## THE TEHUANTEPEC RAILWAY AND TERMINAL PORTS.

No. I.

ONE of the most remarkable features in connection with the early conquests by the Spaniards was their knowledge of topography, and this in spite of the fact that the maps which existed in those days were of the very crudest character. It did not take Hernan Cortes, the conqueror of Mexico, who landed on the coast on March 4th, 1519, very long to appreciate the best way of getting across the huge continent. Those who study a modern map will see that the Spaniard selected the very narrowest neck of land; and the question is how he arrived at the knowledge which influenced him. In a letter which Cortes addressed to his Sovereign, Charles V. of Spain, after pointing out that he had "despatched an expedition to Guatemala" he says:—"I have received information, as well as of the great riches of that country, that in the opinion of my navigators there is a strait leading from that bay into the opposite sea, which is the thing above all others in the world I am desirous of meeting with on account of the immense utility which I am convinced would result from it to the advantage of your Imperial Majesty."

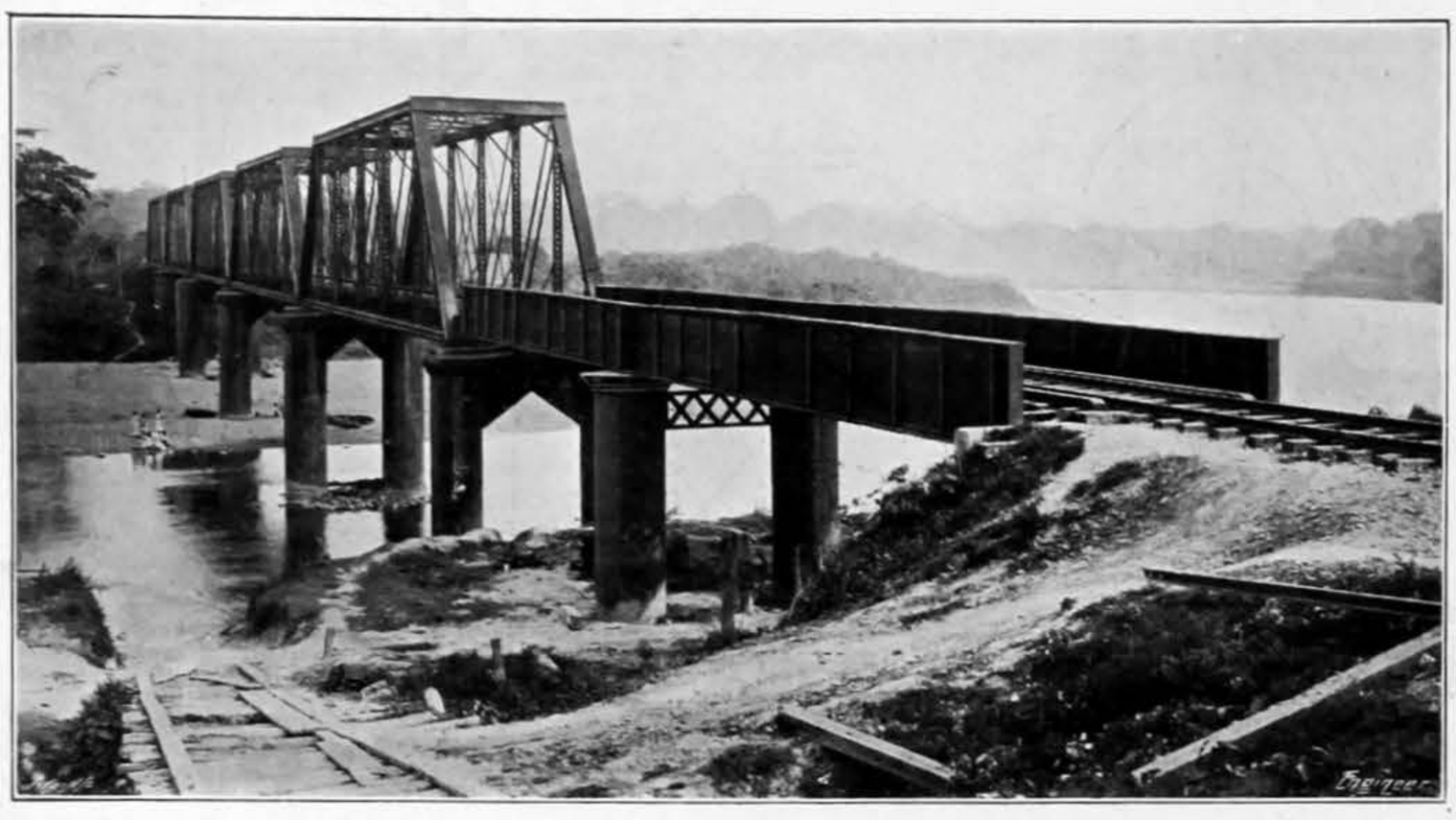


Fig. 1—BRIDGE OVER THE JALTEPEC RIVER AT SANTA LUCRECIA

After Cortes came the Colonial Governments of Mexico, which were also prompt to realise the geographical and strategical importance of the Isthmus of Tehuantepec. Again and again under successive governors, the route was explored and surveyed, the idea being, there can be no question—for documents prove it—to cut a canal through the isthmus in practically the same way as that at Panama is now being made. A certain Agustin Cramer, an engineer of some repute in his day, was commissioned by the Viceroy, Don Antonio M. de Bucareli, in 1774, to make the necessary surveys of the isthmus, and, this being done, he strongly advocated the opening up of a canal to connect the Pacific and Atlantic Oceans. Either the Government lacked the funds or the pluck to make the attempt; but, the advantages of such an undertaking being obvious, efforts were made by American capitalists to take up the project. A notable American civil engineer, Captain James B. Eads, having expended some time and much trouble upon surveying the ground in 1881, drew up plans for a ship railway, a scheme which, as it may be remembered, was at one time strongly recommended for the Panama route as also for that of the Darien. Experience now proves conclusively that a ship railway would have been impossible in practice.

