the production of power.

To be concluded in the April Number

Current Topics

No one is surprised nowadays to come across a story with which he has been familiar time out of mind,—disguised or varied more or less the story may be, but still recognisable. Matters of scientific interest are not excepted in this regard, but the stories in this case usually concern a device or formula reinvented or rediscovered; or they accredit the discovery or device to another than the real inventor. A story of this kind that is now going the rounds relates to a so-called new poison, many times more powerful than prussic acid, which has been discovered by an English chemist, who has named it cyanide of cacodyl. This is a white powder which, when exposed to the air, gives forth a slight vapour, the inhalation of which means instant death. A combination of potassium acetate with white arsenic, producing a fuming liquid called cacodyl, was made a number of years ago by a French chemist, and this, so the item states, the English chemist has further combined with cyanogen, a radical of prussic acid, producing the deadly substance named, the most potent so far in the records of chemistry. For the sake of accuracy, it may be noted that the liquid referred to was formerly called " the fuming liquid of Cadet," and was discovered by him some time in the eighteenth century. Bunsen's researches before the middle of the nineteenth century showed that this was the oxide of a peculiar complex radical which he named " kakodyle." Further, the cyanide of kakodyle is described in most of the old text-books on chemistry, and reference may, for instance, be found to it in Silliman's Chemistry, 1848, in whch it is stated to be " fearfully poisonous." So much for this new poison.

ANOTHER instance of this type of story, now current in the news and technical press, is one which gives to Lord Kelvin the credit of being the original inventor of the mirror galvanometer, the instrument which he adapted so cleverly and beautifully to the operation of the first Atlantic cables. Lord Kelvin's fame is so well established that it stands in no need of that which belongs to others. The story goes that one day while Lord Kelvin, then Professor Thomson, was experimenting, his eye-glass fell off and swung in front of the magnet, reflecting its movement, and instantly the idea of the mirror galvanometer suggested itself. " Thus," adds the narrator, " a monocle may be credited with a direct effect on modern science.'' It is a pity to spoil so interesting a story, and more especially to deprive the monocle of the honour of this beneficent effect on modern science, but the fact is that Gauss and Weber, in 1833, in the operation of their electric telegraph system, used the reflections from a mirror attached to a magnet by which to read arriving signals; while Weber's reflecting galvanometer employed the same principle at a time when young William Thomson was hardly in his teens. To a student and reader like Professor Thomson, the falling of his monocle, if he wore one, was not necessary to suggest the reflecting galvanometer.

As somewhat apropos of this general subject, it may be mentioned that a statement, which may perhaps give credit where it is not altogether due, has been started on its rounds within the past few weeks to the effect that a telegraph repeating relay that admits of the direct reception and transmission of currents from one line to another, with marvelous results in increasing the distance to which signals can be transmitted telegraphically, has been recently introduced upon the lines of the Western Union Telegraph Company in this country, as though this were a device of recent origin. In point of fact, the method of directly receiving and transmitting currents from one line to another by means of a direct repeating relay has been employed in the operation of the Wheatstone automatic duplex system on the Western Union lines for over twenty years, on circuits extending from Chicago to San Francisco, and the same method has been in use in Great Britain for possibly forty years. The only imaginable difference between the use of the direct repeating relay now proclaimed as novel, and for the recent application of which to telegraphy some honour is claimed in certain quarters, and its previous use for over twenty years on the Wheatstone automatic system, is that in the latter instance it has been utilised in comparatively rapid signaling, while in the former case it is presumably applied to lines on which manual transmission of signals is employed. If it has been supposed that some novelty consists in applying a direct repeating relay to manual transmission lines, which relay hitherto had been applied to only high-speed telegraph transmission, the supposition is hardly tenable in view of the fact that direct repeating relays, by means of which currents were transmitted from one line to another, were used in manual transmission by Morse over sixty-five years ago. Direct repeating relays in automatic telegraph repeaters have been in use also for simplex working in Continental Europe for twenty-five or thirty years with excellent results. It would appear, therefore, that any claim for honour for so tardy an application of this well-known and admittedly high-efficiency direct-repeating relay to manual transmission should at least be accompanied by an apology to the stockholders of the above-mentioned telegraph company for the technical or official oversight that has withheld this acknowledged betterment to the service for so many long years.

It is somewhat difficult to determine the exact manner in which a name can be so generally and erroneously applied to a device or system as it is in the case of the arrangement which for many years has been termed the ''Wheatstone Bridge,'' after the well-known inventor, Sir Charles Wheatstone. This arrangement was in reality due to Dr. Christie, but having been applied by Wheatstone to the measurement of electrical resistances, his name has become attached permanently to it, notwithstanding that Christie's original work in connection with the device has been pointed out over and over again.

The Corliss valve gear idea for locomotives is once more in evidence. Ever since George Corliss himself, about fifty years ago, equipped a locomotive with valves and gear of his pattern, similar experiments have been made by others, particularly French locomotive engineers; but in every instance the "trappy" character of the gear, to use a bit of Yankee slang, proved fatal to its continued use. There were altogether too many breakdowns and too big a repair account to offset the good points of the mechanism. The latest Corliss locomotive venture is being made in the United States on the Chicago & Northwestern Railroad, two locomotives on that line having been equipped with what are known as Young rotary valves and gear, named after the patentee, Mr. O. W. Young.

Much interesting and practically valuable information on the making and uses of concrete is given in a paper read some time ago by Henry W. Edwards before the American Institute of Mining Engineers. Among other things, Mr. Edwards says that concrete should never be dropped from a height for the reason that, invariably, the mortar and stone separate, and weakness results. For example, if it be necessary to get to the bottom of a deep excavation, it pays to lower the concrete in a tub or bucket, or if the excavation be large, to lower the wheelbarrow itself. In a case of this kind it pays best to disregard the wheelbarrow entirely, mount the mixing gear close at hand, erect a temporary derrick, which will command not only the mixing gear, but the area of the whole excavation, and then carry on the work with a tub.

As to the seasoning of concrete, and the recurring question as to how long a period should elapse after laying the concrete before it should be loaded, Mr. Edwards says that the answer depends on two conditions:—First, the season of the year, and second, the use to which the work is to be put. In summer time or in a dry, winterless climate, concrete rapidly reaches its full strength, and it is best to retard its too rapid hardening by covering it with a layer of sand or dirt, which is frequently moistened. Under these conditions the concrete may receive its load in a week or ten days, or even sooner, if it is entirely below ground where the mass has no opportunity to spread. In more northerly localities where the winters are cold, concrete, if built late in the autumn or in the winter, will not be really solid until warm weather has set in. The influence of temperature on the hardening and seasoning of concrete is very distinct and must be taken into account. The second condition which has to be considered before applying the load is the purpose of the structure. If the load be applied gradually, as, for example, in the case of a retaining wall to be gradually filled up from behind, loading may commence after a week or two of warm weather. It would be unwise, however, to set an engine to work on a green concrete foundation, although there would be but little harm in mounting it in its place after a week or two have elapsed. Thin work, such as floors and flues, naturally solidify much more rapidly than heavy masses. Mr. Edwards tells of having used a floor on the third day after its completion, merely taking the precaution to place a few old boards where there would be the most traffic. Unless in winter, the cribs can be removed on the third day. In heavy masses, hardening and seasoning will go on for many months. Beyond delaying the setting until warmer weather, frost, even if the wet concrete itself be frozen, does not appear to be in the least injurious.

One of the uses of concrete spoken of by Mr. Edwards in the above-mentioned paper was the making of flues for metallurgical furnaces, and in the resulting discussion Mr. Edwin H. Messiter told of one such flue designed by him with walls from 2¼ to 3¼ inches thick, made by plastering cement mortar on expanded metal lath. In regard to the effect of sulphur dioxide and furnace gases on the cement, Mr. Messiter found that in certain cases this is a matter which must be given very careful attention. Where there is sufficient heat to prevent the existence of condensed moisture inside of the flue, there is apparently no action whatever on the cement, but if the concrete is wet, it is rapidly rotted by these gases. At points near the furnaces there is generally sufficient heat not only to prevent internal condensation of the aqueous vapour always present in the gases, but also to evaporate water from rain or snow falling on the outside of the flue. Further along a point is reached where rain water will percolate through minute cracks caused by expansion and contraction, and reach the interior even though internal condensation does not occur there in dry weather. From this point to the end of the flue the roof must be coated on the outside with asphalt paint or other impervious material. In very long flues a point may be reached where moisture will condense on the inside of the walls in cold weather. From this point to the end of the flue it is essential to protect the interior with an acid-resisting paint, of which two or more coats will be necessary. For the first coat a material containing little or no linseed oil is best, as the lime in the cement is said to attack the oil. For this purpose Mr. Messiter used ebonite varnish, and for the succeeding coats, durable metal coating. The first coat will require about one gallon of material for each 100 square feet of surface.

In order to reduce the amount of flue subject to condensation, the plastered flues have been built with double lath having an intervening air space in the middle of the wall. In building thin walls of cement, such as flue-walls, it is particularly important to prevent them from drying before the cement has combined with all the water it needs. For this reason the work should be sprinkled freely until the cement is fully set. Much work of this class has been ruined through ignorance by fires built near the walls in cold weather, which caused the mortar to shell off in a short time. Besides the saving in cost of construction which the concrete-steel flue makes possible,—about 50 per cent.,—there is the advantage that such a flue is tight as compared with one of brick. There is nearly always a serious leakage through the walls of a brick flue.

The establishment of a Fessenden wireless telegraph circuit was recently commenced, designed to extend from Para to Manaos, on the Amazon River, —a distance of 1000 miles,—with relaying stations at frequent intervals along the river. The intention, in fact, is to supplant the present submarine cables that follow the course of the Amazon River between the points named, because of the unreliability of these cables, owing to injuries and breaks due to the swiftness of the current, and also, it is said, to a fondness which the alligators that infest that river have developed for submarine cable as an article of diet. Thus far but two stations have been established, namely, at Breves, a suburb of Para, at the mouth of the Amazon, and at Pinheiro, further up the river. In all about twelve stations will be established between Para and Manaos, and it is expected that the circuit will be ready for business in about three months; but at present not any of the stations are in commercial operation.

The electric fan possesses possibilities additional to those of providing comfort in the hot-weather period. Mention has previously been made in these columns of the use of such fans in show-window compartments in cold weather as a means of preventing frosting of the glass, but a more recent suggestion is that of turning the air current from the fan on steam and hot water radiators as a means of increasing their efficiency. We get, thus, a modified form of hot-blast heating apparatus of the kind with which every heating and ventilating engineer is familiar. Where, as is often the case in dwellings, the radiator is a bit too small to properly warm its apportioned space, this improvised fan service is said to have proved a most satisfactory heating auxiliary, and, indeed, there is good reason why this should be so. In connection with the American hot air furnace heating system, in which the warmed air is led from the furnace in the cellar through ducts to different parts of a dwelling, the electric fan likewise is recommended as an adjunct to comfort. It is not unusual for some one of the ducts to yield only a scant warm air supply, or even to reverse its action. In such a case the electric fan can be easily arranged with a cardboard hood and set in front of the duct opening in the wall so that it will help to draw air from it; when there is a floor opening, the same effect may be secured by placing a box covering over the floor register and setting the fan in one side of the box, blowing outward and away from the register. Withal, the electric fan is no longer merely a warm weather servitor.

Some interesting statements concerning the use of live steam for feed-water heating were made by Mr. Irving H. Reynolds in his paper on "Pumping Machinery," read last fall before the St. Louis International Engineering Congress. In one instance where an exceptionally high thermal efficiency had been obtained with a quadruple-expansion engine the results were ascribed principally to the use of feed-water heaters placed in the exhaust pipe, third, second and first receivers, taking the feed-water from the condenser and passing it through the heaters in the order named, on its way to the boilers. This arrangement caused considerable condensation in the receivers (about 15 per cent. of the total steam used by the engine), and the gain in economy was due to the utilisation of the latent heat in these 15 per cent. condensed. Many years ago Mr. James Weir took steam from the intermediate receivers of compound marine engines and used it to raise the temperature of the feed-water. He secured an economy of about 8 per cent. in the boilers, and he lost about 4 per cent. in the engines, being a net gain of 4 per cent. But taking the feed-water through intermediate receivers would seem to be something new. The usual practice is to raise the temperature in them and not to lower it. The heating of feed-water in the way stated thus presents an interesting problem concerning which *The Engineer*, of London, says:—"We take it for granted that all the water of condensation was carefully withdrawn from the receivers, and that being done, the temperature of the steam in them would probably remain unaltered. The steam is as efficient per pound as before, but the weight of steam would be reduced 15 per cent. Economy resulted for the same reasons,—whatever these may be,—that render feed-water heating by live steam a means of economy in the Weir, Kirkaldy, or Halpin systems. It is worth while to add that no more engines have been constructed in this way, because, while exceedingly interesting from a theoretical standpoint, the system apparently involved so much complication as to bar its general introduction."

It is generally well known that electric motors are now largely employed in driving the machines, such as mixers, kneaders, and others, in large bakeries, whereby no part of the human body need come into contact with, or even in proximity to, the flour or dough at any part of the process of bread-making, which, apart from the economies effected by means of the machinery, is obviously a very desirable consideration from a sanitary point of view. Another proposed use, but one not so successful, of electricity in bread-making, has recently been announced in a report to the Paris Academy of Sciences. On the mistaken notion that the whiter the bread the better its quality, it appears that the bread consumers of Paris have for years been demanding whiter and whiter bread, with the result that to gratify this demand the most nutritious part of the wheat grain, that which contains the most albumen, is excluded from the flour. It was thought by certain interested chemists that if the wheat flour were brought into contact with electrified air, the ozone possibly might bleach the flour to a whiteness that would please the eye without detriment to its nutritious and palatable qualities. Experiments were, therefore, made to determine these points. The expected result as to whiteness was obtained by the electric treatment, and the amount of phosphorus was the same as in flour treated in the ordinary way. The electrically treated flour, however, was found to be quite unpalatable, the fatty and acid substances varying largely, the fatty substances proving rancid and glutinous and becoming oxidised and partly converted into white sebacic acid which could be dissolved in alcohol. Needless to add, therefore, the use of electricity or ozone for this purpose was not adopted.

No one, according to Sir William H. White, in a recent address on "The Education of an Engineer," can become an engineer, in the proper acceptation of the word, unless he is a practical mathematician. For creative work of a satisfactory and certain nature mathematics are necessary. Physics, or what used to be called "natural philosophy," forms a needful part of the engineer's equipment, for more and more every day the old border line between engineering and physical science is being narrowed. The introduction of electricity as a great factor in doing the world's work emphasises this point. In some branches of engineering a knowledge of chemistry is a necessity; and it would be useful in all, for metallurgical knowledge, which means knowledge of the substances the engineer employs, is founded on chemistry. Here, again, a dividing territory is being absorbed; for now, in the light of fuller knowledge, it is difficult to tell where what is accepted as chemical action ends and physical influence begins. Geology is evidently an essential branch of education for the mining engineer, and also for those who have to do with large undertakings in what is more particularly known as civil engineering, such as railway and canal construction, or the making of docks and designing of water-works; whilst even biology, or the science of life, which at first sight might be supposed to be far removed from the engineer's concern, is now necessary for those who would attack the question of sewage disposal, or other problems in the important field of sanitary science.

An interesting illustration of the ability of the electric motor to displace the inefficient single cylinder type of non-condensing steam engine occurs in recent isolated plant practice where the generators supply alternating current to the installation. It is growing more and more common in such cases to install motor-driven exciter sets for continuous operation, leaving a single steam-driven set to be used in starting up the plant, the latter outfit being shut down as soon as the alternators are running at full speed. The arrangement enables the alternators to be excited with an economy which could not possibly be obtained with a steam engine. An efficiency of 75 to 80 per cent. is readily secured with motor-generator excitation, even allowing for the trifling extra loss in wiring. The load is seldom of a violently fluctuating character as far as the exciter set is concerned, and the cleanliness, comfort and flexibility of the method are far superior in the case of the motor-driven as compared with the steam-driven unit. In very large plants, where an interruption of exciter service is liable to cause great financial loss if the plant shuts down for a single moment, it is often desirable to add a storage battery to the exciting equipment. The battery "floats" upon the exciter bus bars, and, as an additional safeguard, stands ready to supply current automatically the instant that the regular supply fails. It is to be noted that engineers have thought it worth while to use motor-driven exciters for continuous operation, even when the steam-driven set stands idle most of the time, running up a bill of fixed charges. This fact in itself is a significant comment upon the superior efficiency of the newer method.

In discussing the subject of alloys for steam uses recently before the Franklin Institute, Mr. G. H. Clamer referred to the admixture to such alloys of a small quantity of lead with the view of producing a metal sufficiently dense to withstand high pressure. It has long been known by foundrymen, said Mr. Clamer, that a mixture of a small quantity of lead will produce this effect, and, further, it facilitates the machining of castings which contain it. The following interesting experience bearing on this subject was mentioned by him:—In the time of the old bronze cannons, which were made from an alloy (known as "cannon bronze") of copper and tin, a certain founder had taken a government contract for the manufacture of quite a number of guns of this character. According to the specifications, the government inspectors were required to weigh the charges, see that they were charged in the furnaces, and then the foundryman was held responsible for the castings. These guns were subjected to certain pressure, and, after repeated failures, the manufacturers, being familiar with the value of lead in the alloy, decided to have some moulds made of the exact shape in which pure tin was marketed. One night they melted the tin which they had on hand, and added a certain small percentage of lead, then poured it into moulds, and when the inspector came the next day he weighed the pigs, which he had no reason to suspect were anything else but pure tin. The mixture was then made up in the usual way, and, to the utter astonishment of the government officials, the castings from that day all came up to the full requirements.

ASA MARTENS MATTICE

A BIOGRAPHICAL SKETCH

By Walter M. McFarland

IT was a pleasure to the writer to accede to the request of the editor to prepare this sketch, as it gave him an opportunity to pay a tribute of affection and respect to one who has been his intimate friend for many years, and who during the whole of his own career as an engineer has been his ideal as a brilliant, conscientious and supremely efficient master of the profession of engineering. As will appear in these remarks, this opinion is generally held by those who have had the privilege of intimate association with him.

Mattice is a descendant of one of the old Dutch families which settled near Albany, but is himself a native of Buffalo, where he was born August 1, 1853. After receiving his preliminary education in Buffalo, he entered the United States Naval Academy as a cadet engineer in 1872. Here he at once gave evidence of his remarkable ability, and graduated in 1874 at the head of his class.

It is not often given to very young men, especially in a military service in time of peace, to distinguish themselves; but Mattice is one of those men who cannot vegetate, and who find something of value to do under any circumstances. He has always been a great student of engineering subjects, and during this period of rest before the upbuilding of the new navy he was quietly and probably unconsciously preparing himself for the important part he took in our naval renaissance. Many stories are told by his friends of clever things done by him during these early days, which show his steady growth in engineering experience. From 1879 to 1883 he was an instructor in engineering at Annapolis, where his work left a deep imprint, and there is little doubt that it was largely due to his work that the engineering course at Annapolis was one of the best in the country.

The customary alternation of sea and shore duty sent him off on a cruise to China and Japan, and on his return he became an assistant to Commodore Loring, then engineer-in-chief of the navy. He began at once to do excellent work in connection with the designs of machinery for the new navy.

At this time,—in 1887,—Chief Engineer (now Admiral) Melville was invited by Secretary Whitney to prepare designs for the machinery of a fast cruiser which would equal or surpass anything built abroad. Melville chose as his chief aides Chief Engineer Kafer, whom so many of us are proud to call our "engineering father," and Mattice. This gave Mattice a splendid opportunity for the exercise of his talents, and marked the beginning of that admiration for them by Admiral Melville which he has so often expressed by saying, "Mattice is, without exception, the ablest man I have ever known." In passing, I may say that Admiral Melville once said to a number of his assistants, including myself, "You boys have done fine work for me, and I am grateful for it, but I hope you will not feel hurt when I say that none of you is the equal of Mattice"; and the pleasant thing to add is that we all agreed with the Admiral.

When Melville became engineer-in-chief in 1887, he naturally chose Mattice as one of his assistants, and while no one could supplant his old friend Kafer, who is the best and most loyal friend any man ever had, Mattice became a second and younger confidential assistant. It has always been a source of great satisfaction to the writer that he was deemed worthy, at a later period, to occupy this position of confidentia assistant to this famous and lovable man as a successor to two of his own best friends and teachers in the profession.

The building of the new navy found Mattice well prepared for his part in the work, and the results of his labours are still evident in many ways. When the specifications of the original *Maine's* machinery appeared they were unanimously declared the most complete ever issued, and they have remained the model ever since. He was largely instrumental in the introduction of water-tube boilers and very light engines in our steam launches; also in the inauguration of the competitive test of water-tube boilers for large vessels. His activity was unbounded, and covered every branch of naval engineering. Among other excellent things done by him was a reorganisation of the draughting room, and a systematising of all kinds of records.

The writer has elsewhere written of the wonderful power of Admiral Melville to inspire affection and devotion in his assistants, and Mattice has always had something of the same power over his assistants and associates. Indeed, it went so far with some that they really regarded him as infallible in engineering matters. Those who have had a chance to learn his almost encyclopædic knowledge and to see his methods of work can understand this feeling on the part of young men. He is not only a student and a wonderfully keen observer, but his great experience is fully under command and ready for a call at any time. His brain works with unusual swiftness, and, what is rare in such cases, with great accuracy. I am not young enough to think that he never makes a mistake, but many years' close acquaintance have shown that they are very rare. His capacity for work seems inexhaustible, and this, combined with his quick mind, enables him to do the work of several men,—and do it better. I have heard him criticised for giving too much attention to details, but my view is just the contrary. He seems an exemplification of that definition of genius which says that it is an infinite capacity for taking pains. He gives attention to details because on their perfection depends success. He wants work right in every detail before it leaves the shop, and believes that it is true economy to spend some time and money to make things right at the start rather than more of both to correct defects due to oversight and neglect of details after work has been sent out and put in service.

In 1889 the navy lost Mattice's services, just as it has lost the services of so many other able men, because the organisation was such as to reward mediocrity and to offer no adequate encouragement to special ability. From that time until 1900 Mattice was the chief assistant to E. D. Leavitt, the famous consulting engineer of Boston. During this time he was engaged in a wide variety of engineering work of the highest class, and made several trips to Europe to see, by actual inspection, the latest developments there. In December, of 1900, he became the chief engineer of the Westinghouse Electric & Manufacturing Company, and in 1903 of the Westinghouse Machine Company, remaining at the same time as consulting engineer of the former company. His work with these companies was of the same high class as he had always done, and his great ability was soon recognised by all his associates. In April, 1904, he accepted the position of chief engineer of the Allis-Chalmers Company, where he has charge of all their engineering and manufacturing work, a position similar to that of vice-president in most companies.

If, as is often said, great men are always modest, then Mattice has certainly one of the elements of greatness, for he is modest in the extreme. He has done very little in the way of writing for the technical press or reading papers before societies, and thus is not so widely known as his record and abilities entitle him to be. Indeed, it is partly to enable more people to know him well that I have gone into some details in this sketch. He believes in letting his work speak for him, and it does so in no uncertain way to those who come in contact with it. Like Moltke, he can be silent in seven languages when there seems nothing to say, but when there is occasion to talk he is a brilliant conversationalist, and one cannot but admire the vast store of knowledge on which he draws so readily.

He has a remarkable fund of anecdotes, and nothing gives him more pleasure in a congenial crowd than to tell his latest stories. He has always been popular with his associates, and this was shown in a marked way when he left the navy. All the younger engineer officers, and many of the old ones, joined in presenting him with a handsome silver service. This is the only case of such a general testimonial within the writer's knowledge. Others have been so honoured by friends immediately associated with them, but there was no united action throughout the service. Mattice is one of the best of friends, holding fast to those who have proved themselves worthy of his regard, and counting nothing too much that they may ask of him. The writer has personally been the beneficiary in so many cases that he takes special pleasure in here acknowledging it.

Mention should also be made of his public spirit. This comes naturally from his desire for thoroughness and efficiency, and his own great capacity for work. Some years ago, while he lived in Cambridge, near Boston, the project was mooted of building a dam which would turn the marshy back bay into a beautiful lake. During his visits to Europe, Mattice had seen the beneficent results of such plans in the lake at Hamburg and the lovely reaches of the Thames. He accordingly procured, at his own expense, a series of fine lantern slides of these European examples, and, having made a thorough study of the subject from all sides, gave a series of lectures to educate public opinion. As is well known, the project was afterward carried out and proved very effectual.

Knowing the high esteem in which Mattice is held by his old naval chiefs, the writer asked them to complete this sketch by contributing a few comments. They have kindly sent the remarks which follow. John C. Kafer writes thus:—

"My old friend Mattice is a remarkable man, and this became evident at a very early period of our associations as teacher and pupil at the Naval Academy. Further services together as fellow instructors at a later date confirmed the earlier impression. What specially impressed me was the rapidity and clearness with which he solved the most difficult problems which we encountered, and his ability to make them clear to others. In this respect he often aided instructors in other courses. His leadership was not confined to professional subjects, but he was active in social affairs, and every gathering counted on him as an important factor in its success. He made a mark in amateur theatricals. The ladies were always anxious to have him with them in their festivities, for no matter what was projected, it was done better by Mattice than any other could do it.

"When he returned from sea in 1886, he was, at my suggestion, brought to the Bureau of Steam Engineering by Engineer-in-Chief Loring, and began the splendid work which he continued under Melville. To him more than to any other is due the credit for incorporating the many useful devices that have placed the machinery of our naval vessels in the very front of engineering progress, as well as for securing maximum efficiency and power with minimum weight.

"Mattice's work since leaving the navy has been of the highest order, and is enough to make any engineer feel proud. His ability for turning out work is marvellous. He is a never-tiring worker, and I have personally known him to work twenty hours out of the twenty-four for several days, at important times, and make every stroke count.

"Socially, he is one of the most agreeable men of my acquaintance, and I deem it a rare privilege to have been connected so closely with the education and practical life work of the best and most genial mechanical and marine engineer whom I know,—Asa M. Mattice; and in saying this I would not disparage the brilliant abilities of many other of my former pupils and friends, among whom is the author of this sketch, who are now shining lights in the engineering world."

Commodore Charles H. Loring says:—

"It was because of the good name he had made for himself by his work while a member of the engineering educational staff at the Naval Academy that the subject of this memoir was selected for duty in the Bureau of Steam Engineering where the designs for the machinery of certain of the earlier ships of the new navy were then in hand.

"His work there fully sustained the reputation that had preceded him. He displayed from the beginning the attributes of character so fully set forth by the author of this memoir.

"His fertility of mechanical resource, his indomitable energy and industry, his clear and quick insight into intricate subjects, his facile use of pen and pencil, and his freedom from self-conceit, though firm in his convictions, made him an able and agreeable counsellor. I think I shall excite no 'yellow' criticism in saying that Mattice is the perfect fruit of the system of engineering education at the Naval Academy."

Admiral George W. Melville adds the following:—

"Your too limited sketch of the work of our good friend Mattice is interesting, but I hardly think you have done him full justice, in spite of your usually facile pen. I could not do so, and I doubt if any one could. Perhaps after he has passed away some one who has known and admired him, as we do, may give an adequate account of his capacity and work. I endorse every word you have given as coming from me, though I would make them more vigorous; and I will only add that, in my opinion, he has not an equal in the United States to-day as an engineer and general physicist."

PHOTO BY WALTER DAVEY & SON, HARROGATE

BENJAMIN TALBOT

THE ORIGINATOR OF THE CONTINUOUS PROCESS FOR THE MANUFACTURE OF BASIC OPEN-HEARTH STEEL

SEE PAGE 528

CASSIER'S MAGAZINE

Vol. XXVII APRIL, 1905 No. 6

THE KRUPP WORKS

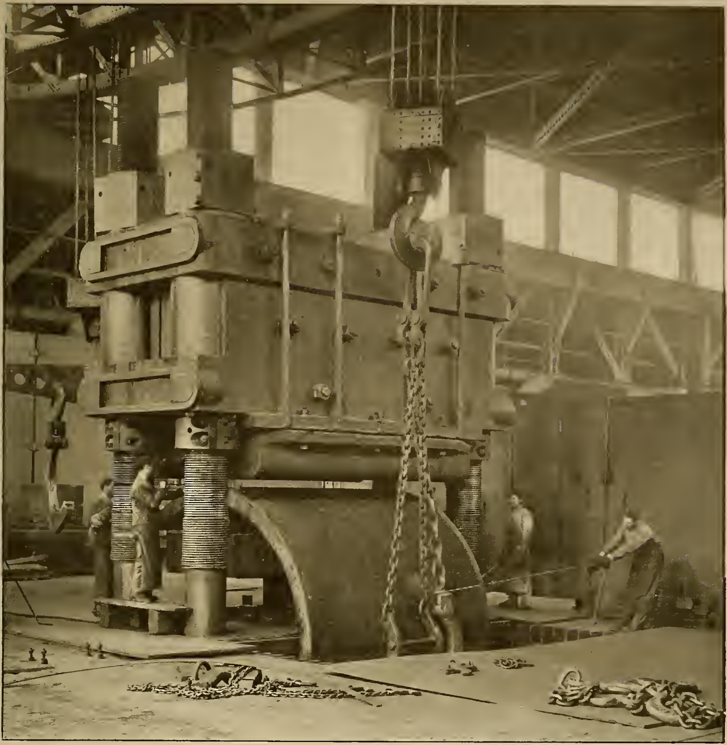
By Emile Guarini

THE famous Krupp Works, like most of the great European industrial establishments, started from very humble beginnings. But to-day they are the most important of all Germany, and even perhaps of the old world. Little by little, guided by genius and aided by circumstance, they increased, until now they give work to nearly 150,000 people, of whom 25,000 belong to the Essen branch of the establishment. The entire works are made up of eight different groups:—

1.—The steel works at Essen, with the testing field of Meppen;
2.—The steel works at Annen;
3.—The Gruson Works at Buckau;
4.—The Germania Dockyard at Kiel;
5.—The four blast furnaces at Rheinhausen, Duisburg, Neuwied, and Engers, and the steel works at Sayn;
6.—The three coal mines of Hannover, Hannibal, and Salzer & Neuack;
7.—Numerous iron mines in Germany and a share in the Bilbao mines in Spain;
8.—The Rotterdam Dockyard.

The management of this extensive whole is entrusted to a board of twelve directors sitting at Essen. The Essen Steel Works are busy manufacturing all kinds of steel, ordinary as well as special steel, for the construction of ordnance of every description and industrial appliances, material for tramways, ships, steam engines, armour-plate, rolling mills, machine tools, etc. The factory, properly so-called, is

THE ESSEN CRUCIBLE STEEL FOUNDRY



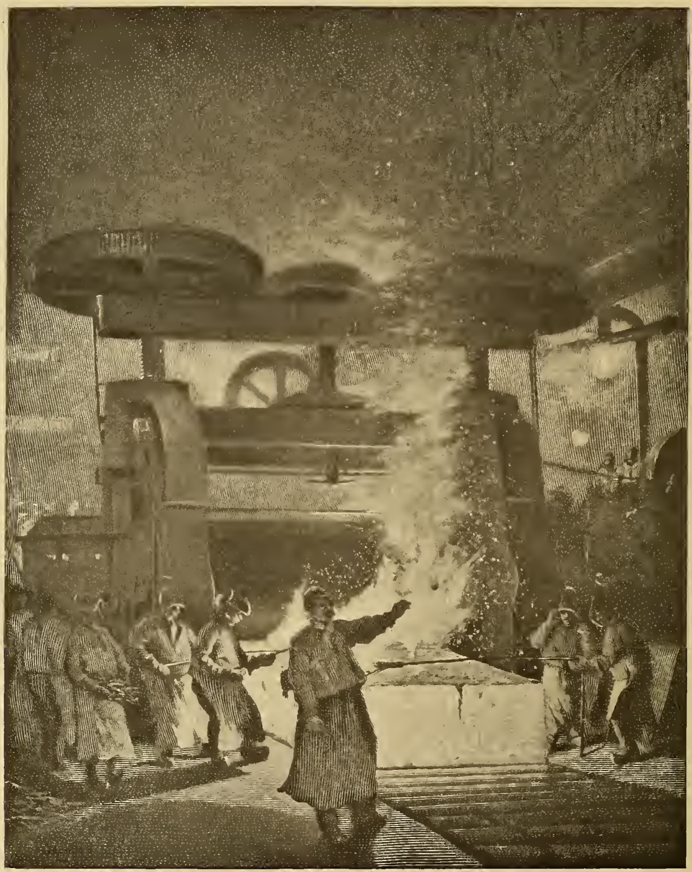
HYDRAULIC ARMOUR-PLATE BENDING PRESS AT ESSEN

divided into 60 departments, and includes about 5300 machine tools, 22 rolling mills, 141 steam hammers, 63 hydraulic presses, two of them bending presses of 7000 tons each; one forging press of 5000 tons and one of 2000 tons, 323 fixed steam boilers, 513 steam engines, ranging from 2 to 3500 horse-power (aggregate horse-power, 43,848); 369 electric motors, and 591 cranes of varying power. The total area is composed of about 820 acres, of which about 151 are covered. The yearly consumption of coal amounts to 1,678,175 tons. The fire-brick and crucible factory turns out every year 123,300 bricks and 2000 crucibles.

The supply of water is secured by four independent installations, supplying yearly more than 4,082,665,750 gallons of water. The gas works supply more than 519,184,400 cubic feet of gas a year for lighting purposes.

The electrical equipment includes three generating and seven distributing stations, 20 miles of underground cables, 30 miles of overhead cables, 1169 arc lamps, 9740 incandescent lamps, and 369 electric motors, as already stated. The yearly supply of current amounts to more than 7,098,547 kilowatt-hours.

The works equipment comprises also a normal-gauge railway with



ROLLING AN ARMOUR PLATE AT ESSEN

more than 50 miles of line, 16 tank engines, and 712 carriages; and a narrow-gauge railway with 32 miles of line, 27 locomotives, and 1209 carriages.

These railways are directly connected with the neighbouring main line stations, the service to and from these stations comprising 50 trains daily.

The telegraphic system of the factory includes 31 stations, with 51 miles of wire. It is connected with the imperial telegraph of Essen, and exchanges annually with the latter about 20,000 messages. There is, besides, a telephone system with 224 miles of wire. The number of conversations is about 2500 a day.

The factory is provided also with a permanent fire brigade, numbering 100 men.

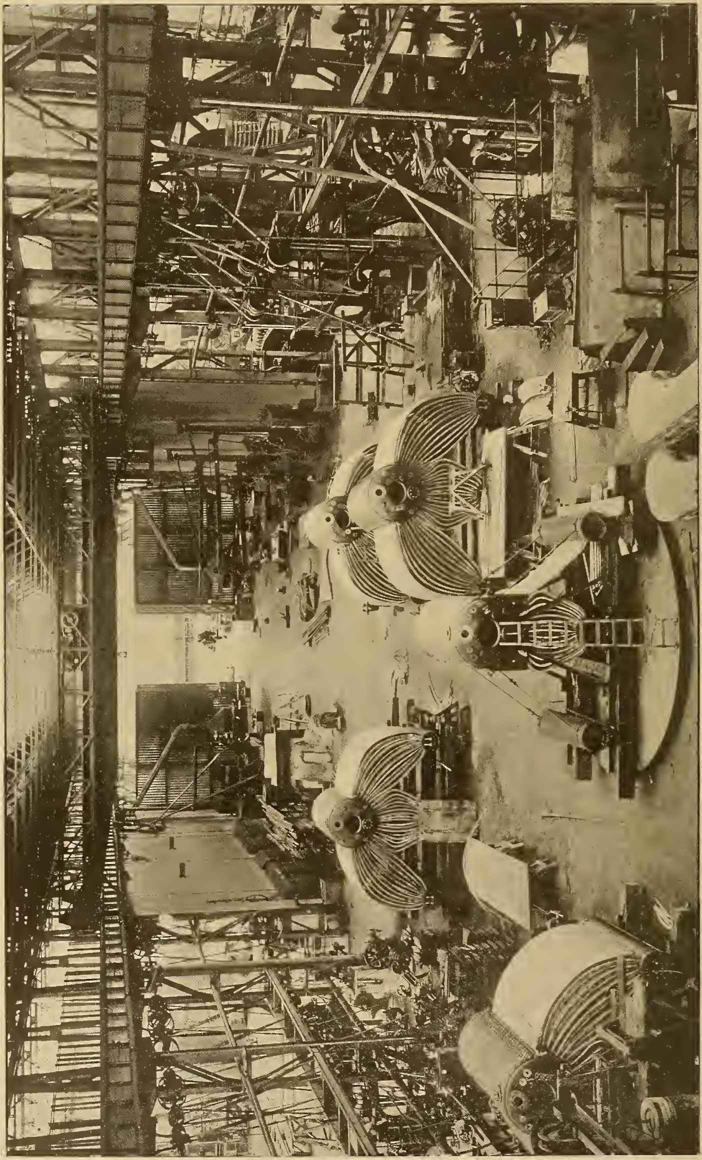
The testing field of Meppen covers an area $15\frac{1}{2}$ miles long and three miles wide. The yearly average of ballistic experiments carried on amounts to 750, requiring 250 guns, 90,000 pounds of smokeless powder, and 700,000 pounds of projectiles. The factory itself possesses a testing field where 45,000 pounds of smokeless gunpowder and 730,000 pounds of projectiles are consumed every year. Nearly 25,000 shots are fired every year in both proof benches taken together.

The three previously mentioned coal mines, of which the Salzer & Neuack mine is at Essen itself, while the two others are near Bochum, possess together seven pits, and supply fuel exclusively to the Essen factory and to most of the other establishments belonging to Krupp. The annual output is 1,479,334 tons. The number of men employed in the mines is about 6000.

The Salzer & Neuack mine possesses two coking plants, with an aggregate of 160 ovens. The two other mines have only 144 ovens altogether. The total output of these 304 ovens amounts to 700 tons a day.

The Salzer & Neuack plant comprises three winding shafts, of which the deepest measures about 1300 feet. The Hannover and Hannibal mines

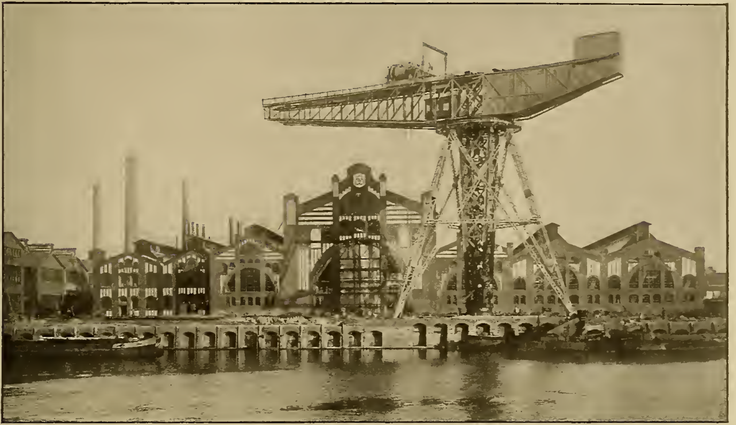
UNDER THE 5000-TON HYDRAULIC FORGING PRESS AT THE ESSEN WORKS



IN THE BOILER SHOP OF THE GERMANIA WORKS AT KIEL. SCHULZ BOILERS ARE HERE SHOWN IN VARIOUS STAGES have seven shafts, of which five are for hoisting, the deepest measuring about 1600 feet.

The blast furnaces at Rheinhausen were erected in 1897. They are three in number, with outputs each of from 180 to 230 tons a day. The waste gases from the furnaces are used underneath the fifty steam boilers which form part of the plant. Each of the furnaces is blown from four compound-vertical engines.

Two compound-vertical steam engines of 250 horse-power are used for dynamo driving; also a gas engine of 40 horse-power, using gas from the blast furnaces. There are at Rheinhausen also two open-hearth furnaces with a capacity of 25 tons each, with the required gasogeneous engines, an electric crane of 50 tons to manipulate the casting ladles, a travelling steam crane of 5 tons, a 500-pound hammer, worked by compressed air, to forge the steel-testing rods.



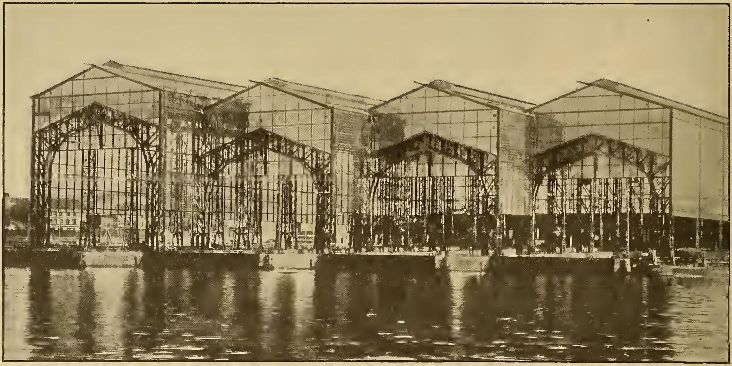
THE 150-TON CRANE AT THE GERMANIA WORKS

The steel works at Annen, in Westphalia, turn out Siemens-Martin and crucible steel. The works comprise three Siemens-Martin furnaces, two furnaces for crucible steel, of a capacity of 100 crucibles each, with the four necessary heating furnaces, machine shops, a rolling mill, etc. Steel castings are turned out for ships, locomotives, dynamos, steam engines, small arms, etc.

The specialty of the Gruson Works is white iron castings. By selecting and mixing specially appropriate varieties of ore, and by using metal moulds instead of sand moulding, a much harder casting is produced than the ordinary one, the surface being chilled by the contact with the metal. The depth of this hard coat may be altered according to requirements.

These castings are used in the manufacture of arms and of industrial machinery. When a greater resistance, but no greater hardness, is required than in the ordinary cast iron, the same mixture is cast in sand instead of metal moulds. The Gruson Works produce, besides, steel castings for wheel work and for machinery of every description, and specially hardened steel castings. Including the proof bench of Buckau, the area covered by the Gruson Works amounts to 75 acres, and includes about 50 different workshops.

Besides the testing field of Buckau,



THE GLASS-ENCLOSED SHIPBUILDING SHEDS AT THE GERMANIA WORKS AT KIEL

the works possess also near Tangerhütte a shooting field for great distances, connected through a junction with the Magdeburg-Wittenberg Railway. This establishment keeps at full work 100 furnaces, 66 steam engines of an aggregate power of 2015 horsepower, 82 electric motors of 970 horsepower together, 1461 machine tools, 376 travelling cranes, revolving cranes, and lifts of a capacity of 150 tons maximum.

A normal-gauge railway, nearly 5 miles long, with 40 turn-tables, runs through the workshops and loading stations. This railway is in direct connection with the Buckau railway station. The access to the workshops and communication between the several shops is secured by a narrow-gauge railway, 3½ miles long, with 65 turntables.

For the conveyance of armour-plate the factory possesses a steam traction engine and 10 special trucks, of which the largest is 25 yards long, and can carry 95 tons.

All the shops and offices can communicate with one another through a special telephone connection. Moreover, the factory possesses three connections with the exterior telephone system. A telegraph station allows the factory to communicate directly with the imperial telegraph office at Magdeburg. All the workshops and offices are lighted by electricity. The system includes altogether 495 arc lamps and 2700 incandescent lamps.

The mechanical properties of the materials which are used are continually subjected to tests with regard to wear, to bending, and to resistance to shocks, with the aid of special apparatus. Several chemical laboratories also are adjuncts to the works.

The superintendence of the fire department is assumed by a detachment of Magdeburg firemen constantly on duty. Their detachment is composed of one sergeant and three firemen, who, in case of need, can call to their assistance ten trained men thoroughly acquainted with the fire service, and belonging to a body of guards whose duty it is to watch over the general safety of the works. This body is composed of one chief and thirty-four men. The factory possesses besides two steam fire engines always ready, forty-eight reels of hose pipe and thirteen electric fire alarms. The number of people employed at the works amounts to nearly 3000.

The last purchased, but not the less important of all the Krupp establishments, is the Germania dockyard at Kiel. In order to make this dockyard yield as much as possible, and to raise it to the height of modern requirements, it was thoroughly transformed immediately after it was acquired. The new establishment covers now an area of nearly 59 acres. The buildings alone cover an area of 20 acres.

Special attention has been bestowed upon the construction of the shipbuilding docks, of which there are to be a dozen, but of which seven only are finished at present. Their length varies from 400 to 640 feet, and their width from 90 to 100 feet. The three which are not yet constructed will be larger still, being intended to reach a length of 750 feet.

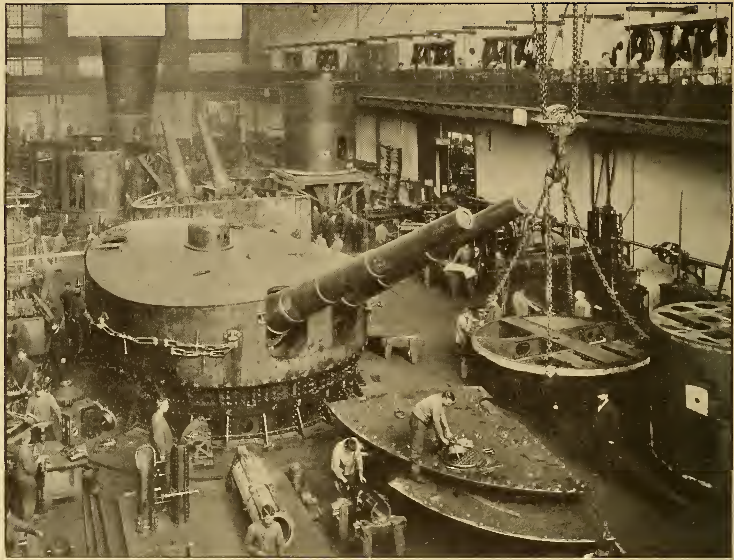
Of the seven drydocks which are finished, four are entirely roofed with iron and glass. The largest one is 102 feet high on the wharf side and 120 feet on the water side. Both sides lengthwise have been left open to a certain height. The facade towards the dock is also glazed, at least its higher part.

Each shed is equipped with two electric travelling cranes moving side by side, and capable of lifting 6 tons each. It is expected that the use of roofed docks will considerably shorten the time required for the construction of ships, as there will be no need to stop work on account of bad weather. Besides the roofings will protect the ships and the machinery employed in construction. At present the roofing

AN INTERIOR VIEW

CONVALESCENTS' HOME IN THE KRUPP WORKINGMEN'S COLONY, ALTENHOF

A STREET IN ALFREDSHOF,—ANOTHER OF THE KRUPP VILLAGES



ERECTING SHOP FOR HEAVY NAVAL AND COAST DEFENCE GUNS

of the other docks is delayed because the first ones, at present the only ones of the kind in Germany, are first expected to prove their superiority, and advantage will thus be taken of the acquired experience.

Next to the roofed docks is a great unroofed one, where five or six torpedo boats can be built simultaneously.

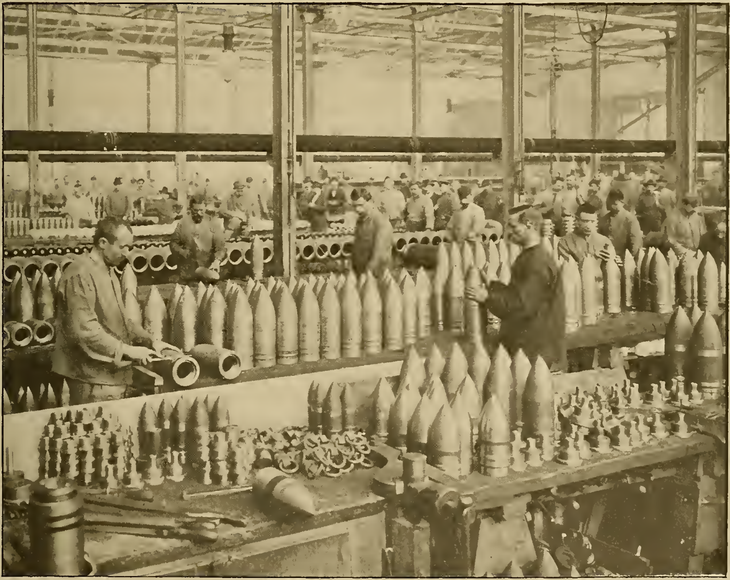
The various workships, forges and warehouses are grouped round the docks. Nearest the wharf, a workshop extends for a length of 450 feet, while its depth reaches 150 feet. This workshop is equipped with all the necessary machinery for working metals. Each bay is fitted with a travelling crane of 3 tons, and is crossed by four railway lines connected with lines of rails running alongside the docks.

Southwards of this shop are the buildings for the forges. These cover a total area of nearly 2 acres. At present the forge is fitted with two furnaces, sixteen circular hearths, and five double hearths. There are one steam hammer of about 700 pounds and four others ranging from 1200 to 3500 pounds.

Alongside the forge is a single standard travelling crane of 40 tons capacity for handling armour-plate. To the west is the smith's shop, where 400 hands can find working room, and which is equipped with a corresponding number of anvils. It includes about 100 machine tools of every description and size. As the finishing of certain pieces, such as armour-plates, is done in this shop, it has been equipped with a travelling crane of 40 tons. To the smith shop is annexed a workshop for the galvanizing of torpedo boat parts. Opposite the smith shop, on the quay, is a large three-story building, including the carpenters' and joiners' shop, the painters' shop, stores, etc. From the first floor starts a hanging bridge 4½ yards wide, which leads to the ships alongside the quay, ready for rigging, which allows the different rigging gear to be delivered directly from the store to the ship. The joiners' shop is provided with exhaust apparatus for leading the sawdust and shavings to a neighbouring boiler room.

The greatest installation of the whole dockyard is the building comprising the fitting and finishing shops, with the copper forge and the armour-plate shops, forming altogether a building with seven bays, and covering an area of 4½ acres. The principal bay constitutes the fitters' shop, with a floor space 165 feet long and about 36 feet wide. The steam engine shops are remarkable on account of the wealth of their equipment, comprising about 400 machine tools of the latest patterns. Also worth mentioning, in the neighbourhood of these shops, are the testing departments for steam engines and boilers, and the two-story warehouse.

The most remarkable of the buildings of the lower dock is the one containing the principal offices. The length of its facade is 262 feet, and it covers an area of ½ acre. The basement contains the technical offices, and the ground floor the managers' offices, and a great roofed hall 70 feet long and 45 feet wide, in which are exhibited the models of the ships built by the firm. On the first and second floors are the offices of the constructors and draughtsmen. The top floor is occupied by a photographic studio, storerooms for designs, and a central telephone station. Amongst the other buildings of the lower dockyard may be mentioned the firemen's quarters, the canteen, and the baths for the workmen.



INSPECTING FINISHED PROJECTILES

The principal buildings of the upper dockyard are the modelling shop, the foundry, the boiler shop, and the central electric establishment. The modelling shop is on the ground floor of a building of which two stories contain the storerooms for the models.

The foundry occupies a seven-bay building, covering an area of about 2½ acres. It is provided with the most recent apparatus for lifting and conveying, with the most improved cupolas, with machinery to prepare the sand for moulding, to dry the moulds, and to finish the castings. It includes also a small smith shop and a joiners' shop as well. It is equipped with two travelling cranes of 15 to 20 tons, seven stationary cranes, and two wall cranes. For the casting of big pieces there are three pits from 16 to 20 feet in diameter and 15 feet deep. In the two furnaces of the iron foundry 14 tons of metal can be melted every hour.

The neighbouring boiler shop is a little over 400 feet long and 212 feet wide. The two side bays are equipped with two 15-ton travelling cranes, and the central bay with one of 50 tons capacity, besides an auxiliary 20-ton crane. There are also a great number of wall cranes. The shop contains numerous machine tools driven by compressed air, hydraulic rivetting machines, and an outfit for galvanising. Close by the boiler shop extends the central electric establishment provided with five triple-expansion engines, two of 375 horse-power, and three of 750 horse-power. They are connected with a central condenser, and directly coupled to seven direct-current dynamos.

The equipment with regard to machine tools and motive power of these new factories, is indeed the most complete that can be imagined. The number of machine tools amounts to 840, and electric power is almost exclusively in use. Excepting a few installations where for special reasons another kind of power is required, all the machine tools are worked by electricity, either individually or in groups. Excepting the hand cranes, all cranes, too, are operated electrically. The number of dynamos and motors amounts to 260.

Excepting the forges, all the enclosed shops are heated by steam. The buildings and workshops, the dry-docks, and open dockyards are lighted by electricity, being equipped with 450 arc lamps and 4400 incandescent lamps.

The number of workmen and employees occupied in the dockyard of the Germania amounts to nearly 7000.

The workingmen's welfare has been kept prominently in mind in the combination of Krupp establishments. More than a hundred shops and factories supply to the working staff their food products and domestic requisites at reduced rates. About twenty settlements supply lodgings.

There are, besides, a hospital, an aid society for the sick, two institutions for workmen retired on pensions, dispensaries, homes for the aged, and others of similar import.*

At Essen there are an employee's club, a foremen's club, a domestic training school, an industrial school for adults, three industrial schools for girls, a circulating library, a private school for the workmen's children, a savings bank, and a life insurance society; at the Gruson Works there are a canteen, a club for employees, and a workmen's restaurant with 1000 places. Nothing seems to have been forgotten in these great works, which are models of their kind from nearly all points of view.

---

* Those more particularly interested in this part of the Krupp enterprise may find it worth while to refer to the profusely illustrated article entitled "The Future of the Iron and Steel Trades; Solving the Labour Problem," by Axel Sahlin, printed in this magazine in February, 1903.—The Editor.

ROAD WHEELS FOR MECHANICAL VEHICLES

By R. G. L. Markham, M. Inst. Mech. E.

WHEELS may, perhaps, be reckoned among the oldest of mechanical devices, and the fact that we have been so long accustomed to them with little obvious change, combined with their ubiquity, has tended to obscure the importance of the part they play in all forms of traction. With the exception of the bullock sleighs in Madeira, and perhaps in a few other cases governed by special circumstances, wheels are used for vehicles of all classes, from the wheelbarrow to the coach or the racing motor car, and though a man, a team of horses, or a powerful engine be required to propel them, they would all be quite unequal to the task were it not for the unconsidered wheels upon which they run.

While the wheels should, of course, always be suited in construction to the class of vehicle on which they are used, in the case of vehicles drawn by horses or other means extraneous to themselves, the only function of the wheels is to carry the weight, and they play no part in propelling the vehicle. The advent of the cycle, however, introduced other considerations into the design of wheels adapted to the purpose.

In the earliest prints of the bicycle of the "bone-shaker" period we find it fitted with iron-tired wooden wheels, —the usual carriage type of wheel, in fact.

This proved too cumbersome and uncomfortable; and gave way to the lighter wire wheel with rubber tire, but still with straight spokes. Then it was found, since the propulsive force was no longer extraneous to the machine, but was transmitted through the hub and spokes, that this arrangement was not altogether satisfactory, and accordingly tangent spokes were introduced.

Again, solid rubber tires formerly were cemented to the rims, and, with the force of propulsion acting through them, used to stretch and roll off. Were it not for the introduction of the cushion and pneumatic tires, with different methods of attachment, no doubt the natural sequence would have been to wire on the solid rubber tire, as is done to-day in the case of perambulators and motor vehicles using this form of tire.

The introduction of the pneumatic tire was at first not so much an outcome of conditions necessitating its employment as of a desire for greater comfort, but it is apparent that without its use speeds would never have increased as they have.

The motor or self-propelled vehicle has again necessitated changes in the design of road wheels, but the conditions governing those modifications have differed considerably in nature as well as in degree, and were at first but little realised or understood. To some of us of the present day who "know all about it," it may, perhaps, cause a little wondering amusement to note the mistakes of our exemplars of a previous decade. Thus, on the introduction of the motor vehicle, makers in general devoted their whole attention to the mechanism,—the new and fascinating acquaintance, as it were,— while their old and tried friends, the wheels, were ignored. Their extreme

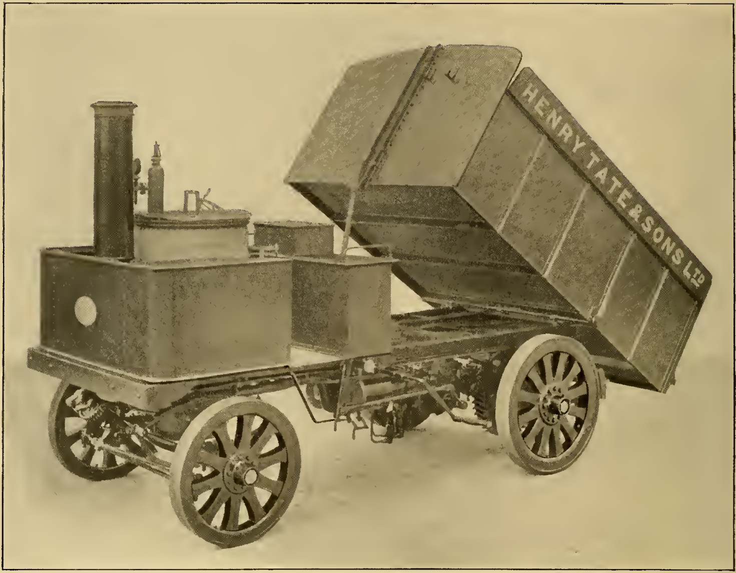


FIG. I.—ARTILLERY TYPE WHEELS

importance, increased even beyond what it had been previously, remained comparatively unrecognised, and they were not improved to the occasion.

In the case of motors for goods transport, or steam waggons, the result was seen in the trials of 1898, organised by the Liverpool Self-Propelled Traffic Association, in which, though the machines themselves were fairly satisfactory for those early days, the wheels gave trouble all around.

Among the judges' "conclusions" following the trials were:—"The forms of wheels and tires adopted by all the manufacturers, though probably perfectly efficient as carriers, were all structurally more or less inefficient as drivers."

Some of these wheels were of wood, of ordinary dray type, and others were of steel with straight spokes cut out of steel plate and given a twist where they were riveted to hub and felloe. In every case the propulsive force, or drive, was communicated, whether by chain or gearing, either through the hub or through a ring attached to the spokes, and, therefore, the spokes and their attachments had to withstand the strain of driving. But in the case of the steel wheels, at least, it is probable that this cause was not entirely responsible for their failure, and that the set and cobble roads over which they were driven had much to do with it.

As a result, steel wheels were abandoned and the heavy type of artillery (wood) wheel became the standard form for all motor lorry work. With this type trouble was at first experienced with the tires. The usual practice with wooden wheels hitherto had been to weld up a ring for the tire and to heat and shrink it on to the felloe.

It was found, however, that thin tires would soon roll out and crack, while with tires of the section it was desirable to employ (about 5 inches wide by $\frac{7}{8}$ inch thick) the mass of metal was such as to cause charring of the wood felloe in the process of shrinking it on; and the subsequent jarring, to which the wheels are constantly subjected in use, caused the tires to become loose by reason of the breaking up of the burnt surface of the wood. The final practice with this type of wheel, and that holding at the present day, is to use weldless steel hoops and to squeeze them cold on to the felloe by means of a hydraulic or other tire setter.

In the construction of a driving wheel for motor vehicles the following are the principal practical considerations, and they may be taken as the conditions necessary to a perfectly satisfactory wheel:—

1.—It must be capable of carrying the required load, which, in some cases, may be as much as five tons per wheel, and with this load it must withstand the strain of being driven over the ground at considerable speed.

2.—It must be capable of transmitting power through itself, either from the hub or from a chain ring secured to it at a point intermediate to hub and felloe.

3.—It must be of sufficient diameter and width of tire, the latter particularly, to enable it to run over ordinary roads without cutting them and so absorbing a large amount of power.

4.—The tire must be such, apart from width merely, that it does not damage the road.

5.—The tire must also be such that it will not spin or skid under slippery conditions of paved and greasy roads, or in frost.

6.—The wheel must be sufficiently resilient to insure for it a reasonable life without jarring to pieces when running over very hard, uneven ground, such as set paved roads.

7.—The wheel should not be unduly expensive either in cost or maintenance, though in view of its importance the former is of minor moment compared with the latter.

In the case of pleasure cars and the lightest class of good vehicles, the problem is much simplified by the possibility of employing solid rubber or

FIG. 2.—AUTOMOBILE EQUIPPED WITH ROUSSEL ELASTIC SPOKE WHEELS MADE BY MM. CADIGNAN & CIE., PARIS

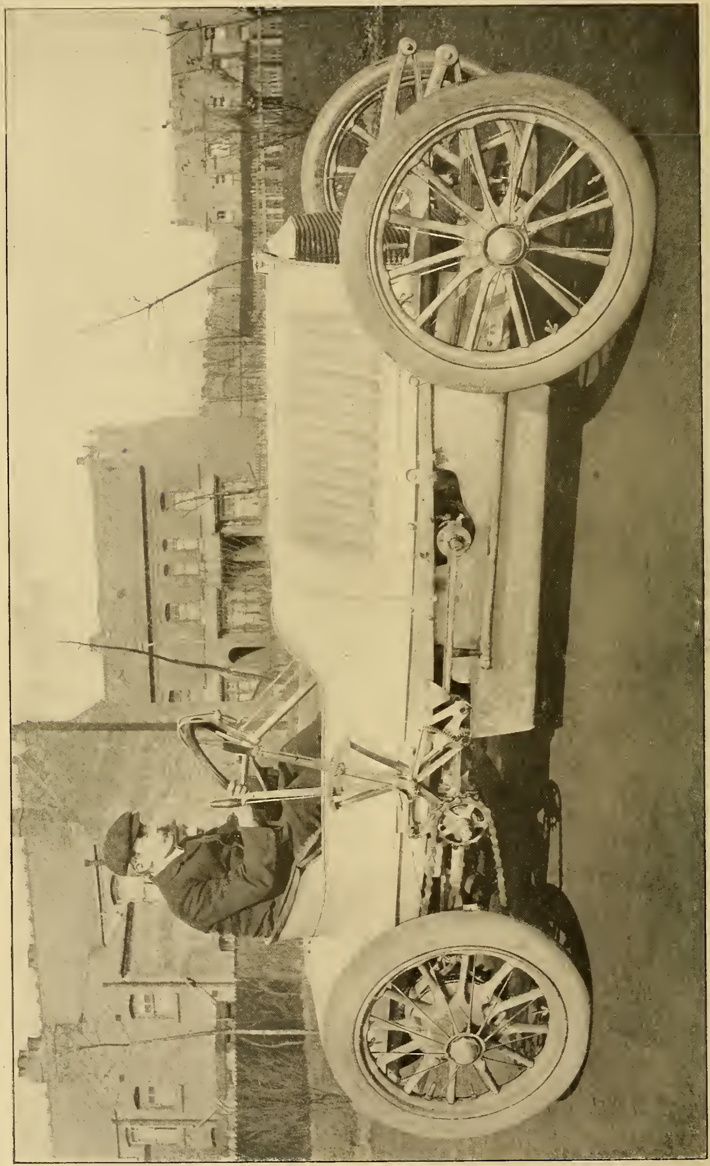


FIG. 3.—A RACING CAR WITH STAYED WHEELS MADE BY THE WOLSELEY TOOL AND MOTOR CAR CO., LTD., ADDERLEY PARK, BIRMINGHAM

pneumatic tires. Where the latter can be used, the only considerations of real moment are Nos. 5 and 7, though devices for prevention of slipping should not be such as to damage the roads. The problem of how to prevent spinning and side slipping is, perhaps, the greatest which confronts all motor users.

In the case of those vehicles using pneumatic tires, the difficulty is met by a variety of devices, some of which are incorporated in the tire, some are loose attachments at the rim of the wheel, while others are mechanical contrivances entirely independent of the wheel.

These various devices are under trial at the time of writing, and more will probably be known of their efficacy before this appears in print; but it is doubtful if any of these methods would be of practical value when applied to the intermediate class of vehicle using solid rubber tires, and certainly they would be absolutely useless for the prevention of skidding of heavy vehicle wheels. But as regards light motors, both this and the varieties of tires are matters upon which it is not proposed to touch in the present article, though there is much to be said about them.