Captain Eads finding no one sufficiently enterprising to support him financially, although the Government gave him every inducement by renewing his concession again and again, a Mexican named Don Delfin Sanchez endeavoured to raise sufficient funds to carry out a contract which he had made to do the work, but he failed, his contract being rescinded in 1888. Don Delfin Sanchez was a very much esteemed engineer, whose *bonâ fides* was unquestionable, and his railway connection eminently commendable. He was granted a regular contract to build the railway, for which he was to be paid at the rate of 25,000 dols. (£2500) per kilometre. The contract was signed in October, 1882, and the line was to be completed and opened for traffic by February, 1885. By the commencement of 1883, however, the arrangement was found to be unworkable; but, meanwhile, Senor Sanchez had received a considerable sum from the Government "on account," payments having been made to him amounting to 700,000 dols. at the offset, while a further sum of 733,134 dols. was paid—562,190 dols. for material used and work done upon 108 kiloms., and 170,224 dols. as an indemnity for having his contract cancelled. This brings us to the end of 1888.

To Don Delfin Sanchez succeeded Colonel Edward McMurdo, of London and New York, who, with that boldness and irresponsibility which characterised him through life, entered the lists as contractor; and there is no saying what might have been the result had not McMurdo died in 1892. That the issue might easily have been chaos is possible when one remembers what happened in connection with the Lorenzo Marquez (Portuguese South Africa) Railway concession, which was also secured by the same enterprising American engineer. At the time that Colonel McMurdo entered upon the scene, as already stated, about some 108 kiloms. of line had been laid—we cannot use the word "constructed"—by Don Delfin Sanchez, and paid for by the Mexican Government. There remained 288 kiloms. further to build, and only a very small proportion of this had been completed when death put an end to McMurdo's enterprise.

In January, 1892, his widow came to an arrangement with the Mexican Government to rescind the contract; and here attention may be called to the honourable manner in which the Government dealt with Mrs. McMurdo, offering liberal terms of compensation instead of demanding recompense for not carrying out the contract, a policy which contrasts vividly with the attitude adopted by the Portuguese Government towards the same lady, as executrix, in connection with the Lorenzo-Marquez Railway. A settlement in this latter case was delayed for years, and finally the question went to arbitration, when a most inadequate award was made in favour of Mrs. McMurdo.

With the disappearance of the American element, other *entrepreneurs* appeared upon the scene in the persons of Messrs. J. H. Hampson, E. L. Corthell and the Hon. Chandos S. Stanhope. In February, 1892, these gentlemen commenced to build and complete the remainder of the line, which they undertook to extend to Salina Cruz by June, 1893. It was a rash contract into which to enter, for, as any practical engineer could have seen, it

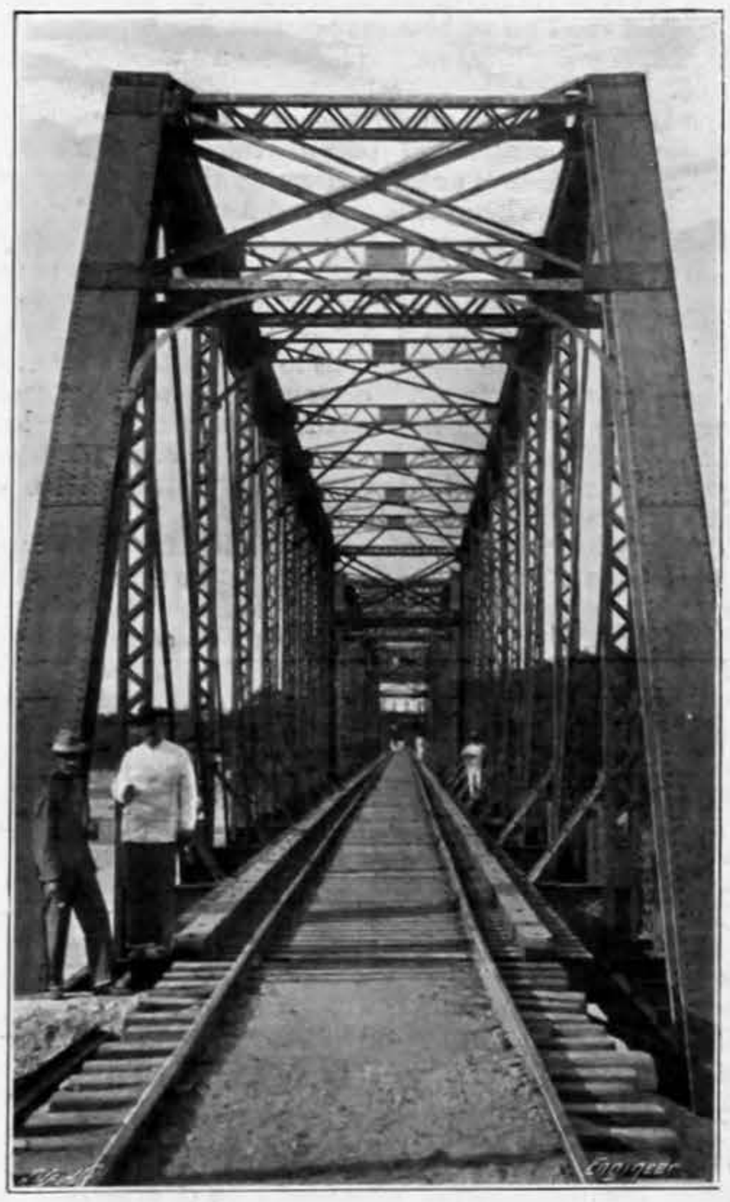


Fig. 2—BRIDGE OVER THE JALTEPEC RIVER

was quite impossible that the line could have been finished in anything like this time. It is not surprising to learn that the combination soon collapsed, Messrs. Hampson and Corthell retiring from the contract, and Mr. Stanhope being left to carry it out as best he could. So much money had already been frittered away upon the undertaking, that Mr. Stanhope found himself almost hopelessly opposed at the outset by lack of funds. After much trouble he formed a small syndicate for the purpose of completing the remaining 60 kiloms. of line. His contract stipulated for a payment of 1,113,035 dols., and the time allotted to him was nine months. By dint of much perseverance and pluck the work was actually completed within the specified period, but, as may readily be assumed, it was of a makeshift character, and such as no practical railway engineer would have passed.

The Mexican Government, however, had never lost faith either as to the completion of the line or its eventual value, and when the opportunity presented itself for entering into an arrangement with a leading firm of British engineers it was taken advantage of, and then it was that S. Pearson and Son, Limited, who had already constructed the drainage works of the Valley of Mexico and the port works of Vera Cruz, two enormous engineering enterprises which had baffled the skill and resources of centuries, came upon the scene, destined to complete the undertaking and to bestow upon it the seal of permanency and prosperity.

This, then, is the early history of the Tehuantepec Railway, which now runs from Puerto Mexico—formerly known as Coatzacoalcos—on the Atlantic side to Salina Cruz on the Pacific side, a total length of 310 kiloms., with a branch line from Juile to San Juan Evangelista, a further 28 kiloms. To these may be added a recently opened branch from Carmen—37 kiloms. from Puerto Mexico—to Minatitlán, about 14 kiloms in length, a small branch which was constructed especially for the convenience of the oil refinery belonging to S. Pearson and Son, Limited, which is situated at the little town of Minatitlán.

In this article it is proposed to deal with the Tehuantepec enterprise in three sections—firstly, a description of the railway line; secondly, with the two terminal ports of Puerto Mexico and Salina Cruz; and thirdly, with the advantages of the Tehuantepec route as compared with those of other isthmus routes, and general conclusions with regard to the whole undertaking. In our issue of February 1st, 1907, we gave an article on this railway and its ports, in which we printed maps of the railway and of the ports, as well as a number of engravings showing various portions of the undertaking, some being in the text and some in a special supplement. We would refer our readers to this article in order that they may better follow the text of the present series.

### RAILWAY ROUTE.

The Isthmus of Tehuantepec has a width at its narrowest point of 125 miles, and it lies between 16 deg. and 18 deg. north latitude and 94 deg. and 96 deg. west longitude. With the single exception of the Isthmus of Panama, this narrow neck of land forms the slenderest slip of territory on the Western Hemisphere, separating the waters of the Atlantic and Pacific Oceans. The engineering conditions for building a railway across this isthmus necessitate a gradual ascent from the mouth of the Coatzacoalcos River, crossing many effluents of that stream until a fairly flat tableland is reached. At a distance of 79 miles from Coatzcoalcos there is a depression at the Jaltepec River, and between this point and the Atlantic the gradients are about 60ft. to the mile. The heaviest climb, however, commences at the point known as Santa Lucrecia, at which point the Jaltepec River is crossed on a steel bridge 560ft. in length—composed of five spans—and of this an engraving is given in Figs. 1 and 2. The bridge crossed, the Malatengo Canyon is entered at a distance of about 38 miles beyond, and there the route is through rock-cuts and chasms leading up to Rincon Antonio, which is known as the "divide," and is, in effect, a junction of considerable dimensions. Here are found the extensive yards and shops of the company, the entire area having been rescued from a sandy waste and converted into a model township, occupied entirely by the railway and its workpeople.