While on the subject of light and medium vehicles, however, the question of expense may be considered for a moment. The ideal wheel and tire are, of course, those which combine a maximum of comfort to the passenger as well as a minimum of shock and stress to the motor, with low first cost and small maintenance expense, and according to the nature of the case, so will the balance of these points vary.

The influence of speed on the type of wheel employed (and the tire is here regarded as an integral part of the wheel) is very considerable, and the greater the speed, the softer needs to be the running of the wheel. In the case of pleasure cars, therefore, pneumatic tires are almost universally adopted, in spite of the expense involved, since, apart from the prime consideration of comfort, the use of even solid rubber tires would soon tell its tale on the other parts of the wheel as well as upon the rest of the car.

With pneumatic tires the design of the rest of the wheel is comparatively unimportant so long as it is of sufficient strength, and as the loads are light, this involves no difficulty. The cycle type of tangent spoke wire wheel was at one time first favourite, but has now been generally superseded by the artillery type, shown in Fig. 1. In the case of the high-powered and heavy cars, the side strain is a factor to be reckoned with, and in the racing Wolseley cars, Fig. 3, this has been considered by staying the rims to prolonged hubs by supplemental wire spokes.

The expense of pneumatic tires and their liability to puncture has led to attempts to replace them by solid tires and to achieve the same end of softness of running by other means. Undoubtedly the best place to absorb road shocks is at the point of inception; the nearer to this point, the better. For this reason, among others, shock-absorbing devices incorporated in the hub are generally unsatisfactory.

Other devices which have been designed for the purpose, usually involve sliding or telescopic spokes, or a system of levers, with rubber pads or springs interposed. Here, however, the pressure is taken on a small surface of rubber, which soon perishes, while springs are liable to fracture as well as to variation of tension. At all events, complexity is added. Moving parts in a wheel should be sedulously avoided.

Perhaps one of the most hopeful of elastic spoke devices is that known as the Roussel wheel, made by MM. de Cadignan & Cie., of Paris, in which a series of spring steel hoops take the place of the usual straight spokes, as shown in Fig. 2.

These hoops, being securely fixed to both hub and felloe, involve no moving parts, and yet give considerable elasticity to the wheel.

With the weight of the vehicle the

expenses of pneumatic tires, both initial and running, increase rapidly until they become prohibitive. There is also a practical limit to the weight which can be carried by such tires as at present made.

In a table published by Michelin, giving the weight per axle and horse-power for various sizes of tire, no tire is shown of greater size than 120 millimeters, and the maximum weight per axle suitable to this tire is stated to be under 24 cwt., while the maximum horse-power at the driving wheels is given as 18 to 20. Thus, in the case of motor omnibuses and vans for medium loads, pneumatic tires are discarded in favour of solid rubber tires, the general design of wheel remaining the same, but of course with its parts proportioned to the extra weight and power of the machine. With these classes of vehicles, so great a speed is not required, though having regard to the total running weight, it is considerable and some form of cushion tire is desirable.

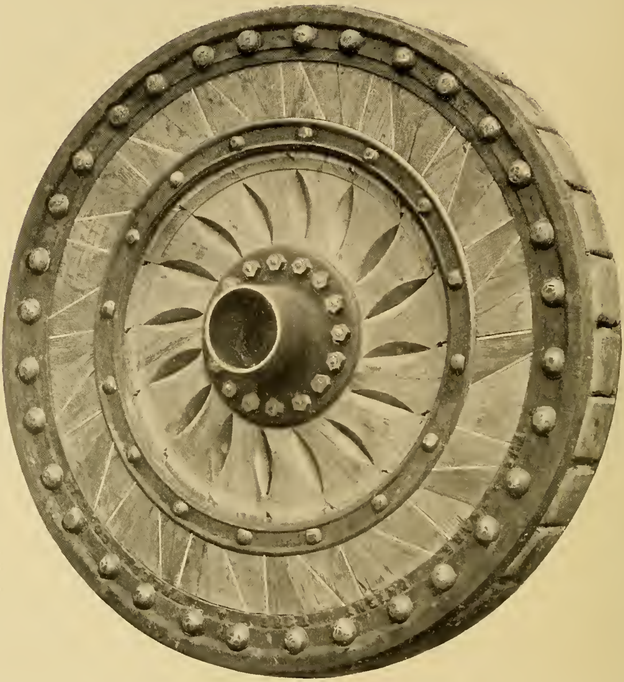


FIG. 4.—THE GARE WHEEL, MADE OF WEDGE-SHAPED WOODEN BLOCKS WITH A BEDDING OF SOFT RUBBER

Where the commercial class of vehicle is concerned, as distinguished from the purely pleasure car, the matters of wheel cost and maintenance, particularly the latter, become of vastly increased importance while mere comfort is of quite secondary consequence. At the same time regard must be had to the wear and tear of the machine as a whole, and it becomes a question of how far "wheel expense" will save "vehicle and machine expense." Of course, in the case of public passenger vehicles, comfort has still to be considered if dividends are desired, and in consequence the wheel expense may be increased beyond what would otherwise be advisable.

Solid rubber tires of one type or another, and there are many, are usually fitted, and in the case of public passenger vehicles, the cost of maintenance of wheels may be about £250 per vehicle per annum. Or, put another way, the rubber tires for such a vehicle cost from 2½d. to 3½d. for every mile run.

FIG. 5.—COMPOSITE WHEEL MADE BY THE LANCASHIRE STEAM MOTOR COMPANY, LTD., LEYLAND

Returning now to the heavy class of motor vehicle—lorries constructed for loads of 4 or 5 tons, the total moving weight will be 10 or 11 tons, and, in certain cases, may be as much as 15 tons. Obviously, any form of pneumatic or even solid rubber tire is out of the question, and obviously, also, the wheels themselves must be of special construction if they are to conform to even the absolutely essential conditions of the list mentioned.

Actual practice varies according to the type of vehicle and the conditions under which it will generally run. Normally, for service upon ordinary English roads, the wheels are of the artillery type, having metal hubs, oak spokes, ash felloes, and steel tires. They are generally about 3 feet 3 inches in diameter and have tires about 6 inches wide. For heavier vehicles the diameter and tire width are increased, the present maximum practice being 5 feet for the former and 24 inches for the latter. Both dimensions directly affect the crushing of the road and consequently the draught of the vehicle, and Mr. Douglas Mackenzie, as the outcome of ex-

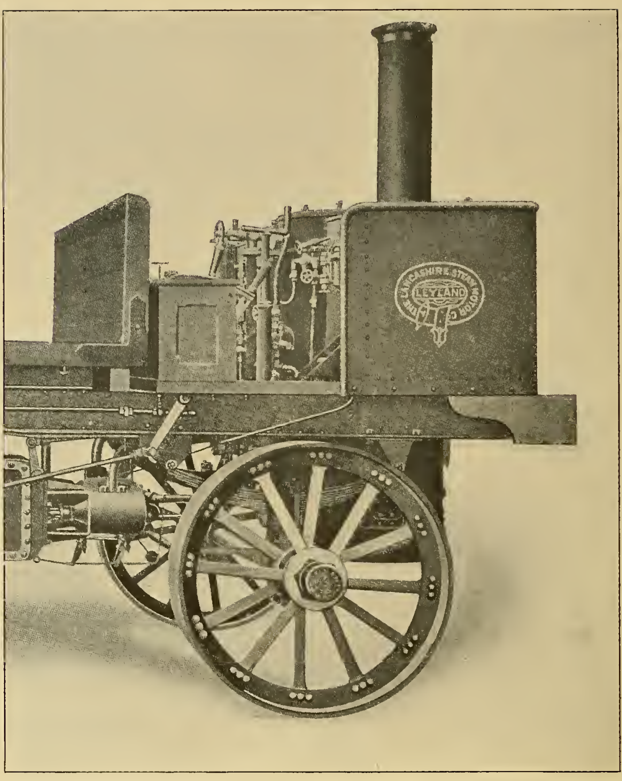


FIG. 6.—WAGGON WITH STEEL SPOKES CAST INTO THE HUBS. MADE BY THE LANCASHIRE STEAM MOTOR CO., LTD., LEYLAND

periments which he made, has found that increase in diameter has more effect than width of tire in preventing road damage.

In his evidence before the Departmental Committee of the Local Government Board he stated, "from experience of roads within 50 miles of London, that it is necessary with a 3-foot driving wheel and a total load on the axle of 10 tons, to provide a tire not less than 12 inches wide, and with 3 feet 6 inch wheels, not less than 11 inches wide. If with such axle loads the tires are less than this width, they will be found to cut into flint roads and damage the surface."

The recommendations of this committee, upon which the regulations for heavy motor cars will be based, follow the same line. In effect, they advise that with the maximum permitted axle load of 8 tons, and using a wheel 3 feet in diameter, the width of tire shall be about 10½ inches. If the diameter be increased to 4 feet the tire width may be reduced to about 9½ inches, and conversely the tire must be wider for a less diameter than 3 feet, but in an increased proportion.

If such regulations be introduced, they should be of benefit both to the motor waggons and to the roads on which they run, but they will involve some modification in the design of wheels.

It will not be a difficult matter to build steel wheels to comply, but it may mean the final blow to the artillery type, as it will not be easy to obtain suitable wood of the requisite section, and at least it must make this type of wheel more expensive. The regulations proposed would, however, appear to draw distinctions in favour of a wheel with a non-metallic resilient tread, and this may lead to the introduction of other forms. At present the "Gare" wheel, Fig. 4 (to be referred to later) seems the only important one of this class. The artillery type of wheel (previously mentioned) as now used, has proved to be fairly satisfactory in general. In one case known to the writer, the driving wheels of a 4-ton steam waggon working on good macadam roads ran for about 9000 miles before it was considered necessary to have the wheels repaired. This, however, must be reckoned a performance above the average, and it should be noted that the drive was taken direct on to the felloe and not through any other part of the wheel.

Owing to the great weight borne, and to the fact that the driving strain is generally transmitted through the spokes, as well as to the comparatively insecure attachment between spokes and felloe, the first sign of weakness in these wheels will manifest itself in the loosening and working of the spokes and sections of the felloe.

To meet this difficulty as well as to give a better support to the felloe than can be done with ordinary spokes, a special form of wheel, Fig. 5, has been designed by the Lancashire Steam Motor Company, Ltd., of Leyland, Lancashire, and also adopted as standard by them after considerable trial. This wheel has hollow spokes which are cast all in one piece together with a steel rim. This rim has a narrower circumferential band around it which

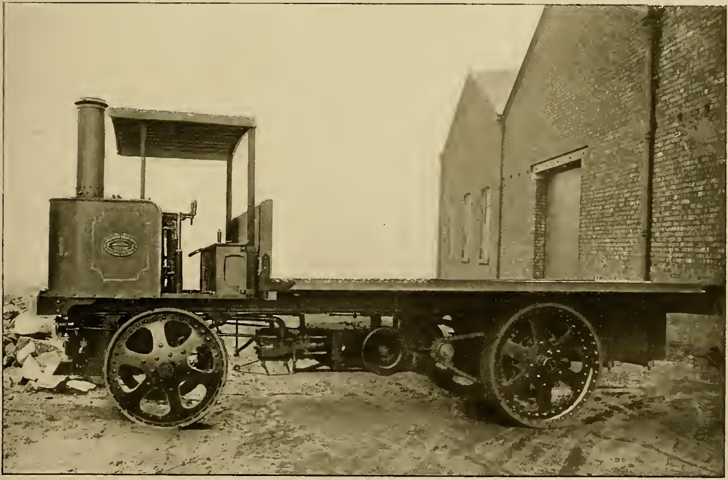


FIG. 7.—THE WHEELS HERE HAVE SPOKES MADE OF STEEL PLATES CUT SO THAT ALL THE SPOKES ON EACH SIDE ARE IN ONE PIECE. MADE BY THE LANCASHIRE STEAM MOTOR CO., LTD.

fits into a corresponding recess in the wood felloe, and the usual steel tire, being squeezed on afterwards, holds all tight. A somewhat similar form of wheel is adopted by the Hercules Motor Company, but in this case the rim, or under felloe, takes the form of a channel in which the felloe proper is held.

Wheels of these types would probably be found the most satisfactory all around, but with increased loads and the soft ground which the motors sometimes encounter, it is difficult to provide sufficient diameter of wheel and width of tire in this form. Accordingly, built-up steel wheels are again being tried.

One usual type is that with comparatively narrow mild steel spokes, cast into the hub and rivetted to a tree or angle-ring felloe on which again is rivetted an outer steel or iron tire in sections, generally taking the form of diagonal cross strips. This wheel, manufactured by the Lancashire Steam Motor Company, Ltd., of Leyland, Lancashire, is shown in Fig. 6. This type is the one generally used in traction engine practice, and with variations in the arrangement of the spokes and in the section of the felloe

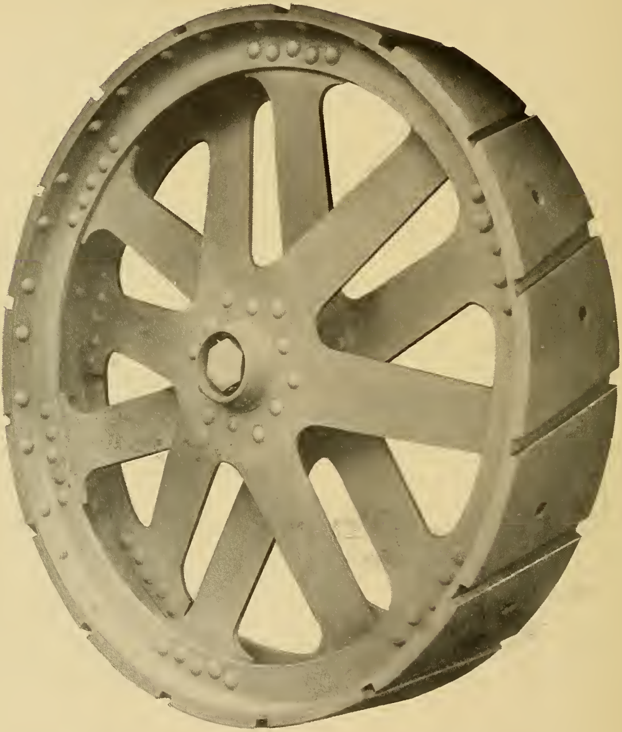


FIG. 8.—DOUBLE PLATE INTERLACED SPOKE WHEEL MADE BY THE THORNYCROFT STEAM WAGGON CO., LTD., BASINGSTOKE

rings, it is now being employed by several steam waggon makers.

Another type is constructed of mild steel plates cut in such a way that all the spokes from each side of the hub are in one piece, and are rivetted to both hub and felloe. This wheel, made by the Lancashire Steam Motor Company, Ltd., is illustrated in Fig. 7.

A variation is to use separate plate spokes and to rivet each to both hub and felloe.

With each of these types the arrangement of spokes may vary. Sometimes the spokes from opposite ends of the hub are butted together at the felloe, but more often they are alternated and interlaced, being taken to the opposite of two tee rings at the felloe. A wheel of this type is made by the Thornycroft Steam Waggon Company, Ltd., of Basingstoke, and is shown in Fig. 8.

FIG. 9.—CAST STEEL WHEELS ON ONE OF THE WAGGONS OF THE THORNYCROFT STEAM WAGGON CO., LTD.

Another type of all-metal wheel, shown in Fig. 9, which is employed by the Thornycroft Steam Waggon Company, and which is coming into favour with other manufacturers, is cast complete in one piece from a special grade of crucible steel. This has no separate outer tire, and there are no rivets in its construction; if cross strips are needed for gripping purposes, they are cast on with the wheel.

All of these wheel types comply with numbers 1, 2 and 3 of the conditions previously enumerated. If the tires are provided with cross strips sufficiently spaced to be really effective in preventing spinning and skidding, they are liable to damage the roads, and therefore conditions 4 and 5 are not both complied with. Number 7 may be considered fairly well satisfied in view of other issues involved. In the case of number 6, however, the wooden wheels are only fairly satisfactory, while all the forms of all steel wheels must be reckoned distinctly unsatisfactory. The continual hammering to which they are subjected when travelling over setts, as in Lancashire for instance, causes constant trouble with the rivets, while the mild steel spokes themselves fracture after a time.

Repairs to the artillery type of wheel can generally be simply and cheaply effected, but in the case of the wheel with cast in spokes, and in that of the complete cast wheel, a fracture practically means condemning the whole wheel. The cast-steel wheel, however, seems to last longer with less trouble than the built-up wheel, owing to the absence of rivets.

To overcome the difficulty of obtaining considerable resilience with a

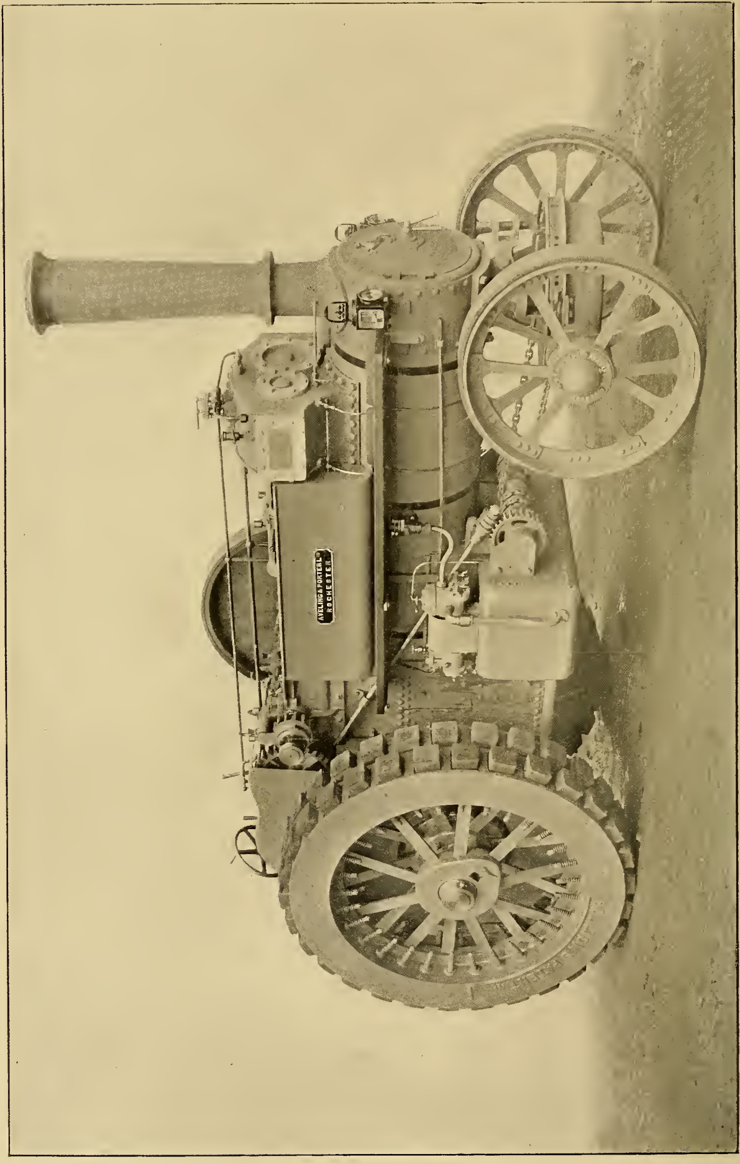


FIG. 10.—BOULTON WHEELS AS FITTED TO A TRACTION ENGINE BY MESSRS. AVELING & PORTER, LTD., ROCHESTER

steel wheel having a wide tire, and at the same time to obviate the trouble of slipping, the Boulton wheel was introduced. This type of wheel, fitted to a traction engine built by Messrs. Aveling & Porter, Ltd., of Rochester, is shown in Fig. 10. In this the felloe is a casting, round the circumference of which, or what would otherwise be the tire, are two or more rows of holes alternately spaced. Blocks of hard wood in metal cases, but with their outward ends exposed, are loosely inserted in these holes and are retained in place by spring-backed bolts. The wheel in consequence has practically a wooden tire which effectually nullifies the hammering effect of the setts upon the wheel. The blocks, of course, require renewal from time to time, but this is not very expensive, and the advantages gained by this type of wheel, under circumstances which require it, are sufficient compensation. The construction of this wheel necessitates its being of considerable diameter; it is very heavy, and its initial cost is great, which causes have combined to prevent its adoption for the motor waggons.

FIG. 11.—A DOUBLE PLATE WHEEL MADE BY THE LANCASHIRE STEAM MOTOR CO., LTD.

So far as the wheels of light locomotives (or motor cars, as the new act calls them) are concerned, not one of the types at present in common use complies satisfactorily with condition number 5. The law ordains that tires shall be smooth, and consequently diagonal cross-strips at sufficient intervals to be of value are not permitted to the light road locomotive as they are to its heavy confrere.

Various other devices have been suggested and tried to overcome this greatest bane of motor transport, but mostly with doubtful or only partial success. They generally consist of some form of removable attachment to the tire, such as an outer ribbed tire in sections, or a long-link chain of special design. The former is used with Thornycroft waggons, and the latter with Savage's "Universal Carrier"

Leyland vehicles are fitted with a series of studs which are screwed through felloe and tire from the under side and sufficiently long to enable them to be screwed out beyond the tire as they wear down. This is perhaps the most satisfactory arrangement, as it is self-contained in the wheel and is always there when wanted, which is not invariably the case with detachable devices.

Such anti-slipping devices are termed snow shoes or frost studs, which is explanatory of the purpose for which they are primarily intended, and they would be of very doubtful legality if used under other conditions on the public highway. But probably no device of this kind would prove of any value upon greasy, paved roads, where it is really most in request.

Perhaps the most hopeful and certainly the most interesting wheel for heavy motors is that recently invented and introduced by Mr. Gare, of Liverpool. This wheel is illustrated in Fig. 4. So far as the writer has been able to judge of it from a few months' actual experience, this wheel would appear to comply very well with all the requirements enunciated, except perhaps where special circumstances necessitate a very broad tire.

The wheel is constructed of wooden blocks which are cut wedge shape at suitable angles, and placed tangentially to the hub. The tread or wearing surface is formed of V-shaped blocks which fit into the centre blocks, but which are insulated from them by a bed of soft rubber so arranged that the load is distributed over a large surface. The elasticity of the rubber, consequently, is not destroyed by excessive pressure and long usage.

The wooden blocks are thoroughly impregnated with a special rubber solution, making them impervious to the effects of wet or dry, heat or cold. The blocks are held together by steel bands round the face of the wheel, but in such a way as not to restrict the working of the wearing surface blocks while yet distributing the pressure at the surface of contact with the ground over a large proportion of the rubber.

There is no tire proper with this wheel, the wear being taken partly on the rims, but mostly on the wood, and both can be easily renewed when necessary, though it would appear that the amount of wear to be obtained is very much greater than might be supposed.

The construction of this wheel makes it impossible for any shock to be conveyed direct to the nave, any vibration being distributed over and absorbed in the wheel. The resilience of this wheel is extraordinary, while it combines the further advantages of silence and non-slipping qualities.

This article does not profess to treat the subject fully, but only to indicate the difficulties, requirements, and a few types of wheels in general use or specially deserving of notice. To mention all the wheels, which have been designed of late years to overcome the disadvantages, real or supposed, of existing types, would require a volume. Some are ingenious, but have never found a market, while others can be classed only as freaks. But there is room for a really satisfactory motor-driving wheel which shall fulfill all the conditions mentioned in this article, and motor users are anxiously awaiting it.

SIGNALLING IN WAR SERVICE

WITH TELEGRAPH AND TELEPOHNE

By M. C. Sullivan

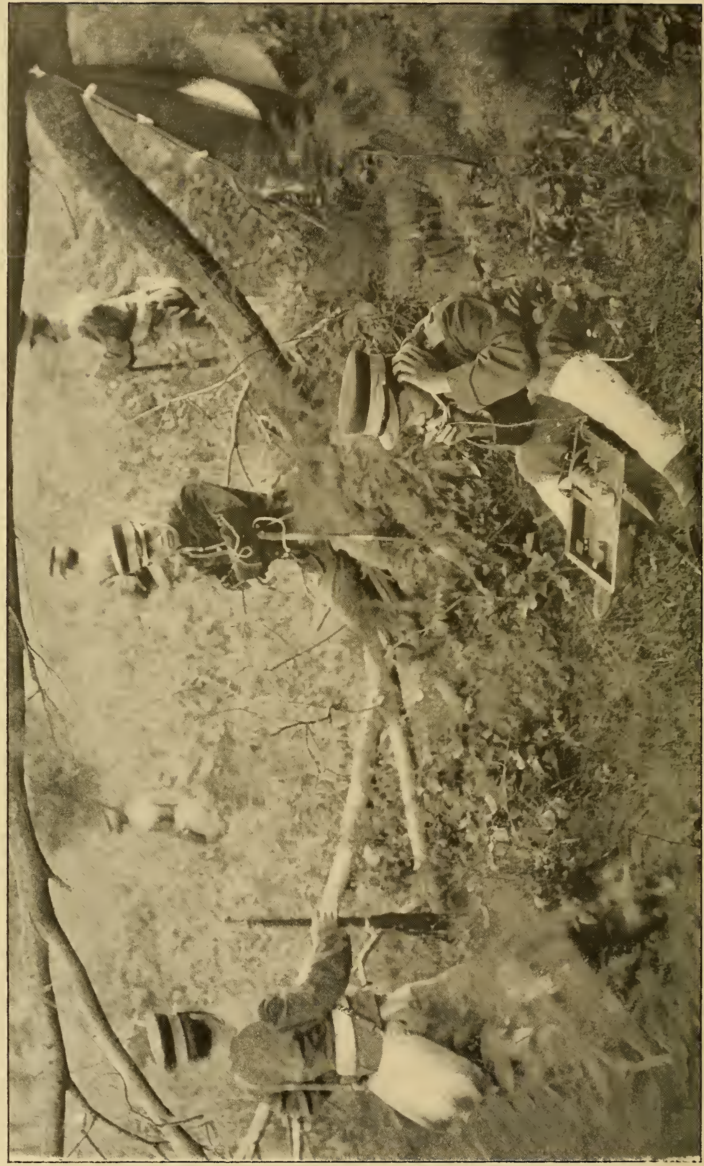
A JAPANESE TELEPHONE OUTPOST

THE lesson which the Japanese have taught the Russians on the plains of Manchuria, and incidentally the entire world, is that the science of war has become so exact and its instruments of execution so terrible that individual or national heroism, when pitted against long-range rifles and cannon, smokeless powder, high explosives, and electrical methods of communication, manipulated by men of skill and ingenuity, can no longer be depended upon in determining the result of war.

It is not so much the bravery of Japanese soldiers that is causing the world to wonder at their prowess, as it is their ability to carry out the superb strategy of their generals, avail themselves of the most intricate of mechanical aids to warfare, and do it in the certain, frictionless manner of well-oiled machinery. To the layman reading descriptions of the recent battles in Manchuria, and comparing them with the world's great conflicts previous to ten years ago, the greatest difference perhaps will seem to be in the massing of troops for hand-to-hand struggles in the earlier fights, and the open formations and long-range firing in the others; this difference results largely from the vastly improved weapons in use by the armies now in conflict in the far East.

The student of military affairs will see, however, that the most striking difference is in the comprehensive signal service of the Japanese Army as compared with the crude and unreliable means of battle communication used in the great fights of the past. From an intelligence department depending upon messengers on foot and on horseback, upon the slow and unreliable "wig-wag," and other visual methods, to the best-equipped, officered, and manned electrical signal corps that has ever appeared on a battlefield, is the main difference between the older armies and the new one of Japan.

It has often happened that battles have been rendered abortive and indecisive because neither of the oppos-



THE TELEPHONE IN JAPANESE FIELD SERVICE

PHOTO COPYRIGHTED BY G. UPTON HARVEY

A WIG-WAG STATION

PHOTO COPYRIGHTED BY G. UPTON HARVEY

ing commanders was able to keep himself informed as to what was taking place even at short distances away to the right or left of his position. The Japanese generals, mindful of Napoleon's maxim, "le secret de la guerre est dans le secret des communications" (the secret of war is in the secret of communication), and the knowledge that many of the disasters which have overtaken armies was due to inadequate means of intercommunication, caused the military geniuses of Japan to develop a signal system that would do away with the transmission of orders and intelligence by slow and uncertain foot and mounted orderlies. The result has been that electricity has never before played so important a part in warfare as it does with the Japanese.

Every general of brigade in the field is connected by wire with his division commander, and the generals of division are in touch by telegraph or telephone with the corps commanders. The necessity of sending aides in every direction with dispatches and reports is a thing of the past. Through the telephone system the commander-in-chief can communicate with all his subordinates, and where two or more of these subordinates are engaged in the same movement, they can keep in touch with one another and develop the plan in absolute unison.

There is something almost humorous in the idea of the commander of a regiment calling up by telephone a brother officer commanding another regiment some wild night among the Manchurian hills and asking him if he is ready for some desperate charge, just as one might ask a friend to meet him at supper after the theatre; but where victory or death hang in the balance, the knowledge that the other man is ready is worth much. By thus

JAPANESE FIELD SIGNAL HEADQUARTERS

FROM A COPYRIGHTED PHOTOGRAPH BY G. UPTON HARVEY applying modern methods of electrical communication, the effective strength of the Japanese Army in the field is much greater than its size would indicate. The work of their signal corps is largely the work of the electrical engineer. Visual signals for communication in the field, except in isolated instances, have been relegated to secondary place.

The Japanese, with their natural ability for adaptation and development, would not tolerate any method of communication but that which would bring the most distant outpost of Manchuria within a few minutes of Tokio, and enable the Mikado to maintain touch with his troops. The result has been seen all through the present war with Russia in the evolution of the Japanese Army, which in the complete subordination of its often widely separated parts, and the absolute and instant control exercised by the commander over the whole field of operations, shows a mechanical accuracy of movement and direction that seems either instinctive or wonderfully fortunate.

In all their operations, the lines of communication follow the movements of the troops. Thus, the Japanese officers, whether in camp or on the firing line, are in instantaneous touch with every portion of their commands both night and day, without regard to distance, weather, or topographical conditions. The extraordinary strategical combinations which they have made against the Russian Army are the greatest military marvel of modern times, and have blocked the advance of a nation whose vaunted aggressiveness and might made it a terror to the world.

If war to-day were a matter simply of might and physical courage, as it was in olden times when men fought with swords and battle axes, there would be little likelihood of Japan gaining even a single victory against a nation like Russia. In the use of high explosives, and in the rapidity of fire from infantry and artillery, no advantage lies with the army of Japan. But the Japanese have called upon the inventor and the skilled electrician to aid their military and naval commanders, to a far greater extent than have the Russians. Both the telegraph and telephone, but particularly the latter, have been chiefly responsible for their victories.

The operations of the Japanese since the commencement of the struggle comprise many of the most interesting tactical combinations ever undertaken in war. These features have been conspicuous in every department of their army. Many military experts have spoken in terms of the highest praise of the Japanese commissary and medical departments. It is the general opinion of those experts who have witnessed the field operations in Manchuria, that the effectiveness which these departments have shown is largely due to the excellent communication maintained at all times between both temporary and permanent camps.

In even a greater degree does the Japanese signal service contribute to the success of their artillery movements. This is due to the fact that the artillery commander can locate his observing stations at distant points from which the effects of the fire can be noted. These stations as well as the different batteries being connected by telephone with the artillery headquarters, give an artillery commander an extraordinary power of control, and upon his skill depends to a great extent the success or failure of a battle.

Although the Japanese Army depends chiefly on the telegraph and telephone for communication, their signalmen are adepts in the visual methods, and do not hesitate to use them if necessary, whether it be wig-wagging or heliographing by day, or lights by night. The wig-wag can be worked successfully up to 10 or 12 miles, but only under the best weather conditions and by the use of powerful telescopes. The ordinary range, however, is about 6 miles, and even then its usefulness at the front is impaired by the fact that frequently the signal-

HELIOGRAPHING FROM A HILL TOP

PHOTOGRAPH COPYRIGHTED BY G. UPTON HARVEY

man must expose his position to the enemy.