Leaving Rincon Antonio, the line enters the Chivela Pass, which is crossed at a height of 730ft. above sea level, the highest point on the route, and from which the descent to the Pacific is decidedly abrupt in comparison, some of the steepest gradients on the section being here encountered. At the Chivela Pass, which extends from kilom. 209 to kilom. 247, a distance of 38 kiloms., the track runs over two horse-shoe curves and through one tunnel, the latter being stone lined and handsomely faced at both ends. During the reconstruction of the road, which was found necessary almost from beginning to end when Pearson and Son took it over, many of the heaviest gradients were reduced and the curves straightened. The whole line has been adapted to curves of a minimum radius of 150 m. compensated and a gradient of 1·6 per cent., except the track in the Chivela Pass, where the curvature comes to a minimum radius of 80 m. and a maximum gradient of 2.07 per cent.

### CONSTRUCTION WORK.

Some of the heaviest construction work on the line is to be found on the Malatengo Canyon, from kilometre 188 to 202, namely, 14 kilometres. With regard to the bridges, whereas for the first two or three years that the line was working several wooden structures were employed temporarily, there are now to be found upon the route from end to end nothing but steel bridges of the finest construction, the most important of which are the following:—

Chacalapa Bridge, at kilometre 13, with three spans of 23.29 m. each, plate girder riveted.

Santa Lucrecia Bridge, at kilometre 127, five spans of 36.30 m. each, lattice girder, Pratt type.

Tolosa Bridge, at kilometre 159, three spans of 36.30 m each, lattice girder, Pratt type.

Sarabia Bridge. at kilometre 176, one span of 36.30 m., lattice girder, Pratt type, and four spans of 16.38 m. each, plate girders riveted.

Malatengo Bridge, at kilometre 190, two spans of 37.03 m. each, lattice girders, Pratt type.

Tehuantepec Bridge, at kilometre 291, three spans of 61.24 m. each, lattice girders, Pratt type.

There are some other and smaller bridges, having spans between 14 m. and 30 m., with lattice half-through girders, and still others, also small, with spans between

5.30 m. and 13 m., and plate deck girders. The culverts are of concrete on the northern division, and of masonry on the central and southern division. The total number of bridges and culverts is 846.

The finest steel bridge, perhaps, is that over the Jaltepec River, at Santa Lucrecia, the junction of the Tehuantepec with the Vera Cruz and Isthmus Railway. This handsome bridge, 560ft. in length, is composed of five spans, and is of steel throughout. The masonry abutments are of a thoroughly substantial and permanent character, and capable of carrying, with the bridge itself, a weight far greater than they will ever be called upon to sustain.

On the whole, it may be said that as it exists to-day the Tehuantepec Railway is one of the best constructed lines of its kind in the world, capable of sustaining all the freight traffic which can be obtained for it—and that is saying a good deal. The road is standard gauge of 4ft. 8½in., and where it passes over the clayey soil there are rock ballast and gravel. The ties, or, as we call them, the sleepers, are creosoted pine, California redwood and native hardwood. Eighty-pound steel rails are employed, and besides the 190 miles (304 kiloms.) of main track, there are 60 miles (96 kiloms.) of sidings, capable of handling three-quarters to one million tons of freight annually. Regarding the railway's business up to the present time, we shall speak more fully later on.

The cost of this undertaking, including both the railway and harbour works at Salina Cruz and Puerto Mexico (Coatzacoalcos), has up to date exceeded £9,000,000, and before finality is reached the figures will probably stand at a round £10,000,000, which may be divided up as follows:—

| | |
|---|---|
| Reconstruction of railway, rolling stock, bridges, terminal facilities, plans, and buildings... ... ... ... | £3,000,000 |
| Harbour works at Salina Cruz... ... ... ... ... ... | 4,700,000 |
| ,, ,, ,, Puerto Mexico (Coatzacoalcos) ... | 2,300,000 |

The Vera Cruz and Isthmus Railway joins the Tehuantepec National Railway at Santa Lucrecia; the Pan-American Railroad joins the Tehuantepec National at San Geronimo, and is now open for traffic to the important coffee centres of Huixtla and Tapachula, and as far as Mariscal, a distance of 714 kilometres. The old station buildings at Santa Lucrecia and San Geronimo were found to be inadequate to handle the great increases in the traffic moving over the Tehuantepec National Railway in connection with the Vera Cruz and Isthmus, and the Pan-American, and new and substantial masonry buildings have been built this year at both Santa Lucretia and San Geronimo. Between Puerto Mexico and Salina Cruz there are thirty-four stations, the most important being Juile, Santa Lucrecia, Rincon Antonio, and San Geronimo. The distance between port and port in kilometres is exactly 303.5, and the average time occupied in transit is 12½ hours up and 10¼ hours down. Trains leave Puerto Mexico daily at 6 a.m., arriving at Salina Cruz at 6.30 p.m.; and 6.15 p.m., arriving at Salina Cruz at 8.5, while others leave Salina Cruz daily at 8.5 a.m., arriving at Puerto Mexico at 6.15 p.m.; and 7.0 p.m., arriving at Puerto Mexico at 8 25 a.m.

At present the line is a single track only, but provision has been made for doubling it, and there can be no question that the track will have to be doubled very shortly. In this event it will be the only double-track line in the Republic of Mexico, and whenever the decision to build the extra track is arrived at the line will be constructed within a comparatively short time, and the expense attached thereto will be correspondingly light. Sir Weetman Pearson, in a speech made on the 23rd January, 1907, when the President of the Republic opened the line, said:—"I venture to make a prophecy of a double track within seven years, if not within five."

While the passenger rolling-stock used on the Tehuantepec line is necessarily small, in view of the comparatively limited number of passengers now being carried, it is very complete, and comprises the latest type of passenger coaches, with Pullmans running over the line from Santa Lucrecia to Salina Cruz, and *vice versâ*. On the other hand, the freight cars already number over 1200, and an additional 200 box-cars have been ordered this year, to cope with the ever-increasing traffic. There are also about 130 gondolas, each of 30 tons capacity, 80 stock cars, and 60 locomotives, and at the present time every single car, excepting those in the repairing sheds, is in requisition. The Tehuantepec Railway was the first Mexican line to introduce oil as fuel, and all the locomotives have been gradually converted from coal to oil-burning, by which means a saving of something like 30 per cent. is achieved. Throughout the railway workshops the stationary boilers are run by oil fuel, this being obtained from S. Pearson and Son's refinery at Minatitlán. At Puerto Mexico, the Tehuantepec Railway possesses a colossal tank constructed of steel, capable of storing 1,500,000 gallons of oil, from which the latter is distributed to smaller tanks along the line of railway, each of which has a storage capacity of 6500 gallons.

## EXPERIMENTS WITH CENTRIFUGAL PUMPS.

By J. G. DAVIS, B.Sc., and W. R. HARDING.

Little is known of the frictional conditions prevailing and the losses occurring in centrifugal pumps, and, in view of this, the results obtained from systematic tests recently made, and the conclusions arising therefrom, cannot fail to do something towards connecting the several existing theories with actual results.

A general formula for the losses in a centrifugal pump—in terms of the discharge, peripheral speed, and head—has been obtained from quite general theoretical considerations, and has been applied successfully to actual practical cases within wide limits. The closeness with which theoretical and experimental results agree points to the soundness of the theory.

The first tests were made on a small pump, and these will be considered below in such detail as is necessary. The successful application of the formula to these very complete trials led to the attempt, in all cases satisfactory, to apply it to the published results* of the performance of other centrifugal pumps. The wide range of application of this formula leads to the conclusion that it is quite general in form, and applicable to any similar pump, large or small, with a suitable variation of the constants involved. This will allow of an accurate prediction of the performance of a pump under any conditions, once the constants have been determined in the manner indicated below. The possibility of such a prediction of results should render this method of no small interest to manufacturers and others.

It is proposed to deal here briefly with the derivation of the general formula, following with a description of the trials made on a small centrifugal pump, and the verification of the theory by the application of the formula to its performance, and also to the published results of trials on other pumps.

*General Theoretical Considerations.*—In hydraulic engines in general, where moving and fixed vanes are employed, the necessary conditions for the most efficient working are that there shall be no loss of head due to "shock"—incurred by abrupt change of velocity of the working fluid—and that the fluid shall leave the moving vanes with no velocity relative to them. On this hypothesis, the usual expressions for the theoretical performance of the various types of turbines are obtained, and, with suitable modifications to allow for frictional and other losses, apply to results obtained in practice. The question as to what extent a turbine is reversible has been greatly disputed, and practical results have been somewhat unexpected. For example, the 80 per cent. efficiency of a reaction turbine may be reduced to, say, 55 per cent. when working as a centrifugal pump. (See Dr. Stanton's Researches.) This is accounted for by the difficulty experienced, even when great care is taken to avoid shocks and sudden enlargements, in converting the kinetic energy of the water leaving the impeller or wheel of the pump into anything approaching the equivalent static or pressure head. Various methods have been adopted in pump design for the reduction of this loss, due to the partial dissipation of the "whirl" or tangential velocity head. Among these may be mentioned the addition of a "whirling chamber" (Thomson), the backward, or re-curving of the impeller blades (Appold), and the more recent use of "guide passages" outside the impeller (Reynolds).

The loss by "shock," due to more or less abrupt change in the absolute velocity of the water at the impeller exit, may be expressed in terms of the discharge velocity, and is conveniently denoted by discharge velocity head, or $\xi U^2/2g$, where U is the absolute velocity of discharge from the impeller vane tips, and $\xi$ is Borda's coefficient, varying with the type of pump, but having an average value of from 0·5 to 0·6, including the loss in the impeller itself in a modern turbine pump. Especially in the older forms of pumps, where the discharge takes place into a body of water having a much smaller absolute velocity, is this loss exaggerated.

The head lost by friction in the case of a disc rotating in a fluid is proportional to the square of the peripheral speed. The friction is also stated to increase with the area of the pump casing; this is due, no doubt, to the stilling of the eddies by the surface of the stationary casing, and the reacting of this stilled water on the surface of the rotating wheel.