The heliograph is an instrument of great range, and can successfully be used, under perfect conditions, up to 50 miles. In this instrument, mirrors are so arranged that rays of sunlight may be projected in any desired direction, a shutter being used to interrupt the flash. Ordinarily, it must be used from an elevated position in order that the flash be not intercepted by obstructions. But it is at the same disadvantage as the wig-wag, in that the operator exposes himself to the enemy. For night signalling, powerful flash lanterns having about the same range as the wig-wag are sometimes used. While the visual systems have the advantage of simplicity and ease of operation, they are practically useless in bad weather or in rough country where the view is much obstructed.

The telegraph is used to greatest advantage in the rear of an army, where the lines of communication are long and well protected. The telephone has practically all the advantages of other means of communication and none of their disadvantages. It has also many advantages peculiar to itself. The Japanese use it as the principal instrument for field work.

The extensive use of the telegraph, and the still more extensive use of the telephone, require the services of trained electricians and telegraph operators, and the Japanese have supplied them by drawing men from all departments of electrical work throughout the country. The army thus gains the advantage of the years of training which these men have secured in industrial life. The work which they are doing in the field very closely resembles that which they have been doing as a means of livelihood in times of peace. The difficulties are, of course, greatly increased, but since the best electricians in Japan are at the front, no obstacle, it seems, has been encountered by them too great to overcome.

The rapidity with which the Japanese establish telephone communication is remarkable. Lines are laid well in advance of the main body of troops, even when the army is advancing by forced marches, and perfect connection is maintained at all times between the different divisions. Wherever conditions permit, the reels of wire and the instruments are carried in waggons. The line is laid on the ground as rapidly as horse-drawn vehicles can advance. If the line so laid is to become permanent, a detail follows the waggon at leisure and attaches the wire to trees or hastily erected supports.

For "flying lines," or lines in the zone of action, which connect the commander's headquarters with the various divisions on the firing line, the detail following the reel waggon merely lays the wire in protected places on the ground where it is least likely to be disturbed. These lines may be taken up, moved, or abandoned, as the occasion demands. Where the nature of the country or other conditions render the advance of a waggon impossible or inexpedient, the line is advanced by men carrying coils of wire on their shoulders.

The scouting parties as they advance to observe the enemy or obtain information regarding the country, are accompanied by telephonists, who uncoil their line as the scouts move forward. The scouts are thus able to report their observations directly to their commanders and receive instructions from headquarters. When the scouts are called in or are forced to fall back, the line may be recovered by the telephone men, or abandoned after disconnecting the instrument. If the scouts are captured, the operator at the other end of the line is made instantly aware of it by the cessation of signals, and the line is useless to the enemy.

It is thus evident that the use of the telephone in the field eliminates the time element in the transmission of orders and information, and is a guarantee against mistakes. It also affords a means of communicating orders with absolute secrecy.

In some great battles, divisions have been left idle for hours and much-needed reinforcements have been held in check, with resultant disaster, because the means of rapid communication was lacking. It has occurred, also, that a retreat at one point and an attack, real or feigned, at another, would have saved an army from defeat,—movements that were not made because the commander lacked information of what was taking place at these points, or if he was informed, lacked the means of promptly ordering the necessary moves. That the Japanese commanders are at no such disadvantage is made clear by their successfully outclassing the Russian strategists in the field all the way from the Yalu to Liaoyang, by their great victory in overcoming the formidable fortifications on the land side of Port Arthur, and also by their recent advances, which have forced the Russian army back, almost in rout, to Mukden.

ELECTRICITY FROM WATER POWER VERSUS GAS

By Alton D. Adams

GAS is falling behind in competition with the transmitted energy of falling water. This is true in the three fields of light, heat, and motive power, and is best illustrated at the present time in the United States, where the building of large hydro-electric plants has been going on at a rapid rate.

One proof of the comparative gains of transmitted water power is found in its rapidly increasing use at points where gas rates are the lowest. Take for illustration the three great American centres of transmitted energy from waterfalls, namely, San Francisco, Buffalo, and Montreal. At each of these cities the net price of illuminating gas is very nearly, if not exactly, $1, or 4 shillings, per 1000 cubic feet, and this is as low as such gas is usually sold anywhere in America.

In spite of this low gas rate, the sale of electric energy from distant waterfalls has risen during half a decade from almost nothing to 10,000 horsepower in San Francisco, more than 20,000 horse-power in Buffalo, and nearly 30,000 horse-power in Montreal. These figures do not represent merely the results of substituting water for steam power at electric generating stations, but correspond in large part to increased loads on the electric supply systems.

Whatever have been the changes in the volumes of gas distributed in these three cities during the past five years, it is very safe to assume they can show no such increase as that just indicated for electricity from water power. This conclusion is supported by the fact that at Montreal the gas output increased only 6 per cent. between the year ending April 30, 1903, and the year ending April 30, 1904. During the same period the combined income from sales of both gas and electrical energy in Montreal increased 13 per cent., and almost all of this energy was transmitted from water power.

In Hartford, another city that has drawn most of its electrical supply from water power since the year 1900, the number of kilowatt-hours distributed during the year of 1903 was 28 per cent. greater than the number for the year of 1901. This increase in sales of electric water power has taken place in the face of a gas rate of $1 per 1000 cubic feet.

Referring again to the case of Buffalo, it may be stated that, besides illuminating gas at $1 per 1000 feet, the city is supplied with natural gas at only 30 cents per thousand; this natural gas, as is well known, has a heating power of about 1000 units per cubic foot, or 50 per cent. greater than that of illuminating gas as regularly made.

The failure of gas to hold its own in competition with electricity developed by water power is due in part to the superiority of the electric service, and in part to the higher cost of gas for equal results. Between gas lighting and electric lighting of equal candle-power at the same price, few consumers would hesitate to choose the latter, not only because of its more pleasing quality, but also on account of the added fire risk with the gas flame and its vitiating effect on the air. At the same cost of operation per horse-power-hour, who would not choose the clean, cool, silent electric motor, with its great overload capacity, rather than a steam or a gas engine? So also in the matter of heating and cooking, the gas stove with its fire risk, its offensive odours, and its constant outpour of the products of combustion, is far less desirable than the safe, odourless electric heater that works no change in the composition of the air. But the price is the great arbiter of choice, so let us now see whether electricity costs more or less than gas.

It takes an extra good quality of illuminating gas to yield 16 spherical candle-power at an open bat's-wing flame that consumes only 5 cubic feet per hour. At the lowest regular rate for illuminating gas from even the largest plants, namely, $1 per 1000 cubic feet, the cost of the 16-candle flame is thus ½ cent per hour.

In many places supplied with hydraulic-electric plants, the rates for energy used in lighting are less than 10 cents per kilowatt-hour, but even at this rate the cost of operating a standard 50-watt, 16-candle-power incandescent lamp is only ½ cent per hour, or the same as that for the gas flame of equal illuminating power. Of course, more illumination per cubic foot of gas can be obtained with mantle gas burners than with an open flame, just as the arc lamp gives more light than the incandescent lamp, per unit of energy. But despite this advantage of mantle burners, their cost and the undesirable quality of the light they give prevent their general use for interior illumination.

Gas of so low a price as $1 per 1000 feet is not available in the great majority of cities and towns that are supplied with electricity developed by water power, because the cost of gas manufacture depends much on the size and rate of operation of the plant where it is made. This fact makes the comparative rates of gas and electricity for lighting in the majority of places that are supplied with electrical energy from water power, even more favourable to electricity than previously indicated.

In the matter of general heating, illuminating gas is sometimes thought to have a great advantage over electrical energy, but this supposed advantage is not so evident upon analysis. Good illuminating gas yields about 650 heat units per cubic foot with perfect combustion, but where the combustion is imperfect the heating effect is much less. In any event the gases of combustion carry away a large percentage of the heat developed, and as these gases must be discharged into the outer air to avoid vitiation of the atmosphere in heated buildings, the heat that they contain is lost. Through imperfect combustion and the loss due to the high temperature of its products, the heat available from gas is probably reduced by as much as 50 per cent., or to no more than 325 units per cubic foot. At the low rate of $1 per 1000 cubic feet, the 325 heat units are thus obtained for 0.1 cent.

One kilowatt-hour is the equivalent of 3438 heat units, and when that amount of electrical energy is expended in a heater the exactly corresponding amount of heat energy is developed. Where electric energy is devoted to general warming, there is no loss whatever between the heater and the air of the building. Because of the fact that electrical energy for general warming can be used at those times of day when other loads are comparatively small, and because no exact regulation of pressure for the heating load is necessary, a rate as low as 1 cent per kilowatt-hour is not infrequently made for it in hydraulic-electric system. This rate gives 343 heat units for 0.1 cent, in comparison with the 325 units obtainable from gas. In some cases the rate for electric energy from water power drops as low as 0.5 cent per kilowatt-hour for heating purposes, thus giving 686 units for 0.1 cent.

In the field of industrial heating for cooking, welding, the reduction of certain chemical compounds and the like, electrical energy from water power has a great advantage in cost over gas, because of the rapidity of the electric action and its power of concentration at a particular point. Take for instance an electric welding machine at work on steel frames for carriage "dashers"; here at least a score of electric welds are made in the time that would be required for one made with gas heat.

Little is now heard of the gas engine in competition with electricity developed by water power, for the simple reason that gas has been completely distanced in the race. With gas that yields 650 heat units per cubic foot, a good gas engine at nearly full load will develop 1 horse-power for each 20 feet of gas consumed per hour. The cost of gas per horse-power-hour is thus 2 cents at the lowest regular rate of $1 per 1000 cubic feet. At partial loads the efficiency of the gas engine falls rapidly, and the cost of its power therefore rises.

One kilowatt of electrical energy will develop fully 1 brake horse-power in all motors save those of the smallest sizes, when loads are varying from one-half to full capacity. As electricity from water power is frequently sold as low as 1 cent per kilowatt-hour for motive power purposes, it is no wonder that successful competition of gas engines with electric water power is difficult to find in practice.

HANDLING COAL FOR THE POWER HOUSE

By H. S. Knowlton

At every step in the design of a power plant it is important to realise that the generation of electricity, whether it be from the potential energy of coal or the kinetic energy of a waterfall, is a manufacturing process. Precisely the same methods of obtaining operating efficiency apply to the establishment where the output is kilowatt-hours as in the plant where the product is shoes or machinery. In laying out a plant, therefore, which is to produce electric power at a profit, we must select equipment of the proper proportions, install it with due regard to the sequence of operations which mark the transformation of energy from the coal pile to the bus-bar, and finally, operate the plant with a minimum expense for labour consistent with reasonable demand upon the men and reliable service.

The handling of coal is the first process to be considered. The subject is too large to be effectually disposed of in a few paragraphs, but it is certainly worth while to emphasise a few points which are often overlooked in the design of power plant fuel supply. In most modern factories the force of gravity is utilised at every possible point in the handling of material. The manufacturer has long realised that the cheapest way to transfer material from one place to another is to let it fall to the desired place. Hence, one often sees a factory in which the raw material goes to the elevators but once, and then to the top of the building, whence it falls, stage by stage, to the shipping floor, practically without the touch of hands, as far as its transportation is concerned.

Many of the larger power plants are so designed that the coal is fed to the boilers by gravity, but a still greater number of small or medium-sized plants are operating to-day under conditions which demand two or three handlings. Sometimes the local conditions in the way of restricted space prevent anything better, but this is not the general situation. The cost of an extra helper or two in the boiler room does not look very formidable at $1.50 per day each, but the matter appears different when these wages are capitalised. At 5 per cent. interest it pays to spend almost $9000 to eliminate such a man if he works but 300 days a year, while if he works every day in the year, it pays to spend at least $10,000 to replace him. Of course, in figuring a particular case of replacement, the fixed charges and operating expenses must be taken into account, as well as the comparative performance of both man and machine.

It would scarcely seem necessary to say that coal should be brought to the power station as directly as possible, dumped by gravity into a place where it will have to be handled but once, if at all, on its way to the furnaces, always weighed by the consumer, and stored in bins which can be reached in case of fire. In some cases it may pay a consumer to rent or own his coal cars, in order that he may secure the benefit of the gravity dumping type. It is a waste of time and money to shovel coal out of cars into bins situated below the track level, and yet more than one plant pays the cost of such needless work to the railways.

Sometimes a plant will install an elaborate gantry crane for the purpose of transferring coal which has been dumped from the cars to a certain level to storage bins at the same level. It would seem as though the investment of perhaps a little more money in railway tracks and switches would have cut down the cost of handling the fuel by eliminating one dumping. After going to the expense of installing and operating the crane, the coal is sometimes allowed to fall into small cars which must be pushed by main strength of human muscle into the boiler room. The results in the cost of handling are obvious.

Separate bins or storing compartments, with fireproof bulkheads between the different sections, are potent preservatives when a fire starts in one corner of the coal pile. In like manner, the coal pockets are good places in which to install thermometers and automatic thermostat alarms. No chances of losing the coal supply should be taken. Fire hose and plenty of water available are the essentials in case of trouble.

Power plants located on tide water can generally be designed for the minimum of coal handling. Usually it is impossible to avoid hoisting the coal from the barge, but if this is done with a motor-driven hoist discharging into a mechanical conveyor system, or better, directly into the main bins, the cost of handling will be brought down as low as is possible. When the power house is located on an inlet which is too shallow for coal barges and tugboats to enter, the only recourse, except dredging, is to haul the coal from the wharf to the power station. This should be done in the company's own coal cars, and not by teams, as is sometimes the case.

The question sometimes comes up as to the quantity of coal which should be stored at the power house bins. There is no definite answer, for the problem depends upon the size of the plant, the capacity of local coal yards, the cost of coal, amount used per day or week, available space, time to obtain deliveries, etc. In general, it is safe to keep several weeks' supply on hand, as the interest on the real estate charges, including the cost of bins, plus the interest on the coal, is a small sum compared with the loss which the community and the company would sustain in case the plant had to shut down for lack of coal. The danger from fire should never be urged as an argument against keeping coal on hand. Improvement is possible in many coal-handling plants through the use of fire-resisting steel or concrete in place of wooden structural parts.

The ideal coal-handling plant is one in which no coal is wasted. It is very common to see coal scattered about the yards and boiler rooms of power stations to the detriment of both the appearance and the economy of the outfit. A little care in this respect will repay the trouble which it takes. In practice, it is seldom possible to obtain the results secured with a perfect plant, but such results can at least be approached by an intelligent consideration of each installation.

THE WATER SUPPLY OF COUNTRY BUILDINGS

By Wm. Paul Gerhard, C. E., M. Am. Soc. M. E.

PART I.—GENERAL CONSIDERATIONS

IN a former article on "The Water Supply of Modern City Buildings," printed in this magazine for October and November, 1904, I discussed the various arrangements for inside water supply. In the case of buildings in the country, the engineer engaged in the problem of water supply has to look, not only after the *inside* water supply, but he must, in the majority of cases, also provide, plan, and design the entire *outside* water supply system.

In building a country home or in locating a public institution beyond the limits of a city, the need of a pure, reliable, and ample water supply should be one of the chief considerations. In advising on the methods of obtaining it and in preparing the plans for it, a great many points have to be considered. The advantages and disadvantages of the different schemes, which offer a possible or a suitable solution of the problem, must be carefully weighed before making a decision. Rather than make a decision for themselves, owners of country mansions or estates and superintendents of institutions should seek the disinterested advice of a competent engineer.

The order in which the different points of importance are taken up is usually as follows:—The available sources of supply, be they springs, wells, brooks, rivers or lakes, surface water, or rain water, must be examined. The location of the proposed source of supply usually determines the question whether a gravity supply or a pumping system has to be adopted. The quality of the water to be used is of the foremost importance; its determination involves chemical and bacteriological analyses, as well as examinations of the water sources, their surroundings and of the water shed. As a rule, mountain springs and deep wells yield pure and wholesome water; shallow wells and water from rivers or ponds must be considered dangerous until their purity is established; cistern water and surface water from cultivated farm land must be viewed with suspicion.

Means for the prevention of the contamination of the source of supply must in many cases be provided, while in others, measures or methods for the purification of the water have to be designed and planned. The quantity of water available from the source selected must be compared with the quantity estimated as the probable consumption; it is likewise necessary to determine, at the outset, the water pressure required for domestic use and also for fire protection. Should the water have to be pumped, various systems may be adopted, such as pumping to a reservoir, to an elevated tank, to a stand pipe, to house tanks, or else the water may be pumped directly into the mains or into pressure tanks.

This subject naturally leads to the consideration of the next matter of importance, which is the determination or selection of the pumping plant and of the power to be used for lifting the water. This, in the case of the smaller farm buildings, may be hand power or animal power; in the case of larger country houses, gas, hot air, gasoline, oil, electricity, the force of the wind or the power of water; in the case of institutions, it may be either steam or electric power.

The water to be pumped must be stored in reservoirs or tanks, and here again several methods are available, such as the construction of a stone or earth reservoir, the erection of wooden or iron tanks on wooden, iron or masonry supports; the building of a stand pipe, either open or enclosed, and finally the use of pressure tanks, located either in the cellar or outside of the building and underground. After pumping and storing the water, it must be brought to the buildings where it is to be used; this involves the consideration of the inside and outside water supply distributions and the arrangement in detail of the water piping. Of the greatest importance in the case of country houses or institutions, located far away from the protection which a good city fire department affords, is the provision for indoor and outdoor fire protection appliances, for which an ample volume of water must be instantly available.

In determining upon a source of supply, it is well to bear several facts in mind, namely, first, that the nearer it is to a settlement of houses, the smaller will be the cost of a water supply system, but the greater becomes the risk that the water may be, or may become, unfit or dangerous for use; second, that surface sources, such as springs, dug wells, and shallow driven wells yield, as a rule, a supply limited in volume; third, that where larger pure supplies are required, deep or artesian wells should be provided; and fourth, that the latter are not liable to pollution from surface impurities.

In some parts of the country springs yielding a pure water abound, and it is, of course, best if they are found located at an elevation considerably higher than the house and grounds to be supplied, so that the water may flow by gravity. A spring issuing from the soil at a lower level than the house to be supplied always requires some form of pumping machinery.

In contemplating a supply by tapping a spring, it is of the greatest importance to give attention to the variation in the yield of the spring, which may occur regularly at the different seasons of the year. It often happens that when a spring, examined only in the early months of the year, is selected, it will be found that its flow becomes so reduced during a dry summer or early autumn as to be quite insufficient for the requirements of a building. It is obviously much safer in such cases to defer the examination or the gauging of a spring until dry weather sets in, and to select a spring only in case it yields, even at such times, an excess of water over the supply required. For the protection of the spring against contamination it is necessary to wall it in and to construct a small storage basin to store up the night flow and to hold a reserve of water. This basin should have a tight cover, or a house built around it, to exclude surface impurities, dust, light, and animals.

Wells are used in the country more than all other sources of supply. Water from wells is really rain water which has percolated through the soil down to a water-bearing stratum; it is rain water purified by natural filtration through percolation, but sometimes changed in character by reason of having taken up mineral constituents of the soil; it is underground water the same as spring water, but in the case of the spring the water has found or forced a natural outlet, whereas wells have to be dug, driven or drilled and the water must be lifted. Although it is usual to distinguish between shallow and deep wells, there is no sharp demarcation between the two, and the designations "shallow" and "deep" really refer more to the nature of the subsoil into which a well is driven than to the depth of the well. Wells which are sunk to a depth of from 15 to 30 feet into a superficial layer of gravel or sand, which, in turn, rests on an impervious stratum, are considered to be shallow wells; deep wells are those which go through earth or rock to tap a water sheet at a greater depth.

Nearly all shallow wells must be looked upon with suspicion because they are liable to become, or to be, polluted, particularly in populous districts, but not to a lesser degree on the farm when located close to outhouses and cesspools, or to a stable for horses or to cow barns. Shallow wells are constructed either by digging a hole of sufficient diameter, and lining it after completion with stone or brick walls—the so-called "steining" of wells (see Fig. 1)—or else they consist of small wrought iron tubes, $1\frac{1}{2}$ to 3 inches in diameter, driven into the ground to the depth of the underground supply (see Fig. 2). It should be noted that the diameter of a well has not so great an influence on the yield of water as is commonly thought.

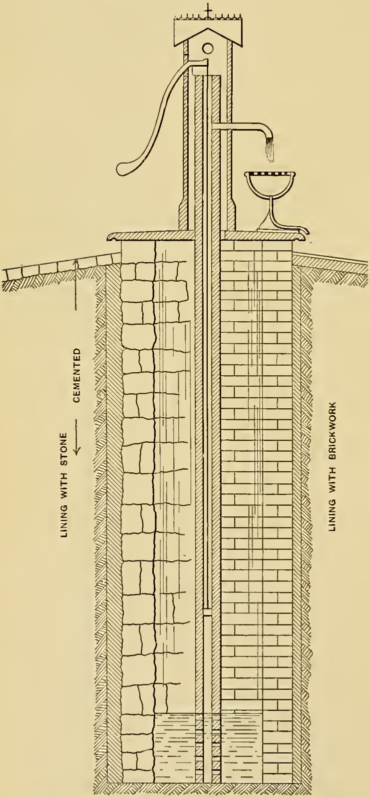


FIG. 1—A WELL PROTECTED AGAINST SURFACE POLLUTION

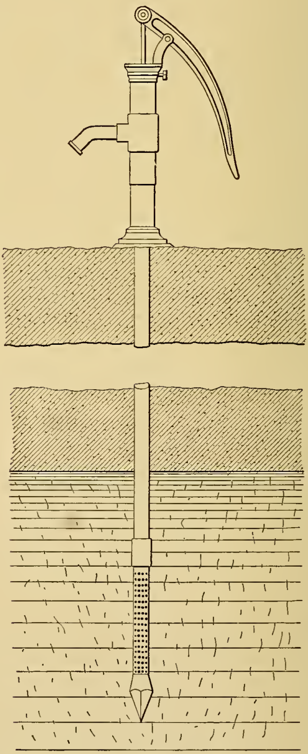


FIG. 2—A DRIVEN-TUBE WELL

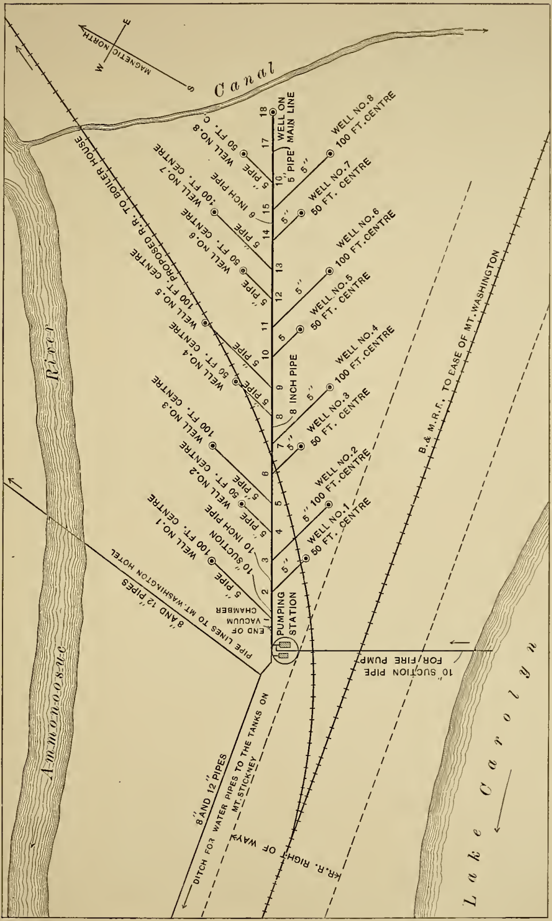


FIG. 3—PLAN OF A WATER SUPPLY SYSTEM, SHOWING THE ARRANGEMENT OF BATTERIES OF WELLS

Deep wells in sandy or gravelly soil are driven or bored with tools similar to an auger, or else a casing is forced through the earth, into which the well pipe is inserted after the proper depth has been reached. In other cases, particularly in rocky strata, driven wells are drilled with special well tools or chisel drills, which are alternately raised and allowed to fall, being at the same time rotated. Deep wells are very often designated as artesian wells, though, strictly speaking, the latter term should be applied only to such wells in which the water flows out on the surface.

Wells of a moderate depth usually yield a good quality of water, whereas very deep wells give, as a rule, a hard water, unsuited for boiler use and in the laundry. Wells located near the sea-shore sometimes yield brackish water, if the rate of pumping from the well exceeds the normal flow. Along the southern Atlantic Coast of the United States many deep wells are driven, which, though charged with sulphur gases, yield a good water for the reason that the sulphuretted hydrogen is soon given off.

Wells taking the water at a great depth from the surface, are usually more permanent than surface supplies, but they are much more expensive. Where subterranean waters are to be utilised for supplies, the engineer would derive valuable assistance from the knowledge of an expert geologist. In certain complex problems the latter's services are, indeed, indispensable. The tubes for deep driven wells must be large to accommodate the deep-well pumping appliance; as a rule, the diameter is from 6 to 10 inches. In pumping water from deep wells the working plunger must usually be located at a great depth below the surface and is not readily reached for repairs.

If one is obliged to use an open cesspool for the drainage of the building, which method is never to be recommended, it is of the greatest importance, in locating a dug or driven well, to examine first into the direction of the flow of the underground water. In one particular locality which I have in mind, many wells on farm properties may be found located "above" the cesspool, the contention apparently being that any soakage from the latter into the underground water course will not contaminate the well, as the flow will be away from the well. In this locality one frequently encounters the assertion that those wells which have a source of contamination above them are dangerous to health, whereas those which have cesspools below them are safe. It should be understood that the words "above" and "below" refer not to the slope of the surface, but to the direction of the underground flow, but even with this understanding the proposition is not by any means always true.

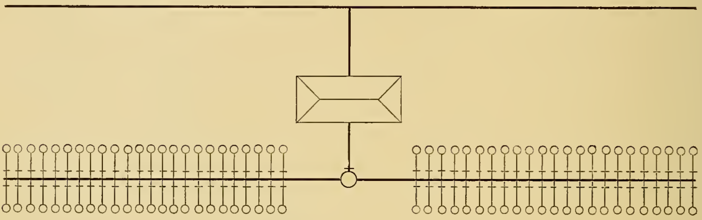


FIG. 4.—ANOTHER PLAN OF WELL BATTERIES

Pumping a large volume of water from a well without doubt would alter the above conditions, for its effect would be not only the lowering of the water in the well itself, but also the

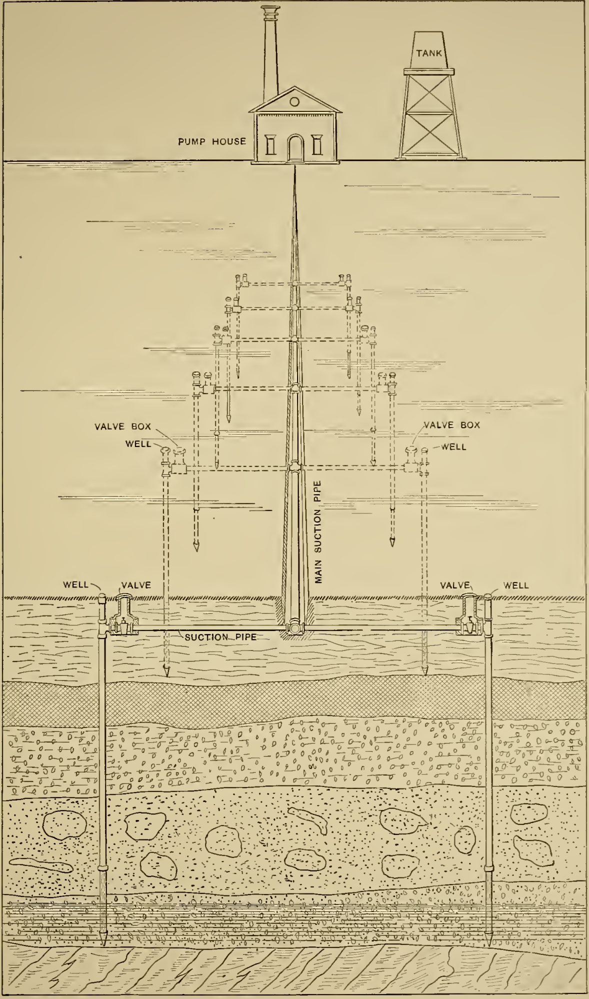


FIG. 5.—DIAGRAM SHOWING CONNECTION OF WELL BATTERIES WITH A PUMPING STATION

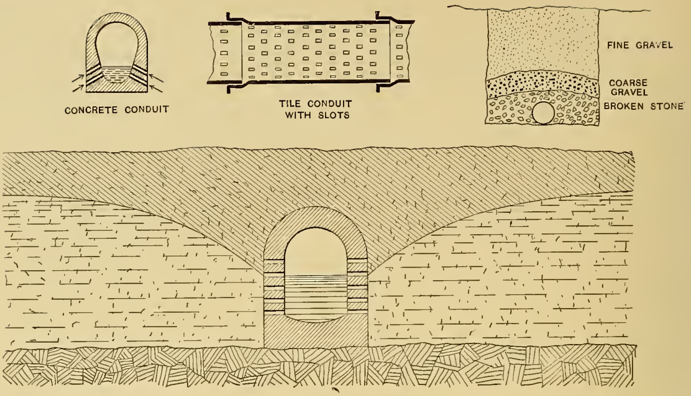


FIG. 6.—COLLECTION OF UNDERGROUND WATER THROUGH A BRICK COLLECTING GALLERY

lowering of the surface of the underground water sheet for a certain distance all around the well. This distance, as is now well known, would increase with the amount of the pumping and thus sources of contamination, like outhouses or cesspools, which ordinarily might be beyond the influence of the well, may be brought within the zone of contamination.

The question whether a well may or may not become contaminated by a cesspool is, therefore, not merely a question of distance and of depth, but the means for drawing the water from the well must be considered. With an old-fashioned bucket, drawing only a few gallons at a time, the danger may be very slight, whereas if a large pumping engine should be put over the same well, the risk may become such as to render the use of the well prohibitive. Care should be exercised in so arranging all dug wells that they are well protected against surface pollution by arranging at the top a tight covering to shed all surface water and by providing the upper end of the well with a water-tight lining or wall, several feet deep, as shown in Fig. 1.

Driven or tube wells are, in the majority of cases, much safer than dug wells, because there is not the same amount of danger of pollution by surface leakage. On the other hand, it is true that very often a driven well may yield water unfit for drinking because the water comes from an already polluted underground water stratum. Where a large volume is required, several wells are driven and then connected together, forming a battery of wells (see Figs. 3 and 4). The manner of connecting the wells to a pumping station is shown in Fig. 5. Where such a system of driven wells, all connected to one suction line, is used, there is apt to be trouble with air and the greatest care is required to make the suction pipe line perfectly tight. It also happens at times that one well may rob the adjoining one of water, particularly if the rate of pumping is excessive.

Another method of utilising the subterranean water is to have a horizontal collecting gallery, built either of glazed earthen pipes of large size and provided with numerous slots, or by building a brick collecting gallery, open at the sides (Fig. 6), the bottom of the conduit being located on the level of the impermeable stratum. This conduit for underground water should terminate in a brick well from which the water is pumped, while at the same time any sand or gravel carried in the water is deposited at the bottom of the chamber. Recent experience has shown that it is necessary, in the storage of underground waters, to keep away the light, as otherwise there is apt to be trouble from vegetable growths, imparting to the water a bad odour or taste or both.

In the country, rain water is always much purer than near large towns, but the water collected during the first part of a storm is often quite impure. Therefore proper precautions should be taken to let the first washings from the roofs run to waste, and if this is done, rain water may be considered a suitable supply in the case of smaller houses or farm buildings. So-called self-acting rain water separators may be arranged on the outside conductor pipes of the house and in this way a pure supply can be secured, even in the case of large buildings or institutions, in which use of the soft rain water can be made for laundry and boiler-feed purposes.

The rain water is stored either in rain water tanks, in the attics of houses, or else in underground brick or stone reservoirs called cisterns. In determining the sizes of these, the annual mean rain fall of the locality should be looked up from meteorological records. After making due allowance for evaporation, the water supply available for storage may be calculated. Instead of merely utilising the limited roof area, portions of the surface of the ground may be used if carefully prepared with concrete and cement.

FIGS. 7 AND 8.—SURFACE WATER IMPOUNDED BY A DAM IN THE CASE OF A MAIN AND TWO SIDE VALLEYS, AND ALSO IN THE CASE OF A SINGLE VALLEY

In the Bermuda Islands, for instance, the water supply of the towns and parishes is obtained from the rain fall exclusively, the porosity of the coral rock causing the rain to percolate so quickly as to render the use of wells impossible. Every visitor to these islands must have been struck with the fact that no matter how heavily it rains, the roads dry up entirely in a few hours, owing to the peculiar geologic formation. Neither subterranean waters nor springs being available, nearly every house is provided with an underground cemented storage tank, which is connected either

FIG. 9.—HOTEL MT. WASHINGTON, IN THE WHITE MOUNTAINS, AFFORDS A GOOD EXAMPLE OF COMPLETE WATER SUPPLY AND FIRE PROTECTION. SEE PAGE 497

with roofs finished with thin slabs or slates of the coral rock, or else the tanks are connected with so-called surface catchment areas, which are specially prepared gathering areas with a good slope. These are sometimes quite extensive and are always enclosed with a railing to keep off the cattle. Underneath the artificially prepared area, and at the lowest point of this slope, an underground tank for storage of water is built. The water supply of the entire islands is obtained in this way, and great care is exercised to keep the roofs and the catchment areas pure, clean, and whitewashed.

Another source of water supply may be found in brooks or in running streams. Subterranean waters are not subject to legal restrictions, but the taking of water from open streams is limited by such considerations. A knowledge of these will prove useful to the engineer undertaking works of water supply in the country, and the law must be carefully considered before any works are planned or undertaken. These legal restrictions will be briefly taken up further on. In considering open water courses, whether brooks, or rivers, as sources of supply, it should be remembered that even in the country such streams are in many cases in danger of pollution by the surface washings from manured fields, and in the case of small rivers the water is often found to be quite impure and unfit where settlements of houses, hamlets, or villages are located above the proposed intake. The supply may be improved by providing a filtering gallery between the stream and the suction well or reservoir. Smaller streams, particularly in mountainous districts, are liable to dry up entirely in hot summer weather and should, for such reasons, be avoided as sources of supply.

The water from lakes may be used as a supply, provided there are no settlements along the shores which may cause pollution of the water. As a rule, the larger the lake, the greater the likelihood of obtaining a pure supply, but even the smaller lakes, as, for instance, those located in the mountains, in sparsely inhabited regions, may be kept fit for use provided a stringent sanitary supervision is exercised.

Water from surface streams may be utilised by collecting it in an artificial storage reservoir formed by building a dam across the valley of a stream (see Figs. 7 and 8). Such impounding reservoirs are to be found in many mountain regions where the land may be acquired cheaply, and where a generally short dam may be constructed across a narrow valley. It is, of course, necessary that there be no settlements or manured fields on the drainage area forming the water shed of the stream; the brushwood, vegetable matter, the peatty soil forming the bottom of the reservoir should be carefully removed; and in some cases strict regulations should be provided for the guarding against pollution of the water supply from a "dammed up" water shed.

Enough has been said in the foregoing to show that the problem of finding a safe and sufficient source of water supply is often beset with difficulties from the engineer's point of view.

In many water supply problems, and in particular in the selection of an available source of supply, engineering questions are not the only ones to be dealt with, for legal considerations, which must be understood and respected, govern or affect the problem. The laws on the subject seem to vary in different countries, and there appears to be a sharp legal distinction between waters flowing over the surface without a clearly marked channel, those which flow in an open natural water course, and underground waters. Briefly stated, the water flowing in an open stream is not the exclusive property of anyone. Its use, subject to certain restrictions, is given by law not only to the owner over or through whose land the water flows, but to everyone having a right of access to it. In other words, all owners of land abutting on a stream enjoy certain privileges of this stream which are known as the "riparian rights." Thus, every one of the riparian owners of a stream has a right to the *ordinary* use of the water flowing

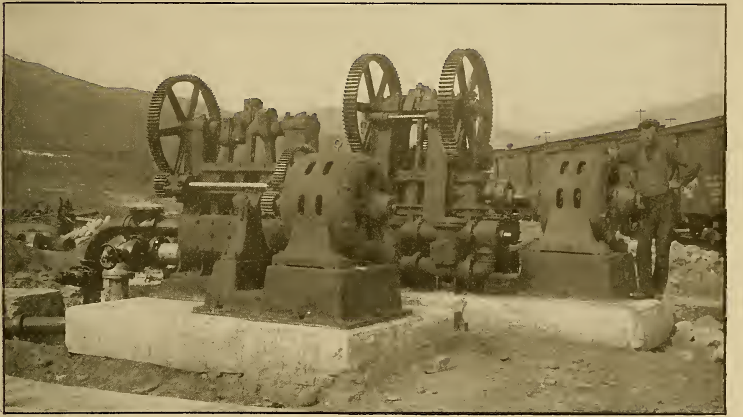


FIG. 10.—THE ELECTRICALLY DRIVEN PUMPS FOR HOUSE AND FIRE SERVICE WERE SUPPLIED BY THE KNOWLES STEAM PUMP WORKS, NEW YORK. THE MOTORS WERE SUPPLIED BY THE GENERAL ELECTRIC CO., SCHENECTADY, N. Y.

FIG. 11.—THE HOTEL MT. WASHINGTON STORAGE TANKS, EACH OF 50,000 GALLONS CAPACITY

along his premises. He may use the water from the stream for domestic supply for his house and for his cattle and horses and in this way he may diminish its volume of flow to some extent.

The right to *extraordinary* uses of the water, such as for water power, irrigation or manufacturing purposes, he has only provided that by such use he does not change its character, or diminish its flow, or make it less useful to the other owners, and in this way encroach upon the legal rights of his neighbours above and below stream. He cannot, for instance, intercept the regular flow of water in the stream for the purpose of a water supply of a settlement of summer cottages to such an extent as to interfere thereby with the rightful uses of water by the other riparian owners. Also, he must not discharge domestic or manufacturing sewage into the stream and thus render the water impure or polluted. Those living further down stream must not by his acts be robbed of the ordinary water which they as well as he require for water supply in the home, for the farm, etc. The rights which they have by law can be interfered with only provided there is a mutual understanding or where a legally sufficient compensation is given.

On the other hand, in the case of underground water, no such rights of neighbours are entertained by the law,

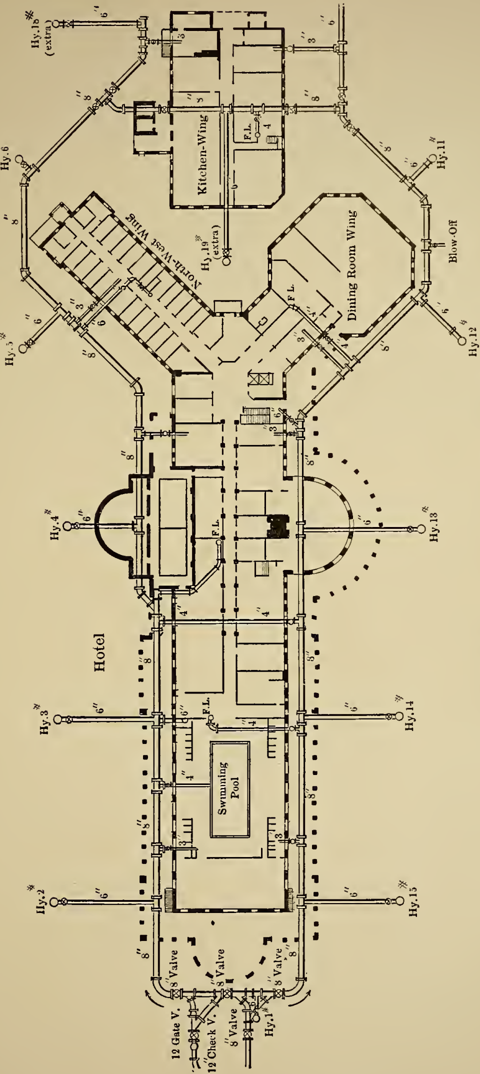


FIG. 12.—GENERAL PLAN OF WATER DISTRIBUTION ABOUT THE HOTEL

hence anyone may dig or drive on his own property a well, of any depth, to tap the underground sheet of water, irrespective of the fact that by so doing he lowers the water in the well or in the springs of his neighbours. An exception to this rule is made by law only in the case of subsurface water which flows in a defined channel.

Surface waters, finally, unless they constitute by law a stream with channel confined between two banks, are not subject to any legal restrictions.*

From the foregoing it will be seen how necessary it is, in the case of country water supplies, for the engineer to become thoroughly acquainted with the legal aspects of the case. It will be found that in the plans for water supply for country settlements it is often advisable or necessary to arrange suitable terms with the owners of the land on which a spring is situated, or in other cases with the riparian owners of a stream from which it is proposed to take a water supply.

In the case of gravity supplies, it sometimes becomes necessary to run conduit pipes across other land, and this cannot be done unless an easement is first obtained, which gives one person the privileges of right of way and also the right of entry for necessary repairs. The person who obtains the easement acquires thereby also certain rights against the neighbour, for instance, the right that he can enjoin him from building houses or planting trees over the line of easement. It would, therefore, seem necessary that a proper compensation should be given for the rights acquired by the easement.

The sources of supply considered in the foregoing may, in reference to the building to be supplied, be located either above or below the same. If at a suitable elevation above the building, a gravity supply can be arranged for in the case of surface waters, springs, lakes or brooks, and inasmuch as the gravity system requires no running expenses after the supply conduit has been constructed, it is in many cases given the preference over a pumping system from wells, rivers, or lakes. The distance between the source of supply and the building has, of course, an important bearing upon the question of cost, and it is usually best not to go beyond a certain distance, but rather to instal a pumping plant.

Where a single source of supply only is available, it is necessary to determine the quality of the water because this may require special means for its purification. When several sources of supply are available, the selection is sometimes determined after a comparison of the physical and sanitary qualities of the water sources. It is necessary, in all investigations of this character, to examine not only the physical characteristics of the water, such as taste, colour, odour, temperature, turbidity, and hardness, but also to subject a sample, or preferably several samples, of the water to both chemical and bacteriological analyses in order to test its suitability from a sanitary point of view. Modern knowledge on the subject of water supply requires that the results of the different analyses should be taken together, much stress being laid now-a-days upon the number and kind of living organisms or bacteria in the drinking water.

In addition to the tests mentioned, a sanitary inspection of the source of supply, or of the water shed or the river basin and its tributaries, or of the lake and its water sources should be made. In the case of running streams it is considered insufficient merely to take a sample of water at the place where it is intended to locate the inlet to the pumps. It is very much better to take additional samples above such point and incidentally to determine by an inspection the character of the country in which the stream runs. It will be found in many cases that the water course is made use of by settle-

---

* See Appleton's Universal Cyclopedia, Articles on Riparian Rights, Water Courses, Filum Aquæ, Lakes, Seashore, Law of Rivers. See also E. B. Goodell, Review of Laws Forbidding Pollution of Inland Waters in the U. S. Published by U. S. Geol. Survey, 1904.

FIG. 13.—THE DAM FOR THE GRAVITY SUPPLY SYSTEM OF HOTEL MT. WASHINGTON

ments located upstream, as a convenient outfall into which their sewers or drains may empty. One must, therefore, make sure of both the present purity of the supply and of its safety from future pollution.

A source of supply may be ever so favourable as regards its quality, but if the quality available falls short of the volume required, it may become necessary to look for other sources. In the case of small springs the quantity yielded can usually be readily measured and small brooks or water courses can be gauged by means of weirs. For large and important buildings it is necessary, when a supply from wells is desired, to drive test wells and to ascertain the supply by means of pumping. In this way the quantity available is readily determined, and the next step is to compare this with the quantity actually required.

Right here it is well for the engineer to remember that the allowance in the case of country mansions should be generous and ample, for on country estates water is apt to be used very lavishly. A fair allowance, as far as the house itself is concerned, for water used in drinking, cooking, washing, bathing, ablutions, and flushing closets would be 50 gallons per head per day, but the number of persons which may occupy the building, or the prospective population of an institution, often have to be guessed at in making an estimate, and this at once introduces a factor of uncertainty. While in cities, as we have seen heretofore, the average daily consumption reaches nearly 100 gallons, of which a large quantity is actually wasted, we find that public institutions, forming a group of detached buildings in the country, sometimes use enormous quantities, such as 200 gallons and over per capita. A part of this is intentional waste, caused by leaving faucets open to prevent the freezing of poorly located plumbing, by too abundant use of water in flushing fixtures or in bathing, and the other part is due to carelessness in not keeping the water fittings of a house, the faucets, ball cocks, and cistern valves in proper repair.

In the case of large country mansions or estates we must add to the

FIG. 14.—A FIRE STREAM IN OPERATION AT MT. WASHINGTON HOTEL

inside or domestic consumption the large volumes of water required for stable use, for the watering of horses and cattle, for the washing of carriages and harnesses, for the cow barns, the dairy, etc., the allowance for these items alone sometimes amounting to from 50 to 200 gallons per day for each horse and carriage. A further large amount must be provided for the watering of roads, for the sprinkling of lawns and flower beds, for the orchard and vegetable gardens, and for the conservatory, which amount rarely falls short of 1000 and even 2000 gallons per day; sometimes 500 gallons per acre of ground are allowed. Where ornamental fountains are provided in gardens, these also consume a large supply, varying according to size and number of fountain jets, at from 50 gallons to several thousand gallons per hour.

Finally, it is necessary to provide in the storage of water a large volume to be drawn upon in case of an outbreak of fire, a danger which is ever present and which becomes serious in proportion to the remoteness of the buildings from the nearest village or town fire department.

The volume of supply which must be provided should be available at the buildings under a suitable pressure, and here the engineer is confronted with the question, what is a suitable pressure of water to provide? It is necessary, in order to answer this question intelligently, to discriminate between domestic service and fire service pressure. Domestic pressure means the pressure required to cause the water to flow at the highest faucet in a house under a moderate but sufficient flow; or, if there is an attic tank, the pressure which will constantly keep the same supplied. Fire service pressure, however, means a much higher pressure, for fire streams must be thrown above the roof of a house with some force in order to be effective.

With the usual height of buildings in the country, it is considered by engineers that the pressure of water sufficient for fire extinguishing purposes should be from 40 to 60 pounds per square inch. In the case of large hotel buildings, 60 pounds in the basement or on the ground floor are the minimum requirement of fire underwriters. In some cases such pressures are furnished by gravity supplies; in other instances, even with gravity supplies, the water must be pumped to give a sufficient head of pressure. The latter is usually attained by providing large tanks on towers built of a sufficient height. It should be remembered that, where small fire hose is used, the friction in the hose is very large and thereby reduces the height of the fire stream considerably.

Only a few exceptional cases occur where the natural or gravity pressure is too heavy, and where, in consequence, in order to avoid any excessive straining of the house pipes and fittings, the pressure must be reduced. This is accomplished by using pressure regulators or pressure reducing valves, but it may be said that the use of these is not to be recommended except where it is absolutely necessary, as even the best of them give occasional trouble by getting out of order.

Having thus determined the source of supply, the quality and the quantity of water, and the desired pressure at the building, the engineer is enabled to decide upon and lay out a supply system, which in the special case under consideration should be looked upon with greatest favour as being the best, most sanitary and most economical in first cost and in cost of maintenance. A gravity supply always seems to be the most desirable and it is sometimes, though not always, the cheapest in the first cost, while it is always cheapest in regard to maintenance and running expenses. A pumping system requires either manual labour or skilled attendance for the pumping machinery and is, besides, liable to give trouble on account of the breaking down or the wear and tear of the latter.

A gravity system may be installed with or without storage tanks, though it is preferable to provide the latter. A pumping system requires the use of reservoirs located on suitably high elevations, if such are available, or else elevated tanks or stand pipes to secure the required storage and pressure. Sometimes pressure tanks are substituted for reservoirs, and in a few cases the pumps discharge directly into the supply mains to the buildings and are then provided with relief valves opening when the pressure becomes excessive. The latter modification does not provide any storage for domestic or fire purposes and hence requires the pumping plant to be laid out in duplicate.

As an example of a complete water supply and fire protection of a large hotel building in the country, a brief description is given of the water supply of an American hotel, the Mount Washington, situated in the White Mountains, near the base of the chain of mountains known as the "Presidential Range." This large building, shown in Fig. 9, is provided with two distinct systems of supply, namely, one a pumping supply from a series of wells, and the other a gravity supply from a mountain brook.

The wells are seventeen in number (see Fig. 4) and were obtained by means of well-driving machinery, an 8-inch casing having been first driven down through the gravel to a depth of from 30 to 40 feet. Into this casing a 5-inch galvanised iron well pipe was lowered; each well was provided with a cleanout and with a valve to shut it off, and the different wells were located on both sides of a main suction line, made 5, 6, 8, and 10 inches in diameter, and which delivered the water to a closed suction chamber connected with the pumps. The aggregate yield of the seventeen wells was about 1050 gallons per minute, the water being pure in quality and of a very low temperature.

The pumping station contains two electric triplex double-acting direct-connected power pumps (see Fig. 10), namely, a house pump rated at 350 gallons per minute, and a fire pump rated at about 800 gallons per minute. These pumps delivered the water through an 8-inch pumping main into a series of three wooden tanks (see Fig. 11) each of 50,000 gallons capacity, and from these tanks a 12-inch delivery pipe was carried to the site of the hotel. The elevation of these tanks was about 150 feet above the basement of the hotel, thus giving a pressure of about 66 pounds per square inch.

The 12-inch main to the hotel was subdivided into two 8-inch lines, which run along both fronts of the building and are connected at the ends and also at intermediate points so as to form a continuous loop. From the 8-inch main there are about twenty 6-inch laterals running to outside fire hydrants, and there are also a number of 3-inch and 4-inch supplies for the inside plumbing, the elevator service and the refrigerating plant. (See Fig. 12.)

In addition to the well supply, a gravity supply was brought a distance of over 4 miles through an 8-inch cast-iron pipe which connected with the 8-inch pumping main from the pumping station.

The montain reservoir contains approximately 1,000,000 gallons of water, which are stored there by means of a plain wooden dam thrown across the stream. (See Fig. 13.)

The fire pump was arranged to draw either from the wells or, by means of a separate suction, from an artificial lake near by. With the pressure from the tanks on the mountain several efficient fire streams were thrown from the hydrants reaching to some height above the top of the building. In case of an accident to the 12-inch main, the water could be delivered from the tanks to the hotel through the 8-inch pipe line, and vice versa.

Part II. of this article, devoted to the consideration of details, will appear in the May number

THE APPRENTICESHIP QUESTION IN AMERICA

By Frank T. Carlton

THE apprenticeship question is rapidly growing in importance in America. The growth of large shops employing highly specialised and systematised methods, the corresponding decrease in the number of small general shops, and the changing character of immigration are three of the important conditions which are pushing this question into the foreground. What are the sources from which American skilled workers of the near future may be drawn? How are they to be trained? What should be the proportion of apprentices to the present number of journeymen? These are the three fundamental elements in the problem now confronting the American employer.

The introduction of minute division of labour, the extreme specialisation of classes of labour, and the rise of the large shop, have greatly reduced the opportunities for acquiring the thorough knowledge of a trade. The apprentice working side by side with the journeyman is now rarely found, for two reasons,—present shop methods have reduced the relative, if not the absolute, number of all-around men, and they have also made the instruction of the beginner a burden upon the journeyman.

In recent years there have been two well-known sources of skilled men,—the little shop, and Europe. Many foremen and skilled men in America are Englishmen, Germans, and Swedes. These two sources are drying up; the haphazard, trusting-to-luck method of providing skilled workers must necessarily be replaced by some more systematic and adequate scheme. Large business corporations now plan for many years in the future. They must plan for a certain and reliable supply of skilled men as well as for customers and markets. If the character of immigration is changing, if the little shop is disappearing, if the big shop without special appliances or courses for apprentices does not furnish skilled workers, special provisions must be made for the employment and instruction of apprentices.

Large manufacturers are beginning to recognise the necessity of training up a body of apprentices. About eight years ago an investigation was made of 116 prominent establishments in the United States,—builders of engines, machine tools, electrical apparatus, and railway repair shops. Out of the total of 116, there were 85, or about 73 per cent. of the total, that took apprentices. In 1902 a different investigator found that 73 out of a total of 112 shops took apprentices, or about 65 per cent.

Railway shops have taken a firm stand in favour of a well-established and thorough system. The first investigator here mentioned found that practically every prominent railway shop in the country took apprentices. During the last year or two many agreements have been ratified between different railroad companies and representatives of the International Association of Machinists, but the writer has failed to find one that did not provide for apprentices.

The usual rule is one apprentice to every shop, and one extra apprentice to every additional five journeymen after the first five. The customary length of apprenticeship is four years. The company usually agrees that the apprentice shall be advanced from machine to machine, or from job to job, as fast as practicable and desirable.

Some agreements specify quite minutely as to the length of time which an apprentice may be retained at a given class of work. For example, the apprentice rules of the Terminal Railroad Association, of St. Louis, specify that the apprentice shall serve three years on machines and special jobs, and one year on general floor work; those of the Chicago shops of the Chicago & Northwestern Railroad specify,—tool room, 3 months; machines, 15 months; erecting floor, 12 months; rod and vise work, 6 months; laying off, 3 months; drawing room, 6 months; and testing room, 3 months. In general, the agreements call for ability to read and write English, and a knowledge of simple arithmetic. The apprentice age is usually 16 to 21 years, inclusive.

These examples show that apprenticeship has not wholly disappeared. Apprenticeship is desirable chiefly for two reasons,—to furnish an adequate supply of skilled men, and to maintain and improve the character and efficiency of workmen. If, however, less than three-fourths of the important establishments employing machinists take apprentices, it is not probable that a sufficient supply of skilled men will be furnished to satisfy future requirements. And are we certain that all the establishments included in the list of those taking apprentices have an adequate system? In order to become skilled in more than one single class of work, a learner must be transferred from machine to machine, from journeyman to journeyman, and from department to department. On the other hand, the interests of a foreman lead him to keep a boy continually upon one class of work rather than to transfer him to other machines or departments. In other words, the foreman is usually more directly interested in the production of machines or tools than in training future machinists.

In many respects the apprenticeship question is similar to the labour problems in connection with immigration. Like the average immigrant, the apprentice works for low wages. The constant and natural temptation for the employers is to subdivide the work and pass certain portions of it on to the apprentice or unskilled worker. Where this is done, the apprentice is kept too long at a single class of work and receives no adequate instruction. Sooner or later the character of the work done in that shop deteriorates, unless there is an outside source from which skilled human material may be drawn. If outside sources can no longer be depended upon, it is time for all employers of skilled labour to take steps to remedy the difficulty.

Temporary expediency is unfavourable to a thorough apprenticeship system. It is only when an establishment looks into the future that apprenticeship becomes a vital question. Aside from all ethical considerations, can manufacturers afford, as a business proposition, to omit all provisions for teaching apprentices so as to maintain a future supply of trained and skilled workers?

The testimony of an American regarding the industrial conditions of Japan contains a lesson for manufacturers and other employers of labour. Writing from Japan, he observes:—"Japan has no trade legislation whatsoever, no system of apprenticeship, no journeymen, no masters. No one ever learns a trade, or even in the course of time comes to thoroughly understand the work of his trade in all its branches. The demand for skilled or even half-skilled labour is always in excess of the supply. For instance, it took about two years to build a stone bridge of only one arch over a shallow creek, only 60 feet wide, in Shimbaslie, Tokyo, and about the same time to build a similar bridge at Nihoubashi, Tokyo, over a creek only a few feet wider." If this gentleman has grasped the true situation, it will be many years before Japan will become an active competitor of Europe and the United States in high-grade manufacture. The lack of skilled men and of opportunity to train such men will prove a great handicap to this progressive eastern nation.

If the United States is to maintain a high place among the industrial nations of the world, she must have a trained class of skilled workers. The workers must be trained either in school or shop, or in both. The trade school is one solution, and a continuation or revival of the old form of apprenticeship is another method of training. The latter is, however, manifestly inadequate. The trade school offers many opportunities for scientific and technical training, but it lacks the commercial motive. Its products are rarely made under competitive conditions. The motive for the use of the latest machines and the most rapid methods for organising the shop system on a sound business basis is lacking.

A combination of shop and school training seems to offer greater possibilities, and several of the best apprentice systems in America are trying to accomplish this. In the shop a foreman of apprentices is employed whose duty it is to see that the boys are shifted from one machine or one department to another at the proper time.

School training is given in night schools, which try to round out and complete the shop instruction. This duty should devolve upon the public school, and the writer confidently expects to see such combination public night schools in every large city within a few years. Many believe, and the reasoning seems sound, that a good apprentice system, such as several well-known firms have established, coupled with public instruction in the evenings or on Saturday afternoons, is far superior to the trade school.

If an apprenticeship system is generally adopted, it becomes necessary to roughly estimate the ratio between the apprentices and journeymen. What is the ratio which will maintain a supply equal to the demand for skilled men? Without going into the intricacies of the question, one rough but approximate test may easily be applied by comparing the number of males in the United States of apprentice age with the total number of males of journeyman age. The apprentice age may be taken as from 16 to 19 years, inclusive. According to the census of 1900, there were 2,981,065 males of this age in the United States. If the journeyman age be taken from 20 to 39 years, inclusive, there were 12,466,309 males of this age. If 20 to 44, inclusive, be taken as the journeyman age, the number is increased to 14,722,225. The ratio of males 16 to 19 years of age to those 20 to 39 years is therefore 1 to about 4.18; in the latter case the ratio is 1 to about 4.93.

This rough and easily criticised method indicates that the ratio of apprentices to journeymen should be at least 1 to 5. If allowance be made for a probable growth in the industry, it seems reasonable that a ratio of 1 to 4½ would not be excessive, and would not lead to an oversupply of apprentices in any industry.

If employers would institute a general and adequate apprentice system by means of which young men might actually, not theoretically, be taught the trade in which they are engaged, much of the trade-union opposition to the unrestricted employment of apprentices would be removed, as well as much of the demand for it on the part of the employers.

The Amalgamated Society of Engineers in Great Britain does not limit the number of apprentices, but the apprentice system is rigid and tends to maintain a high level of skill. Both British employers and employees recognise the desirability of an adequate system.

THE MODERN HORIZONTAL STEAM ENGINE

AS EXEMPLIFIED IN BRITISH PRACTICE

By Leo H. Jackson

Concluded from the March Number

THE standard design of horizontal engine of Messrs. Tangyes, Ltd., of the Cornwall Works, Birmingham, is shown in Fig. 10. It is made with cylinders up to 18 inches by 36 inches. They also make corresponding sizes of cross-compound and tandem engines. These, as will be seen, are of modern design, and are made from a new series of patterns on the interchangeable system. The wearing surfaces are large, and are provided with means of easy adjustment.

The governors, according to specifications, are either of the well-known Pickering construction, or, in the case of the Tangye-Johnson valve gear, of the Porter type. In either case the governor is fitted with safety gear which will automatically shut off the steam if the governor belt should break, and thus prevent the engine from running away.

A larger class of Tangye horizontal engine is shown in Fig. 11, the particular engine there illustrated having cylinders 18 and 32 inches in diameter. With a stroke of 48 inches it develops 425 I. H. P. at 70 revolutions per minute with 120 pounds steam pressure. The details of the Corliss valve gear and the general design of the engine are so clearly shown that any special description is unnecessary. Messrs. Tangyes state that many engines of this class have been supplied by them to the various gold mining companies of South Africa.

The chief feature of the Tangye-Johnson valve gear is its single-eccentric gear. The eccentric drives a main

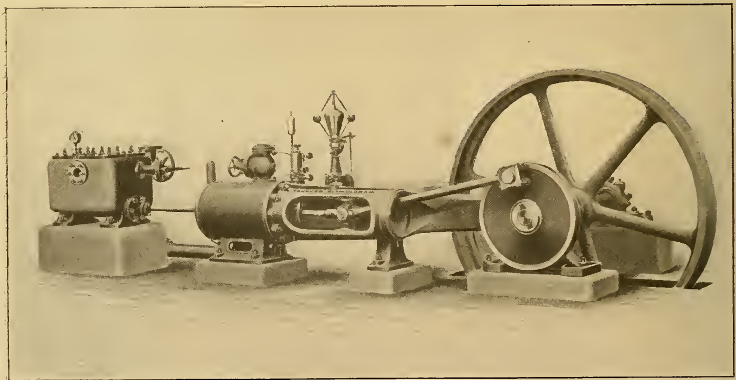


FIG. 10.—STANDARD DESIGN OF CONDENSING ENGINE OF MESSRS. TANGYES, LTD., BIRMINGHAM, WITH TANGYE-JOHNSON VALVE GEAR

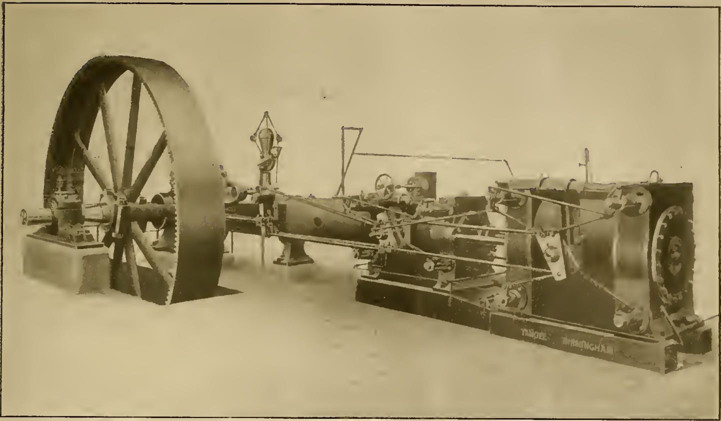


FIG. 11.—A 425-H. P. TANGYE TANDEM COMPOUND CORLISS ENGINE. BUILT FOR THE FERREIRA GOLD MINING CO., LTD., OF JOHANNESBURG, SOUTH AFRICA

distribution valve with a fixed travel. This main slide valve operates the exhaust and compression independently of the point of admission of the steam. Upon its back is fixed a rocking valve, having faces which alternately open and close the steam ports. The exact moment or point of the stroke in which the closing takes place is regulated by right and left hand scroll cams, operated directly from the high-speed Porter type governor, so that the point of cut-off is regulated automatically by the speed of, or load upon, the engine. The higher the position of the governor the earlier the cut-off, and *vice versa*.