The above indicates briefly the nature of the losses to be expected in centrifugal pumps, and we now proceed to outline the deduction of a general type of expression for the actual working head in any pump. This is due to Mr. F. C. Lea, B.Sc., A.M.I.C.E., of the Central Technical College, S.W., to whom best thanks are due for this and other valuable suggestions.

### DEDUCTION OF GENERAL FORMULA FOR THE WORKING HEAD IN A CENTRIFUGAL PUMP.

(1) *Loss of head at entry to impeller vanes.*—Assuming the velocity of flow $u$ of water entering the impeller vanes to be radial—Fig. 1—$v$ and $v_1$ being the linear velocity of the inner and outer tips of the vanes, which make angles $\theta$ and $\rho$ at entry and exit respectively; the vector A B represents the velocity of the water relative to the wheel at inlet. Moreover, a velocity represented by $u_s$ must be impressed by the vane on the water, in order to cause it to take the direction B C instead of B A. B C is the velocity of water relative to the impeller at entry to vane. Thus the loss of head due to the change of velocity impressed on the water by the vane is represented by

$$u^2_s/2g, \text{ where } u_s = v - u \cot\theta \quad . \quad . \quad . \quad (1)$$

(2) *Loss of head at exit from impeller vanes.*—Let $\alpha$ be the angle of guide vanes at the impeller exit, and let P be the point under consideration. The water clearly tends to flow along the tangent to the vane at P, namely, along B′A′—Fig. 2. If the vane at exit had some other angle $\rho''$, so that B″ A″ represented the direction of the vane at P, and there were no velocity of whirl at exit, there would be no loss of head at exit. But in a practical case there is a velocity of whirl (or tangential component of the absolute velocity of the water) $V_1$, due to the blade having some other angle $\rho$ at exit. B′A′ is then the velocity of the water relative to the wheel at exit, and the ultimate absolute velocity of flow along the guide vanes at P will be represented by the vector O′ K′. But in order to cause the water to reach K′ instead of A′, the velocity A′ K′, namely, $u'_s$, must be impressed on it by the wheel. So that the head lost at exit is equal to

$$(u'_s)^2/2g, \text{ where } u'_s = v_1 - u_1(\cot\alpha + \cot\rho) \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

*Other losses occurring in the pump.*—Frictional losses, as yet unconsidered, may be taken as being proportional to the square of the velocity of flow through the wheel, also to the square of the peripheral speed. Thus frictional losses are represented by—

$$s(u_1)^2/2g - t(v_1)^2/2g \quad . \quad . \quad . \quad .$$

where $s$ and $t$ are constants . . . . . (3)

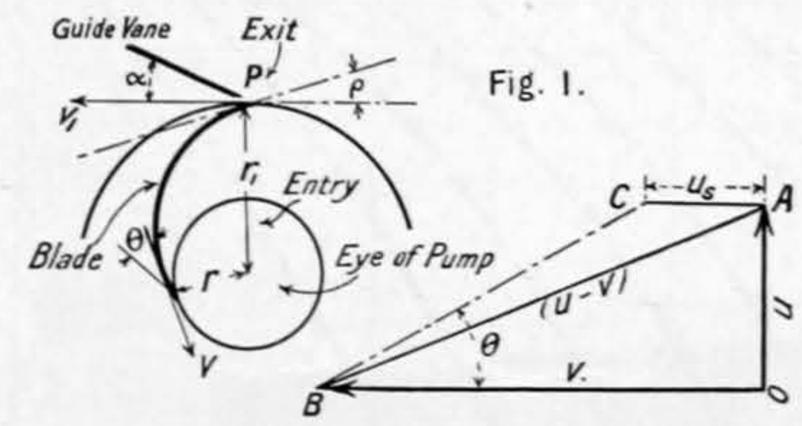



Fig. 1.

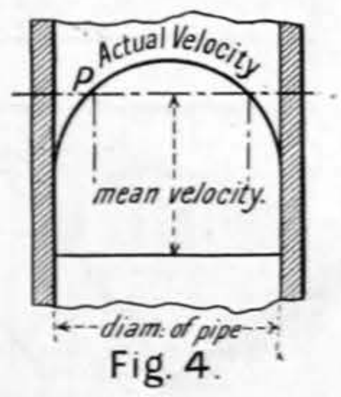



Fig. 4.

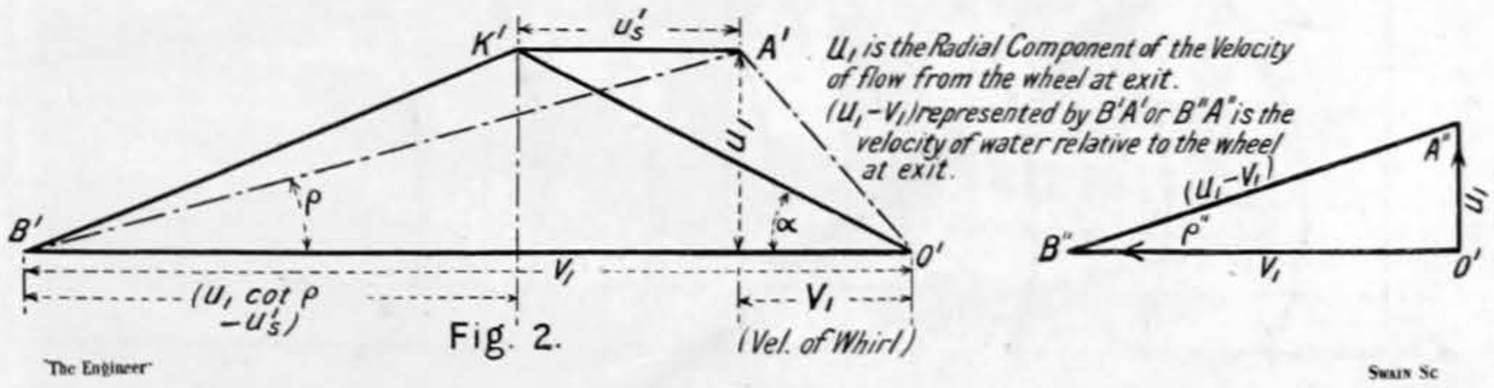



Fig. 2.

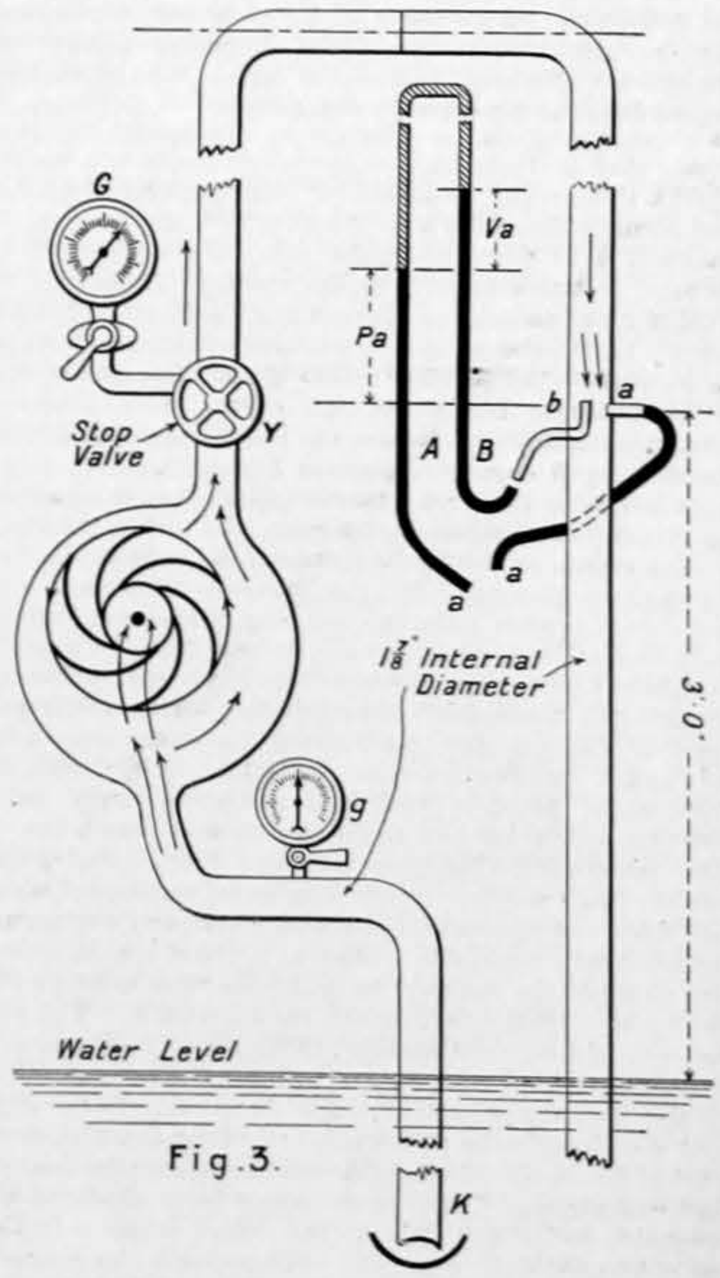



Fig. 3.

* Parsons: "Proceedings," Institution of Civil Engineers, Vol. xlvii., page 272.
Rateau: The Engineer, 1902.
Stanton: Institution of Mechanical Engineers, 1903.
Further details of the derivation and applications of the formula to the above trials will be found in the recently published treatise on "Hydraulics," by Mr. F. C. Lea. (Arnold.)

The centrifugal head will probably diminish as the discharge increases, for any given velocity of flow, since the water leaving the "eye" of the pump—assumed radially—from the suction pipe will have less chance of assuming the velocity proper to it at that particular speed of the pump, the greater the speed with which it passes through the impeller vanes. The centrifugal head thus depends upon $v_1$, and also upon $u_1$, and it is assumed reasonably that the change in the centrifugal head, as the discharge varies, may be expressed by—

$$(k v_1 - n u_1)^2/2g \quad . \quad . \quad . \quad .$$

where $k$ and $n$ are constants . . . . . (4)

The sum of the readings of the two gauges gives the existing head $h$ in lb. per square inch.