In order to facilitate starting the engine, a hand lever is provided for keeping the rocking valve out of op-

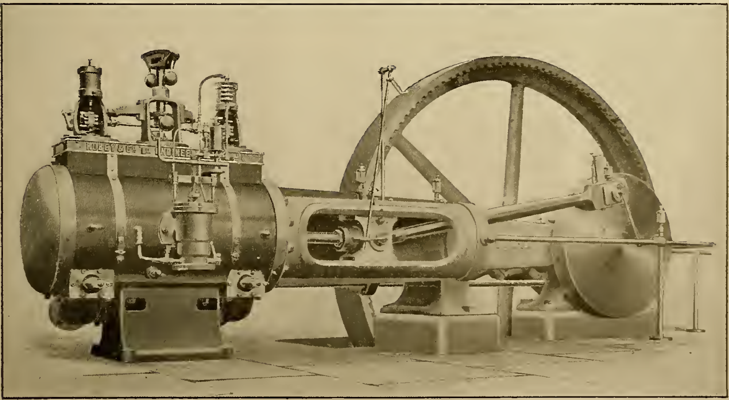


FIG. 12.—A TRUNK GIRDER FRAME, EXAMPLE OF SINGLE-CYLINDER ENGINE BUILT BY MESSRS. ROBEY & CO., LTD., LINCOLN

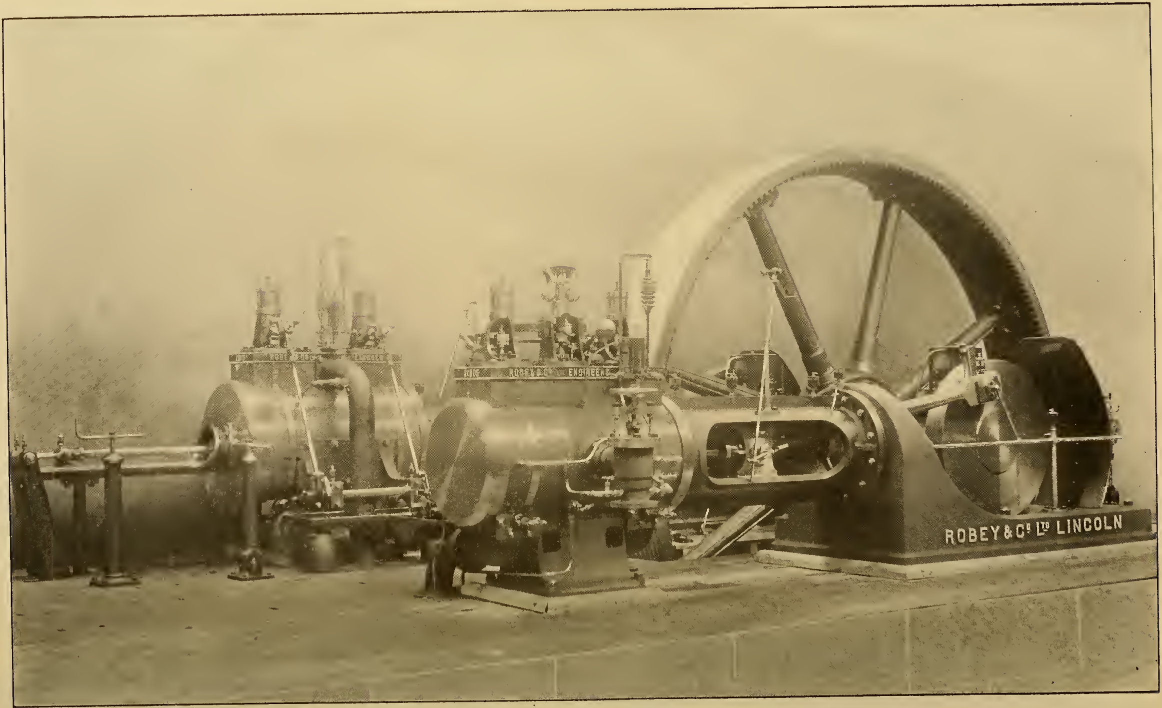


FIG. 13.—CROSS-COMPOUND CONDENSING ENGINE OF "SOLID-BED" TYPE. BUILT BY MESSRS. ROBEY & CO. LTD., LINCOLN

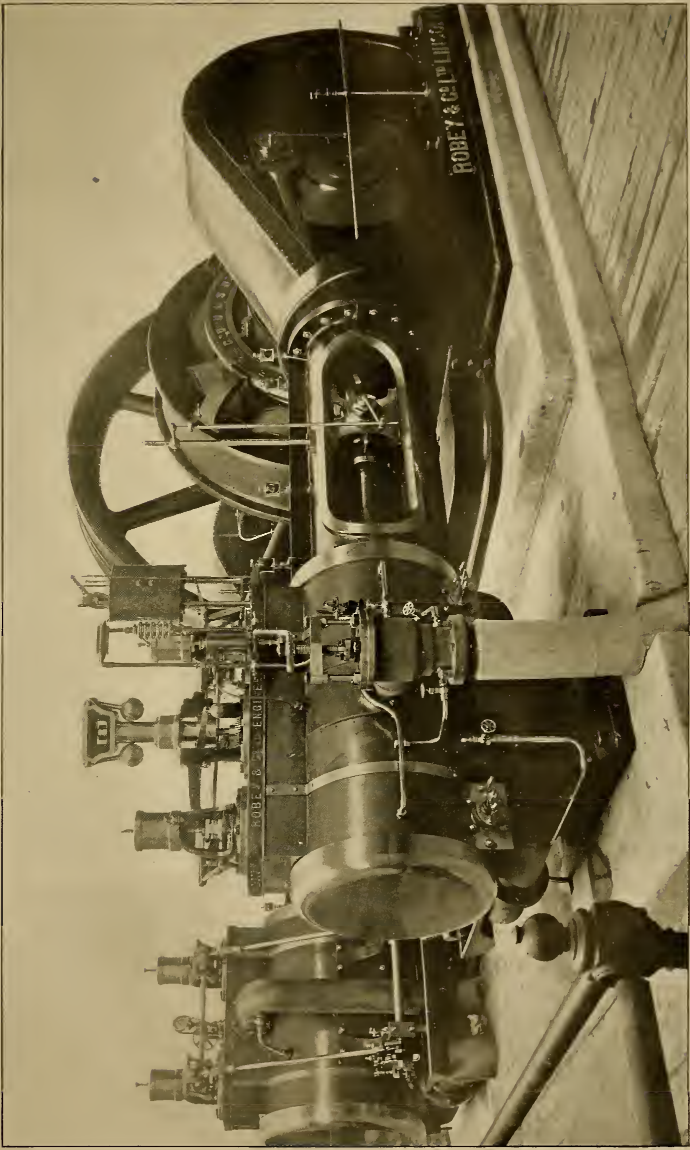


FIG. 14.—CROSS-COMPOUND SOLID-BED CONDENSING ENGINE WITH DIRECT-CONNECTED GENERATOR. BUILT BY MESSRS. ROBEY & CO., LTD., LINCOLN

eration, so that steam is admitted up to three-fourths of the stroke by the main slide valve. When the engine has gained its normal speed the hand lever is released, and the governor takes control.

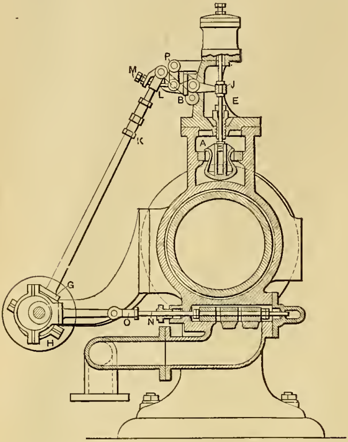


FIG. 15.—CROSS-SECTION OF ROBEY ENGINE CYLINDER WITH RICHARDSON-ROWLAND TRIP VALVE GEAR

Several representative types of drop-valve engines made by Messrs. Robey & Co., Ltd., of Lincoln, are shown in Figs. 12, 13, and 14. Fig. 12 represents a single-cylinder engine with trunk-girder frame. Cross-compound and tandem engines are also made in this style. Fig. 13 shows a cross-compound condensing engine of the "solid-bed" type, and Fig. 14 illustrates a similar engine with directly connected generator for electric traction service.

Each of these engines is of the same general type as regards the moving parts, the principal differences being in the construction of the beds. The trunk-girder engine is of very solid and massive construction, with ample support under the end of the tubular guide and a spreading base under the main bearing.

For the heaviest class of work, Messrs. Robey provide the solid-bed type shown in Figs. 13 and 14, in which engines the casting carrying the main bearing is of great size and strength. From the hold upon the foundation afforded by the large area of the base in contact with it, the shock incurred by the sudden incidence or removal of the wad is absorbed in the mass of the masonry instead of being transmitted along the girder frame to the cylinder. This design is equal to the requirements of direct-connected railway or tramway generator sets, rolling-mill engines, or other engines subject to severe stresses.

Large bearings and heavy fly-wheels are necessary in such cases, and these have been amply provided for in the specifications of Messrs. Robey.

Apart from the all-important question of rigidity in the engine frame or bedplate, and the provision for ample bearing surfaces in the main shaft, crank pin, crosshead, and piston—after all these matters have been attended to, the determining factor in the choice of an engine should be the valve gear. Messrs. Robey & Co. were the pioneers in Great Britain of the drop valve in its modern form, and therefore a description of the well-known Robey trip-valve motion is always certain to find a place in any

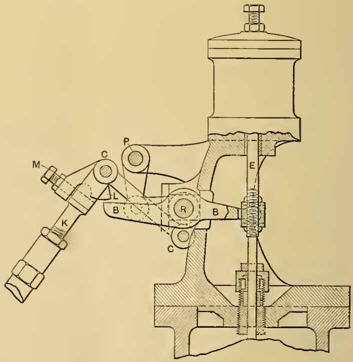


FIG. 16.—AN ENLARGED VIEW OF THE TRIP-LEVERS

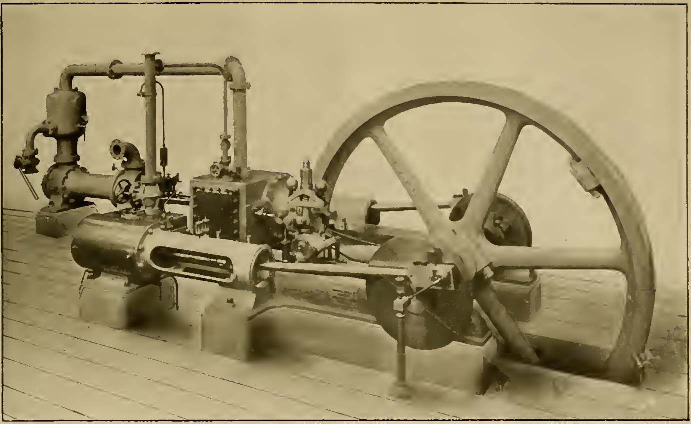


FIG. 17.—CROSS-COMPOUND SLIDE-VALVE ENGINE BUILT BY MESSRS. MARSHALL, SONS & CO., LTD., GAINSBOROUGH

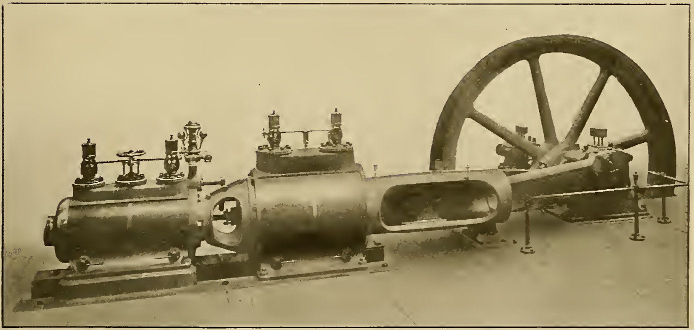


FIG. 18.—TANDEM-COMPOUND DROP-VALVE ENGINE BUILT BY MESSRS. MARSHALL, SONS & CO., LTD.

treatise on the modern horizontal steam engine.

The increasing popularity of the drop valve, owing to the now general recognition of its value where superheated steam is employed, has already been mentioned. The writer is not aware of the precise date of its application by Messrs. Robey, but merely records a matter of common knowledge in stating that their trip-gear engines have been before the public for many years, and that there are a very considerable number of them, some thousands probably, in use at the present time.

The following description of the Robey trip-valve gear is given from information supplied by the manufacturers. The cross section given in Fig. 15, and the enlarged detail of the trip-levers in Fig. 16, show the whole of the gear very clearly for one end of the cylinder. The same lettering is applicable to both engravings. The upper end of the eccentric rod *K* moves in an arc of which the radius is the link *CC*, and raises the valve *A* by depressing the outer end of the lever *BB*. This action occurs just before the commencement of the stroke.

Owing to the difference in the arcs described by the end of the eccentric rod and the end of the lever *BB*, the tripper *L* slips out of contact at a certain point in the stroke and the valve drops, cutting off the steam instantaneously, the tripper being knocked down as it again passes upward.

To prevent the valve being injured by coming down too heavily upon its seat, the stem or spindle of the valve is prolonged upwards, and terminates in a small piston within an air cylinder. A small air-cock at the bottom of this cylinder or "dashpot" regulates the descent, so that the valve falls rapidly, but without concussion. This is the whole of the mechanism concerned in the admission and cut-off of the steam at fixed points in the stroke, although in the low-pressure cylinder of a compound engine the cut-off point, when not controlled by the governor, may be raised by screwing the set-screws *M* in or out.

In the high-pressure valve gear the governor effects a lateral movement of the fulcrum *R* of the lever *BB*. Thus, with the governor at the highest position the fulcrum *R* would be moved towards the right, in the engravings, to an extent which would prevent the tripper *L* touching it at all; hence, the valve would not be lifted, and no steam would enter the cylinder. A movement of the fulcrum towards the left, however, increases the duration of the admission period proportionately to the height of the governor collar at the moment. The touch of a finger is sufficient to effect the movement of the fulcrum, hence the governor, though perfectly efficient, is of very small size.

The exhaust valves are flat gridiron or multiple ported slide-valves are so clearly shown as to need no further description.

Messrs. Marshall, Sons & Co., Ltd., of Gainsborough, Lincolnshire, make horizontal steam engines in a large variety of classes, in addition to their extensive production of other types. Three representative engines built by this firm have been selected for illustration, and are shown in Figs. 17, 18, and 21. Fig. 17 represents a cross-compound slide-valve engine with triple expansion gear controlled by a Hartnell governor; it is fitted with a very neat form of horizontal jet condenser, worked direct from the low-pressure tail-rod. This type of engine is made in sizes up to 400 effective horse-power, and the design of this

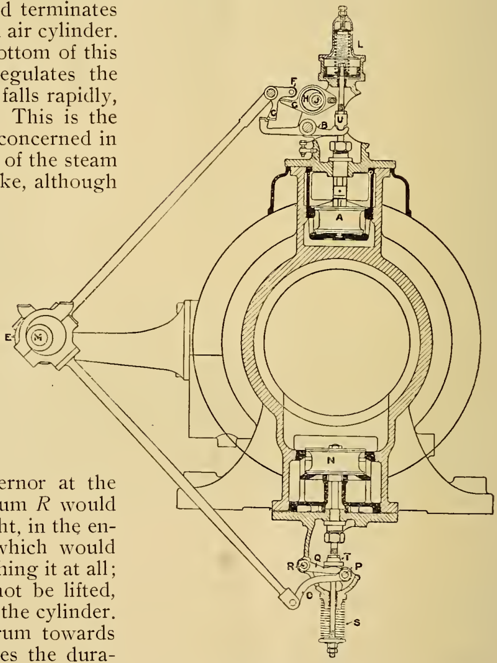


FIG. 19.—CROSS-SECTION OF ENGINE CYLINDER WITH MARSHALL'S TRIP GEAR

bed is, we believe, peculiar to Messrs. Marshall. From its broad base under the trunk and the continuous girders in contact with the foundation, which latter extend forward to a point considerably in advance of the main bearing, it would seem to be a very effective form for all but the largest sizes of engines.

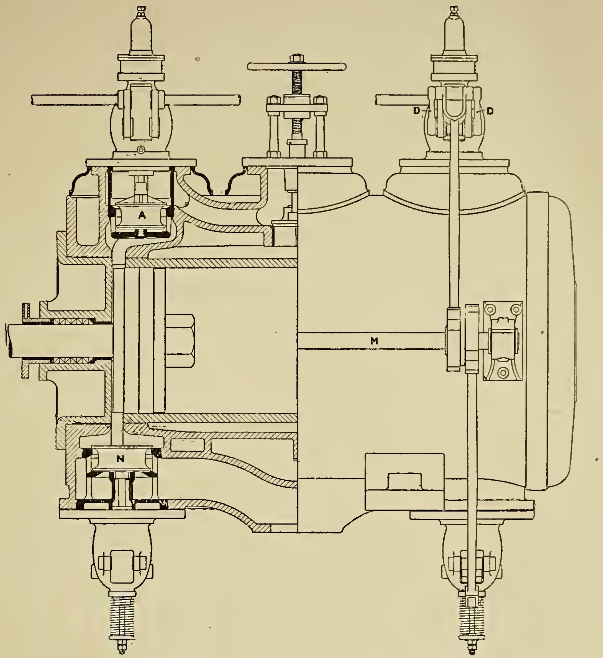


FIG. 20.—LONGITUDINAL SECTION OF ENGINE CYLINDER WITH MARSHALL'S TRIP GEAR

Fig. 18 shows a tandem drop-valve engine, and Fig. 21 a cross-compound engine of similar build. These engines represent Messrs. Marshall's latest practice in the larger sizes, and have been designed specially to ensure economy in steam consumption; they are of ample strength for steam pressures of 150 pounds per square inch, and for piston speeds of 600 feet per minute. The frames are of the usual trunk-girder type, and owing to the formation of the cylinders to suit the drop exhaust valves, the gear for which is below the floor level, the whole engine is kept very low and the cylinder bases are well extended laterally. All of these features tend to produce stability. The chief interest in these engines, however, centres in the Marshall vale trip gear, with which they are fitted.

Figs. 19 and 20 show a cross section and a part longitudinal section of the cylinder in a Marshall engine. Before noticing the gear itself, attention is called to the fine clearance between the cylinder ends and the piston, the exceedingly small "lost space" in the valve chambers, and the excellent natural drainage of

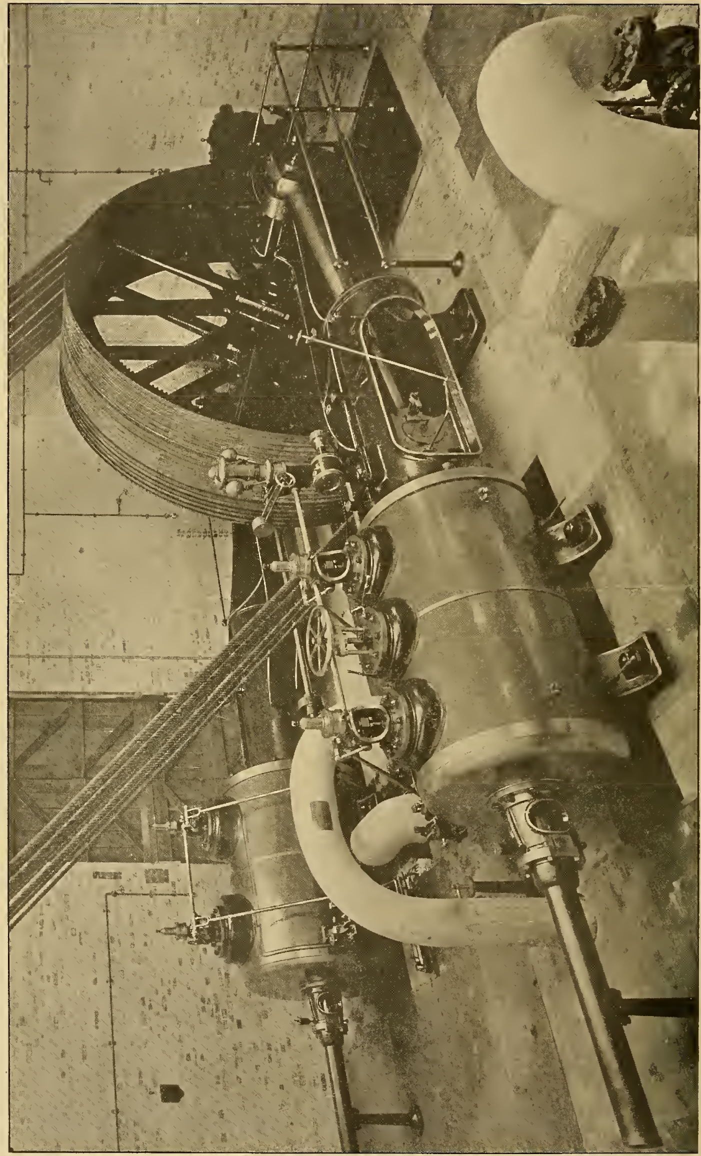


FIG. 21.—A CROSS-COMPOUND DROP-VALVE ENGINE BUILT BY MESSRS. MARSHALL, SONS & CO., LTD., GAINSBOROUGH

the cylinder towards the exhaust orifice.

The steam and exhaust valve seats, shown in black section, are inserted and held in place by the covers above and below them, respectively, with the view of allowing their free expansion and contraction without alteration of form. The gear here illustrated is known as the No. 2, and is applied to engines of 16-inch cylinder diameter and upwards. It consists of double-beat lifting or poppet valves, their motion being derived from a rotating layshaft driven at the same speed as the crankshaft by mitre-wheels.

Referring now to the cross section in Fig. 19, the upper ends of the inclined eccentric rod actuating the steam valve gear move in an arc, being connected by a pair of short links *DD*, shown only in the longitudinal elevation, to a fixed point in the dashpot frame. The double-armed lever *B*, when its outer end is in contact with the lower limb of the right-angled lever *C*, is depressed by the descent of the eccentric rod, and thereby opens the steam valve *A*.

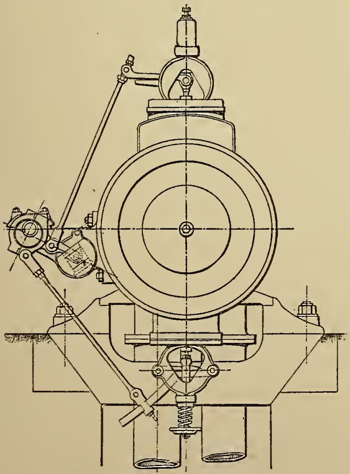


FIG. 22.—LOW-PRESSURE CYLINDER OF TANDEM-COMPOUND DROP-VALVE ENGINE, BUILT BY MESSRS. RUSTON, PROCTOR & CO., LTD., LINCOLN

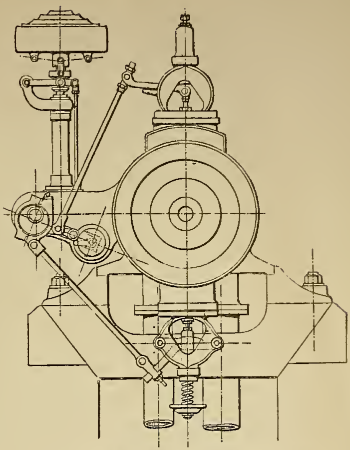


FIG. 23.—HIGH-PRESSURE CYLINDER OF TANDEM-COMPOUND DROP-VALVE ENGINE, BUILT BY MESSRS. RUSTON, PROCTOR & CO., LTD.

The duration of the period of steam admission is determined by the governor, which, by partially rotating the eccentric *B*, raises or lowers the "trip-pad" *G;* this action compels the disengagement or "tripping" at *C* of the steel-tipped end of the lever *B*, and also the consequent drop upon the seat of the valve *A* at the precise point in the stroke required to maintain the prescribed speed of the engine. The action is accelerated by the opening *L*, and checked without injury to valves or seats by the compressions of air under the small pistons of the dashpot, which, in turn, is regulated by a small air-valve adjustable to requirements.

The exhaust valve *N* is raised by the bent lever *O*, which is pivoted at *P*. The lever *O*, in its ascent, rolls upon the under side of lever *Q*, pivoted at *R*, with the result that the valve *N* begins to lift gradually, quickly opens to its full extent, then closes rapidly, but at a decreasing rate, and finally is gently deposited upon its seat. The exhaust period, therefore, is characterised by a full opening almost up to the closing point.

Messrs. Marshall point out that as all their engines are tested and adjust-

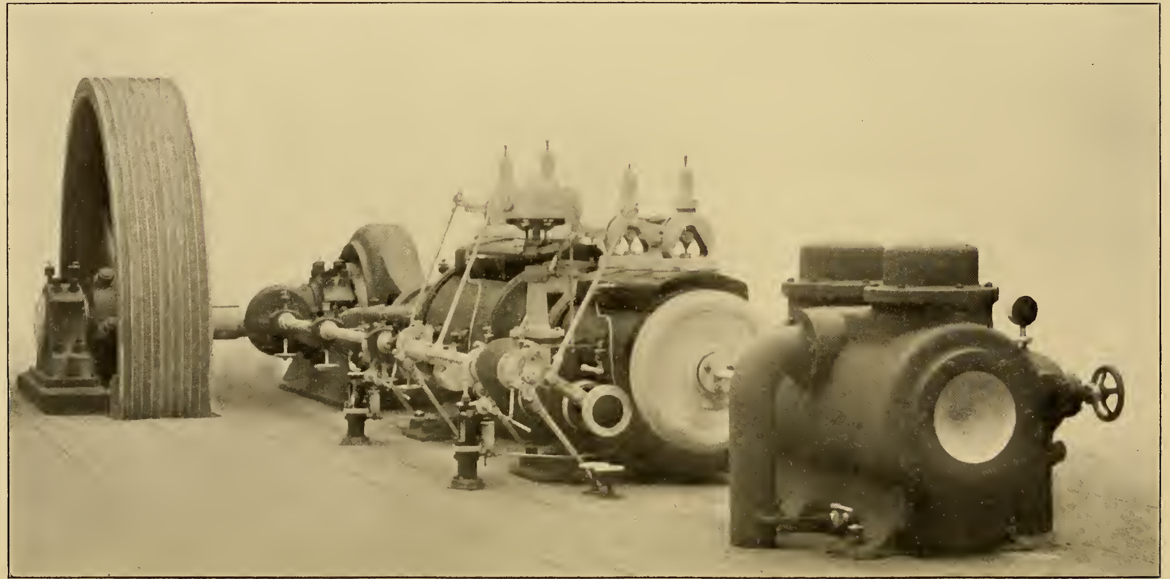


FIG. 24.—A TANDEM-COMPOUND CONDENSING ENGINE BUILT BY MESSRS. RUSTON, PROCTOR & CO., LTD., LINCOLN

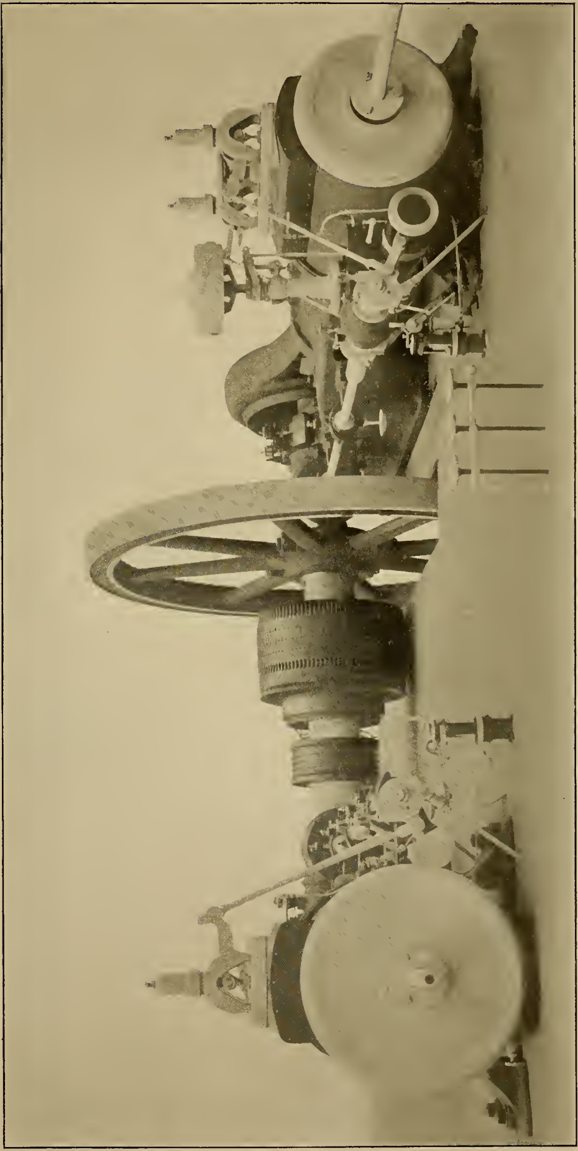


FIG. 25.—A CROSS-COMPOUND ENGINE BUILT BY MESSRS. RUSTON, PROCTOR & CO., LTD., LINCOLN

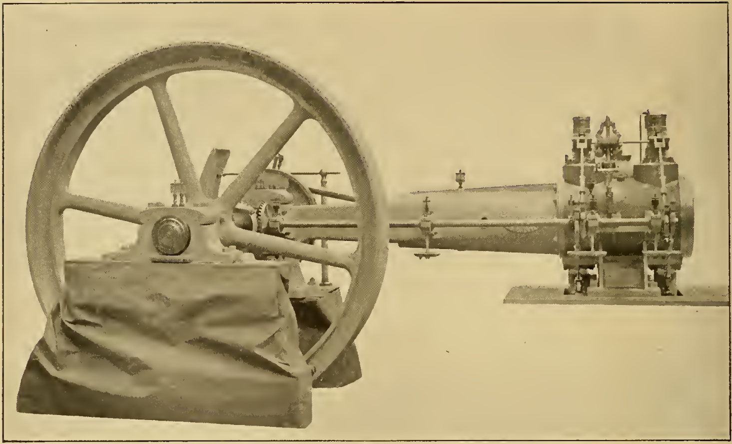


FIG. 26.—SINGLE-CYLINDER DROP-VALVE ENGINE BUILT BY MESSRS. DAVEY, PAXMAN & CO., LTD., COLCHESTER

ed to give the best running conditions at their works, no adjustment will be necessary for a considerable time. Arrangements are made to correct the gear when necessary to compensate for wear, but on no account must any adjustment be made while the engine is in motion.

An entirely new series of long-stroke horizontal engines, embodying several important improvements, have been brought out by the well-known Lincolnshire firm of Ruston, Proctor & Co., Ltd. Of these a tandem compound engine with condenser, and a cross-compound non-condensing generator engine, have been selected as typical examples for illustration here.

These several engines are made in a large range of sizes, and include a special class of high-speed engines adapted for electric light and power installations. A special feature of these engines is their positive drop-valve gear. Both the admission and exhaust valves are double-beat poppet or lifting valves, situated close to the ends of the cylinders, so as to give the minimum amount of clearance space and perfect drainage. The movements in this valve gear are so interesting that, in spite of its apparent complexity, it well repays the trouble of investigation.

In principle it is this:—The eccentric-rod itself does not point directly to the lever which lifts the admission valve, but is carried almost at a right angle to that direction, and terminates in a small block or crosshead which works between parallel slides. Here we have a rod or bar, one end of which describes a circle, and the other end a straight line. Any intermediate point in this rod, therefore, will describe an ellipse which will vary in character, according to its position, from approximately a circle to almost a straight line. At a suitable point about half way along the eccentric rod is pivoted the valve rod proper. Now by varying the axial line of the parallel slides—compare the positions of the dotted-in crossheads in Figs. 22 and 23—a degree of obliquity can be given to the ellipse, and the required motion obtained.

In the low-pressure gear, Fig. 22, this is the whole of the originating mechanism. The upper end of the valve rod is jointed to a short lever directly pivoted to the vertical valve spindle, and rests upon the slightly curved surface of the fulcrum. It will be seen how, as the inclined valve rod is alternately raised and depressed, the lever rolls from one end to the other of this fulcrum, giving a rapidly increasing rate of lift to the valve as it rises, a rapid movement again for the greater part of its descent, but ultimately depositing the valve gently upon its seat.

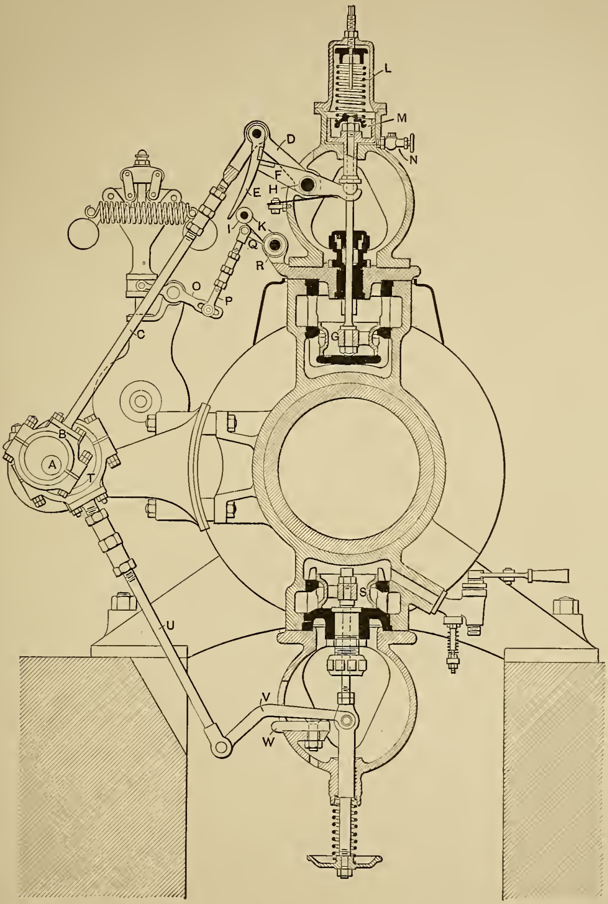


FIG. 27.—DETACHABLE DROP-VALVE GEAR OF ENGINE BUILT BY MESSRS. DAVEY, PAXMAN & CO., LTD., COLCHESTER

In the high-pressure gear, Fig. 23, the valve is not jointed directly to the eccentric rod, but to a second lever, pivoted to the latter at mid-length; its free end is attached to another small block working in a second parallel slide. The action of the governor is to twist the axial lines of these two slides in opposite directions, producing a variable motion and thereby controlling the admission valves' lift. The exhaust valve rod is jointed to the same eccentric strap, and it moves the exhaust valve by means of a bent lever pivoted on the right and bearing upwards against a second lever pivoted on the left; this forms a sort of moving fulcrum for effecting the same differential rate of movement of the exhaust valve.

All this, although complex in description, is really but a combination of elementary geometrical movements, and presents, apparently, but little surface to wear. The positive movement of the valves, which are not tripped and consequently require no dashpots, is the leading feature in this method of steam distribution, and the fact that Messrs. Ruston are prepared to operate it up to 180 revolutions per minute shows their confidence in the system. The new series of engines to which this positive valve-gear is applied are well designed and contain many features of interest which are illustrated in Figs. 24 and 25. It may be well to state that Messrs. Ruston make a specialty of tandem compound engines, and recommend them in preference to cross-compounds wherever possible.

Messrs. Davey, Paxman & Co., Ltd., of Colchester, build single cylinder drop-valve horizontal engines of the pattern shown in Fig. 26 in a large range of sizes. In these engines the leading feature is the detachable drop-valve gear illustrated in Fig. 27. Upon the horizontal valve shaft *A*, driven by a pair of mitre-gear wheels at equal speed with the crankshaft, are four eccentrics separately operating the steam and exhaust valves at the two ends of the cylinder. Starting at the steam admission eccentric *B* and rod *C*, the upper end of *C* is jointed to a short link *D*, which is pivoted to a point in the dashpot frame *H*. Working upon the same pin is the valve-lifting lever *F*, which is fitted with a hardened steel trip. The loose hanging curved lever *E* has upon it a hardened steel projection or catch which, when it engages with the steel trip on *F*, would have an effect on the downward stroke of the eccentric rod *C* of raising the steam-inlet valve *G*.

It will be seen, however, that the hanging lever *E* is in contact with a roller *I*, which latter runs loosely upon a pin at the extremity of lever *K*. The angular position of the lever *K* is determined by the height of the governor, which in Fig. 27 is shown in its highest position. It is evident that with the roller *I* in the position shown, the smallest downward movement of the eccentric would result in the tripping or disengaging of lever *E* from its contact with the lever *F*, and the consequent fall and closure of the inlet valve at a very early point of the piston's stroke.

Later points of cut-off occur as the governor descends and moves the roller *I* out of the way of the curved lever *E*. The descent of the steam valve is accelerated by the spiral spring *L*, but as it nears the bottom, the compression of the air beneath the piston *M* checks its velocity and prevents injury to the valve and seat. The extent of the cushioning is regulated by the small air-valve *N*.

The exhaust valve is worked by its own eccentric *T*, rod *U*, and curved lever *V*, the latter rolling upon the curved surface of block *W* and giving a varying rate of lift to the valve. Following this it will be seen that the exhaust valve is lifted quietly from its seat, and then very quickly raised to its full height. On the closing movement the contrary action takes place.

The details of this valve motion are apparently well worked out, and it would seem that as there is no excessive stress upon any of the wearing parts, it would be quiet and durable in action.

Current Topics

There is a growing use for portable incandescent electric lamps in mines and other places where explosive gases are known to be present, because of the practical immunity from danger with which this lamp can be employed in such places. Even when the bulb of a lamp is broken in the presence of explosive gases, experiments have demonstrated that no harmful results follow. This is, in fact, the only type of lamp which can be used with virtually absolute safety in the presence of such gases, as it removes the temptation from the miner to attempt its relighting by matches. It also avoids the delays consequent upon the blowing out of oil lamps, since an imperative rule of the mines requires the collier to take the lamp back to the lamp station, where it is relighted by an official lamplighter. The electric lamp also gives a much brighter light than any oil lamp, since for other reasons its light is not dimmed by wire gauze. The portable electric lamp for this purpose requires about 6 volts and 2 amperes and weighs about 3 pounds. Small storage batteries are used. The cells are contained in a box about 5 inches square, on the side of which is placed the incandescent lamp. These lamps will burn for 12 hours, and are recharged at the mouth of the pit by current from the colliery dynamos.

It is rather commonly supposed by the ordinary user of incandescent lamps that there are no conditions under which this lamp is hazardous as a fire risk, but while this view is fairly warranted by the infrequency of fires attributable to this source, the view is not altogether accurate. For example, in three months of last year at least five fires were caused by the ignition of inflammable materials due to heat generated by incandescent lamps. Systematic tests have been made to determine the heating effects of, and the extent of the danger of fire from, these lamps, when in proximity to or touching inflammable materials, with the following results. For instance, a 16-candle-power incandescent lamp immersed in a half-pint of water caused the water to boil within an hour. A similar lamp, encased in two thicknesses of muslin, caused it to smoke in three minutes, and in six minutes, when fresh air was admitted to the interior, the muslin burst into flame. A newspaper against which the lamp pressed ignited in three-quarters of an hour, and an article of celluloid ignited in three minutes under the same conditions. There is, however, no comparison between the security from fires due to the use of the incandescent lamp and that of oil lamps, as is evident from the published statistics of fire losses and causes, which show that accidents and explosions due to the use of oil for illuminating purposes amount to many thousands per annum.

What is probably the longest telegraph circuit in the world has been in operation for over a year on the lines of the Indo-European Telegraph Company, between London and Teheran, Persia's capital. This circuit is 4000 miles in length and in its course it traverses the North Sea for 200 miles and passes through Belgium, Germany, Russia, Turkey in Asia, and Persia. The Wheatstone automatic system of transmission and reception is employed on the circuit. In the operation of the Wheatstone automatic system the messages are first prepared by punching holes in a paper strip somewhat analogous to those seen in automatic piano players. Certain combinations of holes in the paper strip correspond to certain letters of the Morse telegraph alphabet. The paper strip is then passed through an instrument which transmits the message over the line. At the receiving station a sensitive relay responds to the letters transmitted, and reproduces them on a paper strip in the shape of dots and dashes, when they are transcribed upon ordinary telegraph blanks by copyists. By the Wheatstone automatic system messages are transmitted at the rate of from 80 to 400 words per minute, according to the nature of the circuit, as against 25 to 35 words by manual Morse transmission. On the London-Teheran circuit there are ten automatic repeating stations, namely, at Lowestoft, Emden, Berlin, Warsaw, Rouno, Odessa, Kertch, Sukhum Kaleh, Tiflis and Tauris. The business for and from Manchester and Liverpool is also handled direct with Teheran. It will be understood that automatic repeaters virtually take the place of operators at the repeating stations. In the case of the circuit under consideration there are repeating instruments and batteries at each of the ten repeating stations. As the line is divided into eleven parts, each part is comparatively short.

The use of automatic repeaters on telegraph circuits corresponds in a measure to that of "relays" in the days of stage coaching. In those days a pair of horses would be detailed to draw the coach to a certain station, having reached which they were relieved by a fresh set of horses termed a relay. The stage was then drawn to the next station, when another relay of horses would be attached to the coach, and so on. The obvious reason for these changes was that the horses had become fatigued, and while they might have drawn the coach further, the work would not have been done so quickly nor so well. What the relay of horses did for the stage coach, automatic repeaters virtually do for the telegraph message. They take it off the hands of a tired wire, if the expression may be used, and pass it on with fresh vigour to another wire. Automatic repeaters are rendered necessary on telegraph wires, because of the fact that a portion of the current on the wire escapes at each insulator and also wherever the wire touches a tree or foliage. Hence, the longer a line may be, the more electricity will escape in this manner, so that on long lines the current that reaches the distant end might become too enfeebled to operate the instrument. Apart from the question of escaping current there would also be the matter of decreased current due to the high total resistance of the wire, besides the retardation of signals due to the static capacity of the line. On a 4000-mile telegraph circuit the total resistance of the line might be 50,000 ohms, which resistance would require an electromotive force of at least 2000 volts on the line to provide sufficient current to properly operate the Morse relays, assuming no escape of electricity on the line.

ON a line such as the one under consideration, which passes over mountain, forest and desert, and which is exposed to floods, sleet and lightning storms, and to dense sea fogs along the Black Sea coast, it is obvious that in order to secure fairly rapid signalling the automatic relays must be comparatively short distances apart. It is, it may be added, of course, well known that the presence of automatic repeaters on a circuit, by the inertia of their mechanism, conduce to reduce the speed of signalling somewhat, but the gains otherwise far outweigh this disadvantage, as the great improvement in the handling of business reported in the case of the London-Teheran circuit since direct Wheatstone transmission was adopted, amply demonstrates.

WHILE, as stated, this is no doubt the longest telegraph circuit in daily operation, longer circuits have been successfully operated experimentally. For example, a circuit on which there were fourteen automatic repeaters, was made up on one occasion from Cape York to Derby, around the coast of Australia, a distance of 7246 miles, over which messages were transmitted at the rate of 11 words per minute. Quite recently, also, in the early hours of the morning, an Associated Press telegraph circuit was made up which extended over almost the entire United States. It included the cities of New Orleans, La.; Memphis, Tenn.; Dallas, Tex.; Louisville, Ky.; Washington, D. C.; Baltimore, Md.; Philadelphia, New York, Chicago, Kansas City, Mo.; Denver and Leadville, Col.; San Francisco, San Diego, Fresno and Los Angeles, Cal. This circuit worked successfully for over two hours, during which a long official report from Gen. Nogi's headquarters was transmitted.

THE advantages arising from a definitely pursued policy of standardization in engineering and ship construction were first recognized in the United States and Germany, but so far as the respective fleets of America, Germany, and Great Britain are concerned, there seems no doubt that the British Navy has got well ahead of all competitors. For many years past the British authorities have been building men-of-war in large classes. This policy has governed the construction of battleships, cruisers, torpedo boats, and latterly, submarine craft. The result is that to-day the British fleet consists of a comparatively few well-marked types. The vessels in each class are of the same size, have similar armaments, and identical manœuvring capacity and ranges of action. Built by different builders, they have, however, been constructed in matters of detail, particularly in the engine rooms, on individual lines. It was some years ago decided to check this tendency on the part of private builders to indulge their individual tastes, and it is now the definite intention of the British Board of Admiralty to insist on the principle of standardization being applied to all the most essential details of the mechanical equipment of men-of-war.

THE new scheme of organisation of the British fleet has effectively illustrated the advantages attached to the policy of building in large classes. The French squadrons at sea, like those of Italy, Austria, and in some measure Russia and Japan, comprise heterogeneous collections of ships with few points of resemblance. British policy has been to work out periodically the best design of battleship, cruiser, gunboat, or torpedo craft, and, after careful model experiments, to embody that design in from six to nine ships. Of late, battleships have been built on the principle of a double squadron of eight ships; consequently, in arranging the distribution of the fleets at sea, the British Admiralty have been able to place eight ships of identical speed and ranges of action in the Atlantic fleet, eight smaller and less powerful sister ships in the Mediterranean, and when the whole of the "King Edward VII." class of 16,350 tons have been passed into the Atlantic fleet (based on Gibraltar), Admiral Sir Arthur Wilson, the commander-in-chief of the Channel fleet (based on the home ports), will have under his control the six battleships of the "Duncan" class of 14,000 tons; the two ex-Chilian ships, "Swiftsure" and "Triumph," resembling in character the "Duncan," in being, like them, of high speed, and four of the eight ships of the "Majestic" class. By the time the reorganisation is complete, the Admiralty will, therefore, have eight "King Edward VII.'s" in the Atlantic fleet, eight "Bulwarks" of 15,000 tons in the Mediterranean fleet, and twelve battleships in the Channel fleet, embracing two squadrons with a trial speed of 19 knots or more, and one heavier squadron of 17 knots. The same attempt to obtain homogeneity is being made with reference to the Cruiser Squadrons, of which one is attached to each three of these battleship forces. In the case of the First and Second Cruiser Squadrons, the idea has been to assign the "Good Hope" and the "Drake" for service as flagships to Rear Admiral E. S. Poe and Prince Louis of Battenberg, the two rear admirals commanding, and to make up the total of six cruisers in each case by assigning five "County" cruisers to each command. In the Mediterranean the Cruiser Squadron is still in a state of transition, and must await reorganisation until the Admiralty have some new ships at their disposal. In the Far East five battleships are serving, four of these consisting of vessels of the "Canopus" type, ships specially designed to pass with ease through the Suez Canal, and the total is completed by the "Centurion," an older ship, which has lately been entirely reconstructed and provided with a more modern armament. The same principle of homogeneity has also been carried out in the organisation of the fleet in commission in reserve.

An interesting illustration of the same principle has been given in the Mediterranean in the organisation of the torpedo boat destroyers attached to this command. There are thirty-six of these vessels, and they have been rearranged so as to bring into each flotilla ships of the same class. The idea is that there shall be four divisions attached to the Mediterranean base, Malta, each comprising nine ships, all by the same builder, and of the same design. By having boats of similar build in the same division, the same parts of engines and boilers will be interchangeable, thus reducing the number of parts the parent ship of each division will have to carry. By this means a great economy will be effected. Each division will have a working flotilla of four vessels continually in commission, with a reserve of three vessels with what are styled "nucleus crews" on board, and one vessel definitely in reserve and probably under repair. The first division will consist of boats of the new "River" class, with high forecastle, great structural strength, and a uniform speed of 25½ knots. These are the destroyers which were built after the "Cobra" disaster in the North Sea. The second division will be 30-knot boats built at Palmer's yard on the Tyne; the third division will consist of 30-knot boats built by Thornycroft, and the fourth division will comprise boats with a speed of 30 knots, constructed by Laird. Thus Malta obtains four homogeneous divisions. At present the division which will be attached to Gibraltar will consist of four 30-knot destroyers and five of 27 knots. The mixture of classes in this case is only a temporary expedient, and as new vessels become available the character of this division will improve.

THE "Cobra" disaster was held to exhibit the weakness of the swift destroyers of 30 knots and upwards which were being constructed for the British fleet. This vessel had turbine engines, and maintained a rate of steaming of upwards of 40 miles an hour. During heavy weather in the North Sea she was lost, and immediately public opinion in Great Britain put pressure upon the Admiralty, and a committee was appointed which enquired into the structural strength of these fast craft. Confidence in such vessels was, for the time, completely lost, not by the officers of the fleet, but by the general public. But the war in the Far East, and the success with which Japan has employed the 30-knot boats built by British firms of wide experience, has convinced the Admiralty that these craft are best calculated to meet the needs of a modern fleet.

THE "River" class of destroyer, which was built during the period immediately following upon the commotion caused by the loss of the "Cobra," have a speed of only 25½ knots. This is too slow a rate of steaming for vessels of the mosquito family moving on the surface, and primarily intended to be able to elude any man-of-war afloat when chased. The British fleet now has battleships which steam at sea under war conditions at 19 knots, and armoured cruisers of the "Drake" family, with a full load on board and without the advantage of clean bottoms, have maintained at sea a speed of 24 and 25 knots. The smaller the boat, the greater the loss of speed in a heavy sea, and there is no doubt that under average conditions an armoured cruiser of even 21 knots' sea speed would be able to overtake a small destroyer having a contract speed simply of 25½ knots. For these reasons the British Admiralty have decided to cease constructing destroyers of this comparatively low speed. The fourteen vessels included in the programme of ship building for 1904-05 are to be of from 30 to 35 knots. Little doubt is entertained that as the builders have been invited to submit competitive designs, they will adopt the turbine principle. The anticipation is entertained that as a result of this trial of designing, the British Navy will acquire boats as seaworthy and as serviceable as those which have done such excellent service in the Japanese fleet, while, owing to the introduction of the turbine of the Parsons type in place of reciprocating engines, a speed considerably exceeding 35 knots will be attained.

THE Schmidt superheater as designed for use in locomotives, although of German origin, has during the past two or three years been adopted in many places and in connection with a considerable number of engines. In Germany, engines of all kinds for express, goods, local, and heavy mountain service, are fitted with this superheater, and on the Prussian State Railway alone, according to latest advices, there are now 190 engines at work with it. On the Canadian Pacific Railway the Schmidt apparatus has been used to a considerable extent, and some notable trials have been carried out. As a result large orders have been given in North America for new engines, most of them to be fitted with the Schmidt apparatus, and a number also with the superheater recently introduced by Francis J. Cole, of the American Locomotive Company. There are now between fifty and sixty superheater engines in use in Canada. About thirty engines fitted with the Schmidt apparatus are in use on various Russian railways, and others are on order, and in Austria, Hungary, Switzerland, and Sweden trial engines are in service on various lines. In Belgium there are about thirty superheater engines. Two engines fitted with the Schmidt superheater have been in use in Cape Colony for some time, and recently locomotives so equipped have been placed in service, or are now under construction for several of the French railways, and for the Great Western Railway in Great Britain. Trials carried out in Germany and Canada have given rather curious results as regards the comparative merits of non-compound and compound engines when fitted with the superheating apparatus. In both cases the trials have shown that the economy which results from the use of superheated steam, as compared with the non-compound non-superheating engine, is very little greater with the compound engine than it is with the simple engine, and the benefit which would be otherwise obtained from compounding is, to all intents and purposes, lost.

THE piercing of the Simplon tunnel through the Alps, proposed as long as fifty years ago, but not commenced until late in 1898, was completed on February 24 of this year, and according to contract the tunnel is to be ready for traffic about the middle of May. Plans and estimates were carefully planned and considered in the year 1893 and the provisional contract for the construction was made at that time between the Jura-Simplon Railway Company and Messrs. Brandt, Brandau & Co., the well-known contractors. The late Mr. Brandt, to whose skill and knowledge much of the success was due, had been in a highly responsible position on the work of the St. Gothard tunnel, and his great experience there enabled him to devise various appliances, particularly his well-known hydraulic drill, by means of which a speed in execution has been attained surpassing that in any other rock tunnel. Herr Edw. Sulzer, of the well-known firm of Sulzer Brothers, of Winterthur; Herr Brandau, Herr Locher, the talented engineer of Zurich, the constructor of the mountain railway up Pilatus; Herr Pressel, Herr von Kager, and others have been associated in the work.

As told recently in the London "Times," doubts were thrown by leading authorities upon the possibility of constructing a tunnel of this great length, with such a height of mountain, about 7000 feet, above the work. This height, according to the calculations of geologists, should correspond to a rock temperature of from 104 degrees to 107 degrees Fahr. It was this high temperature of rock which gave rise to great fears, as in the case of the St. Gothard tunnel the completion of the work proved very difficult even with a rock temperature of 86 degrees Fahr. The Swiss Government, therefore, decided to summon to their aid an international commission of tunnel experts. The governments of Italy, Austria, and Great Britain were requested each to nominate an engineer to advise and report upon the plans, estimates, and proposals. The Italian Government nominated Signor Guiseppe Colombo, member of the Italian Legislature, and afterwards Minister of the Treasury, a most able man; Austria nominated Herr C. J. Wagner, one of the government engineers, and constructor of the Arlberg tunnel, in which considerable difficulties had been met with; whilst Great Britain nominated Francis Fox, member of the Institution of Civil Engineers, and member of the firm of Sir Douglas Fox & Partners, of Westminster, and it is an interesting fact that Mr. Fox is the only Englishman connected with this great enterprise. These three gentlemen in 1894 sat as a commission in Berne, devoting many days to a complete study of the plans and proposals, and after visiting the site of the intended work, presented to the President of the Swiss Confederation their full report. Upon the principles laid down therein, and by the promoters, the tunnel has been carried out. A treaty was entered into, in July, 1894, between the governments of Switzerland and Italy, authorising its construction. The Simplon tunnel is the third one, and longest one, through the Alps. From Briga in Switzerland, to Iselle on the Italian side, it is 12¼ miles long. The St. Gothard tunnel measures 9¼ miles and the Mont Cenis, a little over 7½ miles. The cost of the Simplon tunnel is £3,000,000, borne jointly by the Italian and Swiss governments.

SAWING stone by wire is the subject of an item recently printed, according to which it is regarded as something new,—only latterly brought out in France. Three twisted steel wires are said to be used, passing around pulleys in endless fashion, one of the pulleys being a driving pulley, and a tension carriage being used to keep the wires properly taut. Sand and water really are the cutting agents, so that we have in this simply a development of a practice of many years' standing in marble mills and quarries probably the world over. Marble sawing for time out of mind has been done with saws so-called, consisting of plain strips of soft wrought iron, a little more than 1-16 of an inch thick and about 3 inches wide, sand and water being let into the saw cut as the work proceeded. It may be worth recalling that when worn out these saw blades are very narrow at the centre but of the full width at the ends. At one time these partly used-up blades were thrown away as worthless, but later, in one locality at least, a use was found for them, the old saws being converted into cut nails, for which their toughness admirably adapted them. A very inconvenient waste product was thus turned to good account and made a source of revenue. The nails themselves were of all sizes up to 3 inches in length and were of good quality.

SOME highly interesting facts, says the "Army and Navy Journal," as to the effect of modern gun fire on the engines and boilers of armoured warships have been brought out by an examination of several of the Russian vessels disabled during operations in the Far East. There has been a widespread belief in professional circles that the men stationed in what Kipling picturesquely describes as "the little hell below," would have an exceedingly uncomfortable time of it during a sea fight under modern conditions, but experience has shown that the engine room and the boiler room of the battleship and cruiser of to-day are somewhat the most comfortable parts of such vessels. The captain of the Russian cruiser "Variag" states that after the terrific battering his ship received at Chemulpo her machinery below worked as smoothly as if she had only been engaged in target practice. The battleship "Czarevitch," hammered and almost dismantled in the battle off Port Arthur, was taken in charge by a midshipman after all his superior officers were killed or wounded and steamed away safely to Tsing-Tan with her engines and boilers only slightly damaged. The battleships "Retvizan" and "Pobieda" were both almost totally wrecked in their upper works in one of the engagements off Port Arthur, but were able to return to shelter with their own steam, and so little were their engines and boilers injured that both vessels ran out to sea a few days later. This information, which was given to a correspondent of the London "Standard" by officers of the Russian ships, shows very clearly that while modern shell-fire is terribly effective on the upper works of present-day warships, it involves little, if any, increase of peril to the men on duty below. Another lesson taught by the experience of the Russian vessels is that all present means of communication which are not actually behind the armour or below the water-line are utterly useless in the hour of battle. All speaking tubes and all bells and telegraph lines were shot away and wholly destroyed on the "Czarevitch" and "Pobieda," as were also all means of visual or wireless signalling. The moral is that some simple and primitive means must be devised whereby orders can be conveyed to the fighting position when the agencies now in use are no longer operative. What that method shall be is a matter well-deserving the consideration of navy officers who have had actual experience in sea fighting.

———

The application of dry air blast to the manufacture of pig iron formed the subject of a very interesting paper several months ago before the American Institute of Mining Engineers, by James Gayley, of the United States Steel Corporation. The desiccation of the air used in blast furnaces in such a way as to reduce its moisture to a small quantity, and to keep it uniform, must of necessity contribute in a very marked degree toward the attainment of uniformity in the furnace operations. The advantages from desiccation can be appreciated only after due consideration is given to the volume of air that is consumed per minute and the large amount of moisture which it contains. Managers of blast furnaces are familiar with the chilling effects produced in the hearth by a tuyere that is leaking, which immediately results in a deterioration in the grade of the iron; yet the quantity of water ordinarily entering the furnace under these conditions is not very greatly in excess of the quantity carried in, like a steady stream, by the atmosphere, during a period of the average humid conditions prevailing in many localities. Mr. Gayley's experiments, therefore, eventually led to anhydrous ammonia refrigeration of the air supply to the blowing engines as the best means of moisture extraction, and the Isabella furnaces of the Carnegie Steel Company, at Etna, a suburb of Pittsburg, were selected as the plant at which to install the first apparatus.

———

The plant was put in operation in August, 1904, with immediately beneficial results. When the dry-blast was supplied to the furnace, it became necessary to reduce the revolutions of the blowing-engines, since the air supplied to the engines was lower in temperature than the natural atmosphere and contained more oxygen per cubic foot, and the tendency of the furnace was to drive too fast. Before applying the dry-blast the engines were running at 114 revolutions and supplying 40,000 cubic feet of air per minute; the revolutions were gradually reduced to 96, thereby reducing the volume of blast over 6000 cubic feet per minute and increasing the efficiency of the engines by 14 per cent. With dried blast, 96 revolutions per minute of the blowing-engines burned nearly 1 per cent. more coke and produced 89 tons more pig iron in 24 hours than 114 revolutions per minute with atmospheric air. The reduction in the revolutions resulted in a gain of 150 degrees in the temperature of the blast, which, even with this increase, through lack of area in the waste gas ports of the stove, did not average above 870 degrees. The average analysis of the gas for ten days prior to the introduction of the dry-blast showed:—CO, 22.3 per cent.; CO_2, 13 per cent., with an average temperature of 538 degrees. Later, with dry-blast used entirely, the average analysis was:—CO, 19.9 per cent.; CO_2, 16 per cent., with an average temperature of 376 degrees. This reduction in temperature of 162 degrees is a necessary consequence of the greater concentration of heat in the hearth by the dry-blast combustion and the greater weight of burden heated by the gas, and represents an important saving of heat in the furnace.

The dry-blast has resulted in economies in several other directions. In the use of Mesabi ore, which is very fine in structure, the waste of ore-dust carried by the escaping gases is quite large, and at many furnaces it has become quite burdensome. At the Isabella furnace, before dry-blast was used it amounted to 5 per cent. of the ore charged, and it has been reduced, through the greater uniformity in the furnace-working, effected by the dry-blast, to less than 1 per cent. The saving in coke consumption reduces the phosphorus in the metal, and this, in making Bessemer iron, permits the use of ores higher in phosphorus. As the Isabella furnaces were making basic iron, it was an advantage to keep the silicon as low as possible, provided the sulphur was kept low; and the absence of irregularities in the furnace operations resulting from the dry-blast permitted the keeping of the silicon at a lower range without increasing the sulphur. It has been generally observed by furnace managers that when the silicon is lowered through increased humidity in the atmosphere, a leaking tuyere, or through other causes, the sulphur is rapidly increased; but it has been found in using the dry-blast, that when the hearth temperature was suddenly lowered, principally from accretions on the bosh reaching the hearth, the sulphur did not increase, and in this respect the furnace has shown a remarkable uniformity in composition of the metal produced.

Mr. Gayley points out also that probably the further application of the dry air blast to the Bessemer converter would result in great benefit, since in that apparatus air is used in large quantities, and the varying humidity affects the temparature of the charge and in consequence the quality of the steel. The metal from the metal-mixer employed in many Bessemer works is remarkably uniform, and the additional uniformity secured through the use of dry air would be of further advantage. In American practice, a higher silicon is required in the summer months to maintain the temperature of the blow, in which period it is also more expensive to maintain the right amount of silicon in the pig iron. With the use of the dry-blast in the converter the proper temperature could be secured with a lower silicon in the metal, and this in turn would further reduce the coke consumption at the furnaces. In other processes where air is used in large quantities—particularly in copper and lead smelters and copper converters, in the open-hearth furnace and in cupolas—it seems probable that the use of dry air would effect important economies, and its application to gas-producers, by-product coke and charcoal ovens, for the extraction of the moisture, would be very beneficial.

The development of the internal combustion engine for marine purposes is being watched with great interest. As Sir William White pointed out recently, the adoption of the now familiar motor boat means that the same ranges of power and action as are obtained from the best modern reciprocating engines and boilers can be secured at one-sixth of the weight with the newer motor. This statement he made on the authority of Sir John Thornycroft, who has devoted much thought to this coming revolution in the propulsion of small craft. The British Admiralty are so convinced of the wisdom of adopting the internal combustion engine at sea that they have carried out a series of experiments. The first result has been the decision to build a motor launch for the King's yacht, and there is also some talk of this type of engine being utilised in the new torpedo boats which are about to be built. It is realised that not only does the internal combustion engine give equivalent power to the reciprocating engine and boiler with a great economy of weight, but that the new engine will lead to a further economy in weight owing to the reduction in the engine room and boiler room staff, which it will be possible to make. The motor boat has become one of the toys of the wealthy, and yacht builders report that many lovers of the sea who have hitherto spent a large part of the year in yachting, are now ordering motor boats, which will either supersede their sailing craft or will be used in connection with them.

According to "Engineering," the London, Brighton & South Coast Railway has been experimenting for several years with roller bearings in place of the ordinary axle-boxes of rolling stock, and a new train has now been completely fitted with bearings of this type to enable comparisons to be made on a sufficiently large scale. For nearly two years a bogie passenger coach, with roller bearings, has been running daily on the main line fast service between Brighton and London, having covered a distance of at least 80,000 miles, and the results were so satisfactory that the company decided on the equipment of an entire train, so that comparison might be made with similar trains doing the same service with ordinary axle-boxes. In the roller bearings used, a hardened and ground steel sleeve is pressed on to the neck of the axle, and the rollers, of which there are 14, of $\frac{7}{8}$-inch diameter, run between this sleeve and a similar exterior one. The rollers are kept parallel to the bearing by a gun-metal lantern, between the bars of which they fit, and which slowly travels round the journal. The rollers are solid and made of case-hardened mild steel, accurately ground to size. At a demonstration given on the occasion of the recent inauguration of the new train, one of the bearings, which had seen nearly two years' service without repairs, was dismantled, and all working parts appeared to be in excellent condition. A considerable saving of coal per train-mile is expected, and it is hoped that the more rapid acceleration of the trains, due to the reduction in starting resistance, may enable suburban traffic to be handled more expeditiously.

Candles when lighted should be always placed in a candle-stick made of metal. Workmen very often will place a lighted candle on woodwork and, if occasion requires, they will go away with no thought of the lighted candle and its attending danger, many times causing a serious fire. Some years ago, so Mr. Washington Devereux told recently before the Engineers' Club of Philadelphia, a large hotel in that city considered the advisability of introducing electric lighting. A fire of a very mysterious origin occurred. The electric wiring had been installed in accordance with the best-known methods of the day, but the moulding which incased the electric conductors caught fire. The proprietor had heard many vague and mythical stories of the dangers of electricity and concluded the electric conductors were responsible for the fire, in spite of the fact that no current had ever passed over the wires. The problem was a great one and too much for "mine host." To solve the mystery he summoned to his aid a so-called electric expert. The expert declared the wires had been charged with induced electric current from the electric light mains in the street, which passed within 50 feet of the building. William McDevitt, chief inspector of the Fire Underwriters' Association, was also consulted. The theory of electrical induction did not appeal to him in the least. In fact, he knew the absurdity of the statement. Mr. McDevitt and the proprietor carefully went over the ground. The line of moulding in the cellar, which inclosed the electrical conductors, was considerably burned. At various points along the moulding, candle grease indicated what mode of illumination had been used to aid the workmen while installing the wiring. The inspector called for a small piece of candle, and lighting it placed it upon the moulding, suggesting to the proprietor, "now we will go away and forget the lighted candle, and you will have another fire due to the electric induction." The common-sense solution won the day and the building was equipped with electric light throughout.

As illustrating the rapidly increasing use of cement, R. W. Leslie, in a paper read a short time ago before the Engineers' Club of Philadelphia, stated that there were then in use at least thirty forms of construction for large cement buildings. Each of these thirty systems supplied business for a separate company, each doing work in the building of large structures, such as houses, mills, factories, and other buildings up to eight and ten stories, out of this material, which six years ago nobody thought was adapted to any purpose other than the building of bridges, sewers, and works of a lower level. Some of them involve very little the use of beams; in some the T section is largely used, and in others chains or rib bars are employed, as is also expanded metal, through which the cement is forced on the inner side; and every one of these different systems has its organisation, with its officers seeking business, and all using iron or steel in connection with cement.

To enumerate only a few of the uses of cement, Mr. Lesley cited the case of railways, for example, which are beginning to construct their station buildings of concrete and their ties as well; cement floors, too, are coming into use for the stations, and cement gutters; cement curb walks, cement retaining walls, cement round-houses, cement mile-posts. The agriculturist has cement fence-posts, concrete bins for grain, concrete floors, troughs, reservoirs, and walls. Concrete is used for factory buildings which are on concrete foundations, and they have concrete pillars, when necessary, to support the foundations. Cement pavement is used in front of buildings. The sewers, gutters, and curbs are of concrete. There are concrete bridges in many places; water-towers and water-pipes of the same material; sky-scrapers eight and ten stories high all made of cement and concrete. In mining, the timbers are being displaced by concrete piers. By a most ingenious scheme of pouring cement into damp sand, after a method analogous to that of making iron castings, the most beautiful effects in sculpture are reproduced in concrete, and the statuary of Rome and Greece has been so reproduced, coloured in the most beautiful way, and giving the most artistic effects, and at an expenditure almost insignificant as compared with stone

---

Two rather ambitious schemes for electric traction on a large scale were recently brought before the Electrotechnical Association of St. Petersburg. The first is no less than the electrification of the Trans-Siberian Railway, a project considered by Count A. F. Lubienski as not only desirable, but necessary. The transportation of passengers and goods on this railway, apart from the traffic due to the war, has developed to such an extent that it will soon become necessary to increase the number of trains. Owing to several circumstances, particularly the lightness of the rails and the insufficiency of water, the existing trains are said to have reached their practical limit of speed; and though the water difficulty might be met by canalisation or other means, the relaying of the track would entail an enormous expenditure of money and time. The Count maintains that the most rational and economical way of meeting the case is by the introduction of electric traction on some parts of the line at least. The existing track would be made use of, and the many sharp curves and heavy gradients would not limit the speed of a multiple-unit electric train to the same extent as in the case of a train drawn by a steam locomotive. It is proposed to make use of the rivers and waterfalls along the course of the line for the supply of electric energy, which would be generated at power stations from 100 to 200 kilometres apart, and distributed in both directions to transformer sub-stations at a pressure of 100,000 volts. The second project was brought forward by Mr. G. O. Graftis, and is rather more modest in its scope. He proposes the electrification of the Caucasian railways on the grounds that electric traction is particularly adapted to a mountainous country, and that abundance of power is at hand in the waterfalls of the Caucasus. The large number of rivers and mountain torrents watering the district through which the railway runs constitute an ideal source of power which could be turned to account with little difficulty.

Through that perversity of inanimate things which most of us have encountered at some time, the name of the author in the first section of the article on "The Widening Use of Small Electric Motors," in the February number of this magazine, was printed as F. H. Kimball instead of Fred M. Kimball. Several little reminders of the discrepancy have come from different quarters, complimentary to Mr. Kimball as showing how carefully his writing was read.

BENJAMIN TALBOT

THE ORIGINATOR OF THE CONTINUOUS OPEN-HEARTH STEEL PROCESS

As the originator of what is known as the Talbot process for the manufacture of basic open-hearth steel, Benjamin Talbot has become well known in metallurgical circles on both sides of the Atlantic. He is a Shropshire man, born in 1864, and his first experience was gained as a learner in the Ebbw Vale Steel Works. From there he passed to the position of assistant to the Dephosphorizing Company, which controlled the Thomas and Gilchrist patents on the basic process in Great Britain.

In 1890 he went to the United States to start the manufacture of basic open-hearth steel in the South, becoming superintendent of the Southern Iron Company's works at Chattanooga, Tenn. In 1892 he accepted the position of superintendent of the steel department of the A. & P. Roberts Company, of Pencoyd, Pa. He introduced the basic open-hearth process there, and in 1898 brought out the continuous open-hearth process (otherwise the Talbot process). This process was successfully installed at Pencoyd, Pa., and afterward taken up by the Jones & Laughlin Steel Company, Pittsburgh, which is now operating the largest steel furnace in the world on this process, and is building other furnaces like it, as it has proved to be so economical. He resigned his position as manager at Pencoyd in 1900 in order to devote more time to the introduction of the continuous process in Europe and the United States.

Manufacturing News

A New Automatic Centre Punch

THE new automatic centre punch made by the Brown & Sharpe Manufacturing Company, of Providence, R. I., will doubtless prove of interest both to the employer and to the machinist who has been accustomed to use the old style centre punch and hammer.

The accompanying illustration shows this automatic punch, which is entirely new in design, and which the manufacturers claim combines features that make it much more convenient and accurate for laying out work to be machined or drilled than the ordinary centre punch and hammer. In designing this tool every care has been taken to combine lightness and simplicity with durability, and the various parts were calculated to withstand the most severe usage to which a tool of this character may be subjected. All parts are of steel, proportioned and adjusted to avoid liability of getting out of order, the parts most subject to wear being carefully hardened.

AN AUTOMATIC CENTRE PUNCH MADE BY THE BROWN & SHARPE MANUFACTURING COMPANY, PROVIDENCE, R. I.

The tool is self-contained, the striking mechanism being enclosed in the knurled handle, which is of such a size and form as to be conveniently held in the hand. It is about 5¼ inches long and ⅝ of an inch in diameter.

When following a line or establishing a point by the intersection of lines, one hand can be free to guide the point or hold the magnifying glass, and, after the point is located, it is not apt to slip and lose the setting, as merely a downward pressure of the handle releases the striking block and makes the impression. Another advantage appreciated by machinists is that the punch marks are all of uniform depth, and, therefore, more easily and accurately followed than when of varying depths.

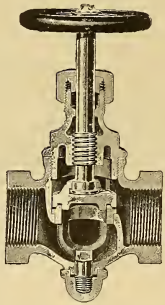


FIG. 1.—A VALVE WITH RENEWABLE SEAT AND DISC. MADE BY CRANE CO., CHICAGO

New Crane Co. Globe and Angle Valves

A NEW valve, with renewable seat and disc, and a new self-packing radiator valve, made by the Crane Company, of Chicago, are shown in the annexed illustrations. From Fig. 1 it will be seen that by unscrewing the nut on the bottom of the renewable seat and disc valve the seat is accessible and removable from the top, thus making it convenient to substitute a new seat when required, or to replace any worn part.

The disc, being attached to the stem by a slot, is easily removed and replaced. The seat and disc can be removed and ground together if necessary.

In assembling the valve, the seat is placed in position, and the nut on the bottom of the valve, which holds the seat in place, is tightened, and the bonnet is screwed on and the valve closed. The construction of these valves is such that they may be packed when open without steam escaping; in so doing the valve is left wide open. The renewable parts are made of a hard composition, and the valves are designed for working under a pressure of 250 pounds.

Fig. 2 illustrates the self-packing radiator valve, provided with a Jenkins disc and non-rising stem. The packing consists of a piece of vulcanised rubber, which can be easily renewed.

The threads on the bonnet of these valves are the same size as those in the Jenkins disc valves, made by the company, and the old style trimmings may be replaced with this new self-packing device without removing the valve from the radiator. It can also be applied, if desired, to any of the company's brass wedge-gate valves with non-rising stem.

A New Channelling Machine

IN the quarry processes of to-day there is a wide field of usefulness for a rock-cutting machine intermediate in its functions between the heavy track channelling machine and the machine drill as applied in the "plug and feather" method of breaking rock. In the development of new quarrying properties also it is advisable to prove up the value of the deposit before heavy investments are

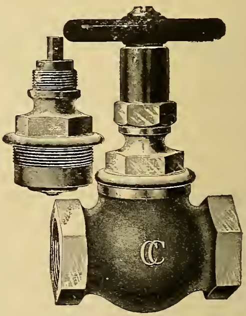
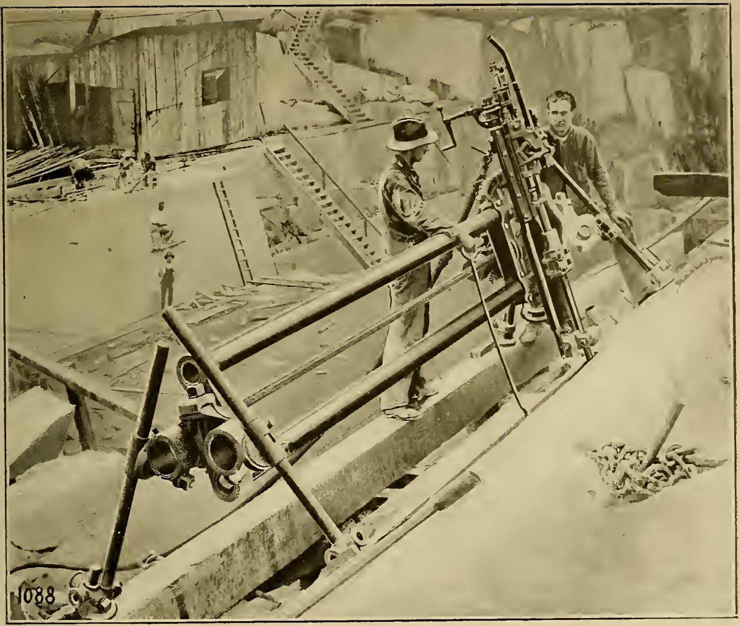


FIG. 2.—A SELF-PACKING RADIATOR VALVE MADE BY CRANE CO., CHICAGO



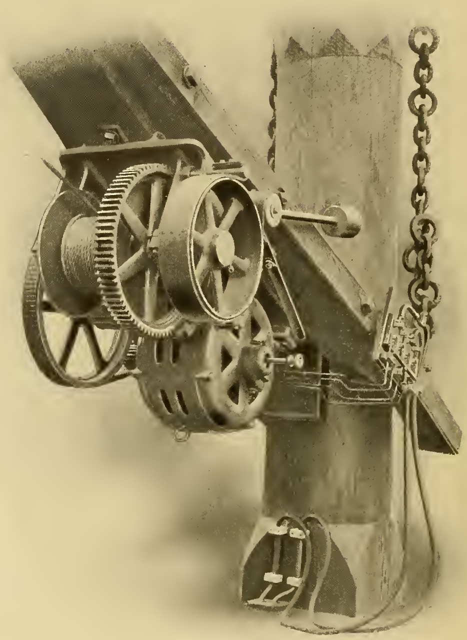
A CHANNELLING MACHINE BUILT BY THE INGERSOLL-SERGEANT DRILL CO. NEW YORK

made, yet the method of hand clearing and prospecting is much too slow. In developed quarries, too, it is often necessary to channel material which has a sharp dip or incline, and there a heavy track channeller is not practicable. In the lighter work of the quarry, cutting sumps and keyblocks, enlarging the walls and working in confined and uneven places, a light, portable machine is always useful and effective.

To meet just such conditions as these the Ingersoll-Sergeant Drill Company, of New York, has designed a type of machine channeller which has been given the distinctive name of " Broncho," because of its rough-and-ready character and its ability to stand up to work under the most severe conditions of service. The construction of the machine and the more important details are clearly shown in the accompanying illustration. It resembles somewhat the old bar channeller, but its distinctive features of design, operation and construction mark it as a new type of machine.

The frame is made of bars of heavy pipe rigidly secured to end castings. Between the bars the heavy steel travelling screw is firmly mounted. The end castings of the frame are swivelled in heavy end pieces, to which are joined the connections. Cone clamp effect is secured at all these joints, and the result is a structure of great flexibility and almost universal adjustment, yet of utmost rigidity when pressure is applied. The swing of the legs and their sliding in the clamps make a mounting adaptable to any surface or any angle.

The channelling machine proper is in no sense a rock drill, but a heavy cutting engine designed to secure great strength and effectiveness. The cylinder has a diameter of 3½ inches and a full stroke of 6 inches, variable down to a minimum of 2 inches. For starting cuts, working through soft spots, and cutting across splits or seams, where the full blow is not desirable, a cushioning device is provided whereby the blow may be varied from the merest tap to one of full power. A tail rod extends through the rear cylinder head and acts as a piston guide. This is also designed to prevent binding or cutting between cylinder and piston, reduce wear on the piston and cylinder walls, and assure a free, easy stroke. The tail rod also serves to operate a small "pilot" valve, which, in turn, controls the pressure to throw the main valve.



AN ELECTRIC DERRICK WINCH MADE BY THE QUAKER CITY ELECTRIC COMPANY, OF PHILADELPHIA. ADAPTED TO EITHER GUYED OR STATIONARY MAST AND BOOM DERRICKS

A novelty of design is the omission of the usual crosshead and guides and the substitution of roller guides in which the steels work direct. The guide rollers are of hardened steel and guide the steels on all four sides. The roller-guide attachment can be removed and the rotation gear thrown in. The drill bit is then inserted in the clamp and the engine can be used to drill a circular hole. The machine may thus cut an open channel and drill a round hole, at any angle from horizontal to vertical. The engine has two rotations,—one around the axis of the frame, the other around an axis at right angles to it.

Vertical feed is provided by a crank on the feed screw. The movement of the cutting engine along the bars is automatically reversed at each end of the travel, and the stops may be set to reverse at any intermediate point. While the best results with this machine are secured by the use of high-pressure steam or air, the valve motion is such as to secure good results with low-pressure and wet steam.

The net weight of the channeller is about 3000 pounds. It is designed to make a cut of 10 feet 6 inches long to a depth of 12 feet. The capacity varies, of course, with the pressure used and the material cut. Its best work is done with a pressure of about 100 pounds at the throttle, and cuts 7 to 10 feet deep. It uses about 175 cubic feet of free air per minute, or requires a boiler of 20 to 25 horse-power.

An Electric Derrick Winch

THE electric winch shown in the annexed illustration was designed by the Quaker City Electric Company, of Philadelphia, to provide a light but powerful lifting mechanism, easily applied and adapted to either guyed or stationary mast and boom derricks.

It consists substantially of one main casting forming the bearings for and supporting the cable drum, countershaft, journals and motor. It fits the under side of the gaff or boom, and is held in place by bolts extending through heavy cast iron straps on the top side of the boom.

The power is transmitted from the motor to the countershaft by silent chain drive, and from the countershaft to the drum shaft by cut spur gears. The motor may be either direct or alternating current of 5 H. P., and may operate at a speed not exceeding 1200 revolutions per minute.

The method of control may be either by an electric controller varying the motor speed, which requires starting the motor from a standstill for each load hoisted and the use of an electric brake with hand attachment for lowering, or by keeping the motor in operation continuously while the derrick is in use and controlling the load with a simple but powerful friction clutch and hand brake. Either of these systems is feasible with direct-current motors, but for induction motors only the latter can be used.

Industrial Locomotives

IN an article entitled "Industrial Locomotives" printed in the September number of this magazine, a third-rail electric locomotive was illustrated and described as built by the Goodman Manufacturing Company, of Chicago. This company, however, are, in point of fact, the selling agents only for this locomotive, while the manufacturers are the Morgan Electrical Machine Company, of East Chicago, Ind.

A New Gasoline Motor

AUTOMOBILISTS, among others, will be interested in the gasoline motor which has recently been brought out by the Adams Company, of Dubuque, Ia. The manufacturers of this motor claim for it distinctive advantages, such as compactness, perfect balance, light weight, wide range of speeds and power, and practical air-cooling qualities under all conditions. The accompanying illustration is a perspective view of the motor as situated in the rear of an automobile body.

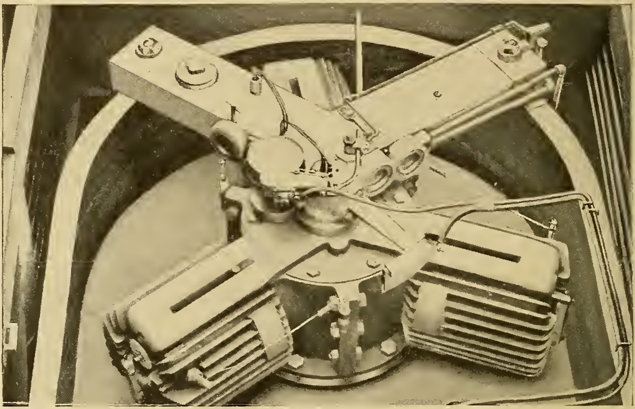
This motor reverses the ordinary practice, in that the engine cylinders revolve and the crankshaft is stationary, instead of the crankshaft revolving and the cylinders being stationary, though it is not what is usually termed a rotary engine. Three units, each being a complete cylinder, with cylinder head and one-third of a central crank case cast in one piece, are bolted together, and the cylinders are bolted to top and bottom steel flanges which have bronze bushings, forming bearings around the vertical stationary crankshaft. This forms the revolving unit, which is perfectly balanced, and which acts as a fly-wheel, and in a 20 horse-power engine, with 5-inch bore and 4½-inch stroke, weighs 190 pounds. The pistons are attached to that part of the crankshaft which is eccentric with the axis of the revolving cylinder unit, which is caused to revolve when the pistons reciprocate in the cylinders.

The lack of vibration of the motor is attributed to the perfect balance of the revolving parts, the manner of revolving the cylinders in a horizontal plane, and to the novel method of controlling the speed of the motor by a variable compression system. No muffler is employed, the discharge acting upon the air similarly to a skyrocket and not like a gun. It is claimed that the exhaust cannot be heard when the motor is working at part power.

Air cooling is effectually accomplished by the cylinders revolving at a rapid rate, drawing in the air at the centre of the revolving unit and expelling it with great rapidity at the periphery.

The variable compression system by which the speed of the motor is controlled consists in allowing that part of the charge of gas not needed by one cylinder to be drawn in by another cylinder by an arrangement of valves. This system of control is claimed to be very economical, conducive to smooth running, to obviate the necessity of heavy exhaust valve springs, to run much cooler, and to keep the cylinder heads and spark plugs entirely free from sooty deposits.

The carburetter is entirely automatic at all speeds, no attention being required after once adjusting, and the spark is regulated automatically by a device which fires the charge at all speeds at a point to produce the greatest efficiency. The oiling of all parts of the motor is cared for by an automatic, positive feed oil pump.



A GASOLINE AUTOMOBILE MOTOR MADE BY THE ADAMS COMPANY, DUBUQUE, IA.

By reference to the illustration, it will be seen that from this position every part of the motor proper is exposed to view and readily accessible, that is, every part that will ordinarily ever require examination or adjustment. With no compression, the cylinders may be easily turned around, bringing any one in convenient position for removing spark plug or valves. Should a valve leak, it can be replaced by another in a few minutes on the road.

There is not a gasket or packed joint about the entire engine, and by taking out three bolts on each side, the two on

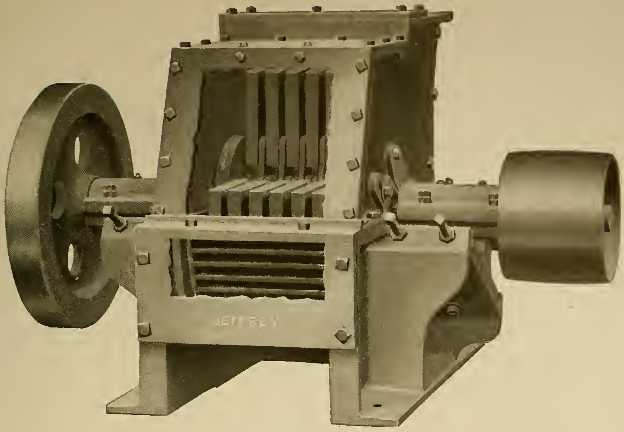


FIG. 1.—A HAMMER PULVERISER BUILT BY THE JEFFREY MANUFACTURING COMPANY, COLUMBUS, OHIO

the top and the two on the bottom flange, any cylinder may be drawn off for examination, or by removing the two cap boxes on the transmission shaft the entire transmission can be removed.

All the novel features, such as revolving the cylinders around a vertical, stationary crankshaft, system of muffling, variable compression control, automatic spark regulator, control from front and rear seat, variable strength springs, carburetter, oiling system, etc., are the subjects of patents granted and pending in America and other countries.

The Jeffrey Hammer Pulveriser

A HAMMER pulveriser made by the Jeffrey Manufacturing Company, of Columbus, Ohio, is shown in the annexed illustrations. Fig. 1 illustrates the pulveriser with its interior or crushing parts; Figs. 2 and 3 show the sectional screen frame, which is one of the special features in this machine.

It is designed for crushing and pulverising material such as rock, coal, clay, shale and many other materials. Strong features are claimed to be its simple beater hammer, V-shaped bar screening surface, simple adjustment of the beater arms to accommodate wear, substantial adjustable, dust-proof pillow blocks, and a top-feed hopper, insuring large capacity and permitting material to be partly crushed while in suspension. The accessibility of its inner

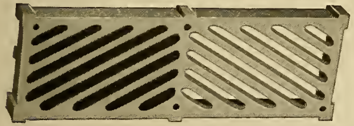


FIG. 2.—A SECTION OF THE SCREEN FRAME OF THE JEFFREY PULVERISER FOR HEAVY WORK

FIG. 3.—A SECTION OF THE SCREEN FRAME OF THE JEFFREY PULVERISER

parts is also one of its features. The taking-off of the rear plate and the hand-hole plates on the side of the machine makes it possible to change the beater arms as well as the screening surface when necessary. The latter is made up in sections, so that it is the work of but a few moments to take it out or change from one size mesh to another.

The pulveriser is made in many sizes to suit the various requirements,—for instance, in coal the capacity varies from 50 to 100 tons of coal per hour, depending entirely upon the degree of fineness. In pulverising material such as rock its capacity is from 10 to 25 tons per hour.

A "Solid" Adjustable Reamer

ONE of the smaller tools manufactured by the Gisholt Machine Company, of Madison, Wis., is a "solid" adjustable reamer, a demand for this, as for many other tools which they have placed on the market, having first arisen in their own shop. An ideal reamer should possess all the solidity of a one-piece tool, and yet be constructed so that expansion is possible, thus providing for wear. A particularly valuable feature in this Gisholt reamer, according to the makers, lies in the size and thickness of the blades, each blade having two cutting edges, and the best tool steel is used in their construction. Also the extra weight and width of stock used materially reduces the liability of breakage. The body is made of high carbon steel, bored and slotted to fit standard reamer arbours, and especial care is taken in building these tools in order to insure an accurate fit of the blade to the body. They are now manufactured in all standard sizes, in both hand and machine reamers.

AN AUTOMOBILE FOR INSPECTION SERVICE ON STEAM RAILROADS.
BUILT BY THE OLDS MOTOR WORKS, DETROIT, MICH.

The Railroad Auto-Car

SUCCESSFUL use of an automobile for steam railroad service was made by the Boston & Albany Railroad recently, on trial trips on the western section of its line, near Pittsfield, Mass. This inspection car, made by the Olds Motor Works, Detroit, Mich., is identical in mechanical construction with their regular Oldsmobile runabout, except that it has flanged wheels and no steering attachment.

The car was designed for one of the Boston & Albany roadmasters, who had a large territory to cover, and under conditions hitherto existing it was impossible for him to give his section the attention it required. This machine meets the demand for a light car with independent positive power for quick runs to any part of a division and for regular track inspection.

The working parts of the car are simple. The gasoline motor is started from the seat, and a turn of the crank will put the engine in motion. The car frame is made up of steel tubing and oak sills. The wheels are of pressed steel, 20 inches in diameter, with a width over all of 4½ inches and a flange 1 inch high. The gasoline and water capacity is sufficient for a trip of 100

AN ELECTRIC TYPEWRITER MADE BY THE BLICKENSDERFER MANUFACTURING CO., STAMFORD, CONN.

miles, and a speed of about 40 miles an hour can be attained. The car easily mounted the heaviest grades and operated the automatic signals and spring switches.

A number of these cars are used in Western America, but the Boston & Albany is stated to be the first steam line in the East to use such a machine. Many of these auto-cars have been shipped to other countries, notably to Great Britain.

An Electric Typewriter

A RECENT development in the application of electricity to machine operation is an electrical typewriter, made by the Blickensderfer Manufacturing Company, of Stamford, Conn., and shown in the annexed illustration.

The electrical part of this invention is a small motor, which is incorporated as a part of the machine, and from which is received power to move the parts. The machine is connected to an incandescent light socket, and the motor is under perfect control of the operator by means of a convenient switch.

This machine is a new Blickensderfer product, but embodies the main Blickensderfer ideas, such as the type-wheel instead of the type-bars, and the revolving ink-roll (on the principle of the printing press) in place of a ribbon.

The superior advantages claimed for this machine are:—

(1) Ease of operation; (2) Speed; (3) Visible writing; (4) Durability.

On the Blickensderfer electric typewriter it is necessary for the operator to but touch the keys lightly and the work is done instantly. This rapidity of movement of the type action permits of the operator's fingers falling upon the keys in rapid sequence, in exactly the same way as do the fingers of an accomplished pianist. This is made possible by an automatic key release, which enables the operator to strike a key before the preceding one has been released (this is called the piano action), and adds speed and ease of operation.

Being a power machine, it is a good duplicator, and it will readily be seen that the touch is no heavier in manifolding than in regular work, so that it is not necessary for the operator to make hammers of his fingers.

Another entirely new device for the saving of time is the automatic control of the carriage. Just the touch of a key, and the platen around which the paper folds travels to right or left and spaces the sheet for the next line. This feature makes the operation continual, as the keys for the carriage control are at the right of the keyboard and do not call on the operator to take his or her hands out of writing position.

The machine is also a visible writer, —that is, the writing is always in sight. It also has interchangeable advantages, such as a variety of types, colours of rolls, and lengths of carriages. Twenty-eight keys produce eighty-four characters, and as the whole of the letters and signs on the type-wheels are cast into a solid block, perfect alignment is assured.

Unlike all present machines, the quality of work done on this typewriter is absolutely independent of the weight of the operator's stroke. The work is done by regular, definite mechanical movements, hence the wear and tear can be quite accurately estimated and allowed for, so that it becomes merely a question of making the parts heavy enough to withstand the strain. But as a matter of fact, the machine is so smoothly driven that it is neither as large nor as heavy as the present so-called standard type-bar machines.

THE EXHIBIT AT THE ST. LOUIS EXPOSITION OF THE A. S. CAMERON STEAM PUMP WORKS, NEW YORK

Cameron Steam Pumps at the St. Louis Exposition

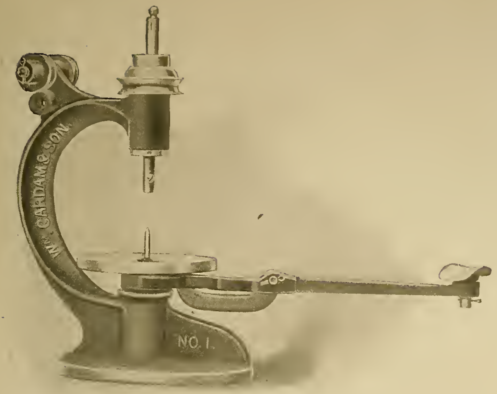
THE annexed illustration shows the exhibit, in Machinery Hall, at the St. Louis Exposition, of the A. S. Cameron Steam Pump Works, of New York, to whom was awarded a gold medal.

A number of pumps were in actual service, the various styles and sizes of these being designed to meet all ordinary and special requirements in mines, quarries, collieries, railroads, rolling mills, plantation irrigations and general pump service. The sectional model, also on exhibition, was arranged with the steam end and water-valve chest open to view, showing plainly the inside mechanism, and enabling the observer to understand the simplicity of design and accessibility of the various parts and the features which conduce to durability.

The Cameron pump has no outside valve gear or moving parts, and the steam valve works in line with the piston without the intervention of arms or levers. This feature is designed to enable the pump to run without danger at a great speed, and without liability of injury should the suction pipe be lifted out of the water. There being no dead centre, they start at any point of the stroke and run so slowly that the eye can hardly detect the motion of the piston rod, or they may be run at a high speed.

Besides a number of regular patterns, a fuel oil pump and heater, for use in connection with an oil-burning system, was exhibited, its distinctive features being the by-pass valves and piping, to avoid, when desired, pumping oil through the heater. Thus exhaust steam may be utilised to heat the oil to any degree necessary by using the by-pass in connection with it. There were also an oil line pump for pumping crude oil or a fine petroleum, a vertical boiler feed pump, a vertical deep well engine, several contractors' differential pumps, and vertical plunger and piston sinking pumps for mine service.

Another type shown was a large pot valve pump, designed for mine station pumping and heavy service. This is for use especially in mines subject to floods due to surface drainages or workings, or cutting into subterranean bodies of water, which necessarily must be pumped out in short order, and also where the water is strongly impregnated with sulphur and the use of the ordinary iron pump is prohibited.



A SENSITIVE BENCH DRILL MADE BY WILLIAM GARDAM & SON, INC., NEW YORK

A New Model Sensitive Bench Drill

MESSRS. WILLIAM GARDAM & SON, Inc., New York, have just brought out a new model of their No. 1 sensitive drill for the special use of opticians, jewelers, and wherever a first-class tool is required for delicate work. As may be seen from the annexed illustration, there are novel features about it to which attention may be called.

The drill, while capable of being adjusted to accommodate the work, remains at a stationary height while drilling, the table being raised or lowered by a lever operated by the arm of the workman, who thus has both hands free to direct his work. This lever is equipped with an arm rest and swings around within a wide radius, so that the raising or lowering of the table may be accomplished either by the right or left arm of the workman. The table is fitted with a centre, and the spindle can be bored to suit the needs of the purchaser.

The spindle has a long bearing, and can be taken out without disturbing the pulley or bushing on which it runs. There is no belt pull upon the spindle, the pull of the belt being taken up by the frame of the machine, and increased rigidity is given by the substitution of lugs upon the frame for the guide pulley bracket of former construction. If desired, a diamond can be inserted directly in the spindle, thereby reducing the vibration and saving the extra fitting of the shank needed to hold the diamond. For ordinary purposes drills up to 3-16 of an inch may be fitted to the machine by means of a chuck. While the machine is shown in position to be driven from a countershaft located above the drill, it can as readily be driven from below by merely changing the shaft to the lower holes shown.

William Gardam & Son have been making this description of tool for about thirty years, so that this little machine, which is sold for a few dollars, represents the results of an experience of a generation in manufacturing and in the actual use of the tool.

A Turbine Boiler-Tube Cleaner

THE illustration on next page shows the "Liberty" boiler-tube cleaner, made by the Liberty Manufacturing Company, of Pittsburgh. This type of cleaner was developed by the company after taking over the business of the Chicago Boiler Cleaner Company, of Chicago, makers of the Chicago cleaner, and the boiler cleaning business of the Sherwood Manufacturing Company, of Buffalo, makers of the " Niagara " cleaner. Both of these latter types have been improved by the company.

The machine consists of a powerful water turbine driving a cutting head, in which are mounted freely swinging arms. The centrifugal force due to the high rotary speed of the machine causes these arms to fly out like governor balls. On the free ends of the arms are mounted rotating cutting wheels which strike the scale, producing a combined cutting, hammer and drill action. The principle involved is the same on all three machines. The "Chicago" and "Niagara" have stationary shafts upon which ball bearings are mounted and around which the turbine wheel revolves. In the "Liberty" machine the ball bearings are dispensed with, and a peculiarly constructed bearing, resembling a thrust bearing, is used, which is found to possess some advantages over the ball bearing arrangement, as used in the "Niagara" and "Chicago" machines, when the machine is used on very heavy scale.

The "Niagara" type machines are used on scale up to ⅛ inch in thickness. For heavier scale, the "Chicago" and "Liberty" are preferred, as the motors are more powerful, and the attachments furnished help in the work. For this heavy work both are provided with a universal coupling, which connects the cutting tool with the turbine. This flexible connection relieves the machine from shock and very materially prolongs the life of the wearing parts. The universal coupling is also particularly well adapted for cleaning bent tube boilers. Where scale is in excess of ½ inch in thickness, or is of very hard nature, the freely swinging arm head is removed and a peculiarly shaped drill is attached to the universal coupling. With this arrangement tubes can be cleaned that are entirely filled up with scale.

In operating the tool a water connection is made with it through a hose. The tool is inserted in the boiler tube, the water turned on, and the operator, grasping the hose, feeds it gradually into the tube as fast as the scale is removed. He can, after a little experience, determine how fast to feed by the sound of the tool cutting in the tube. A great advantage claimed for this type of machine is that it does not in any way injure the tubes. The cleaners are made in sizes for tubes from 1½ inches in diameter up to any size required.

A BOILER TUBE CLEANER MADE BY THE LIBERTY MANUFACTURING CO., OF PITTSBURGH