*Pitot tube.*—For the measurement of the velocity, and, therefore, also of the volume of water delivered by the pump, a Pitot tube is employed. This consists essentially of a small tube $a$ introduced into the delivery pipe, so as to record only the pressure of the moving water, and a second tube $b$ at right angles to $a$, on the orifice of which the flowing water impinges, recording the sum of the pressure and velocity heads. The tubes are connected through suitable reservoirs to gauge tubes A and B, each of some 9ft. length, and in a continuous circuit with one another and with the delivery pipe. The pressure head $P_a$ being common, the amount $V_a$ by which the shaded water column in B exceeds that in A, measures directly the discharge velocity head in inches.

Then $Q/A = k\,2g\,\sqrt{V_a/12} = j\,\sqrt{V_a}$.

The velocity in the delivery pipe is, of course, variable over the section, following a parabolic law—see Fig. 4—and to obtain the mean velocity with a perfect Pitot tube—*i.e.*, one in which $k$ is unity—the tube $b$ would need to be at P, to dispense with an independent calibration. Any possible error due to deviation from this position is however eliminated—provided the pipe runs full—by an independent determination of $k$ or $j$, readily effected by plotting a curve connecting corresponding values of $V_a$ and Q. Q is measured by weighing, or by flow through an orifice or weir, or by any standard method.

*The motor* is a 2 horse-power shunt-wound machine—type E. O.—by Messrs. Mather and Platt, and is stated to take 10 ampères at normal load on a 200-volt supply, running at 2020 revolutions per minute. It is of the two-polar construction, fitted with carbon brushes, and has the usual type of starting switch and field regulating resistances, by which the speed can be very finely adjusted. Sufficient electrical tests were made to give a complete knowledge of the working under various conditions; but although of interest in illustrating the accuracy with which it is possible to work with the apparatus employed, and the overall efficiency of the pump, the results have not sufficient direct bearing on the present work to justify their being given here. The normal brake horse-power of the pump is roughly 0.9, the combined efficiency of pump and motor about 34 per cent., the efficiency of the motor alone at normal load 75 per cent., and of the pump alone about 45 per cent. This efficiency is low, as the pump is small, and the losses consequently more exaggerated than in larger sizes.

In the following experiments, $h$, the head under which the pump is working, or lift, is measured directly in pounds per square inch, and converted to feet of water conveniently by means of a conversion curve. $Q/a$ is calculated from the velocity Q/A in the discharge pipe, the latter being measured by the Pitot tube and converted to feet per second.

A is the area of the discharge pipe in square feet—equal to 0.0191, since the diameter is 1.875in.

$a$ is equal to 0.096 square feet. Thus $Q/a = [0.1995\ Q/A]$. Experimentally it was found that $Q/A = 2.498\ \sqrt{V_a}$.

$v_1$ is directly proportional to the speed of the shaft, and since the periphery of the wheel is 1.54ft. in circumference, we have $v_1 = 0.0257 \times$ R.P.M. in feet per second.

*General observations on experimental procedure.*—In all cases both ascending and descending values of the variables have been observed and plotted. For convenience the quantities have been plotted as observed—that is, without conversion in the above manner—in every case where the mere introduction of a constant factor is necessary to convert quantities read from the curves to a form suitable for the calculation of $m$, C, and K.

Damping the vibration of the gauge pointers as far as possible by throttling with the adjustable cocks is found to give increased accuracy of reading. In all cases the "suction head" increases and the "pressure head" decreases as the flow through the pump increases, the sum of the two readings giving the lift $h$.

The speed and discharge can always be adjusted by suitable regulation of the field resistances and the stop valve to obtain any desired value—within limits—of the head; in the same way, throughout the experiments, any two of the three quantities measured—head, speed, and discharge—can be varied to obtain a desired value of the third.

In every experiment the "mean" of the readings over a period of one minute has been taken; the speed being registered in the case of "constant-head" and "constant-discharge" curves by means of a stop-watch and revolution counter, and in the case of the "constant speed" curves by a specially calibrated sensitive speed indicator.

The primary object of the experiments being to determine accurately the values of $m$, C, and K in expression (D), it is noted that when the discharge is zero the head $h$ becomes $m\,v_1^2/2\,g$. The pump is therefore run with water in the volute space and wheel, having the stop valve closed. Any point on a curve plotted, connecting simultaneously observed values of $v_1$ and $h$, then determines a value of $m$—see Fig. 6.

The mean of a number of such values is found. The values of $m$ for a curve determined from thirty-seven independent experiments vary between 1.058 and 1.096 for a range of speed from 1500 to 2050 revolutions per minute.

The mean value of $m$ is 1.087.

C and K are now determinable from two experiments, from which simultaneous values of $h$, $v_1$, and $Q/a$ are taken, the value of $m$ already obtained being used in the solution of the simultaneous equation.

*Velocity discharge curves at constant head.*—By suitable adjustment of the speed and discharge, a series of fifteen curves has been obtained from 270 independent experiments with the pump working under constant heads of 11 lb., 12 lb., 13 lb., . . . . 25 lb. per square inch (25ft. to 60ft). The corresponding range of speed is 1500

Fig. 5.
Velocity-Discharge Curves at Constant Head (Experimental)

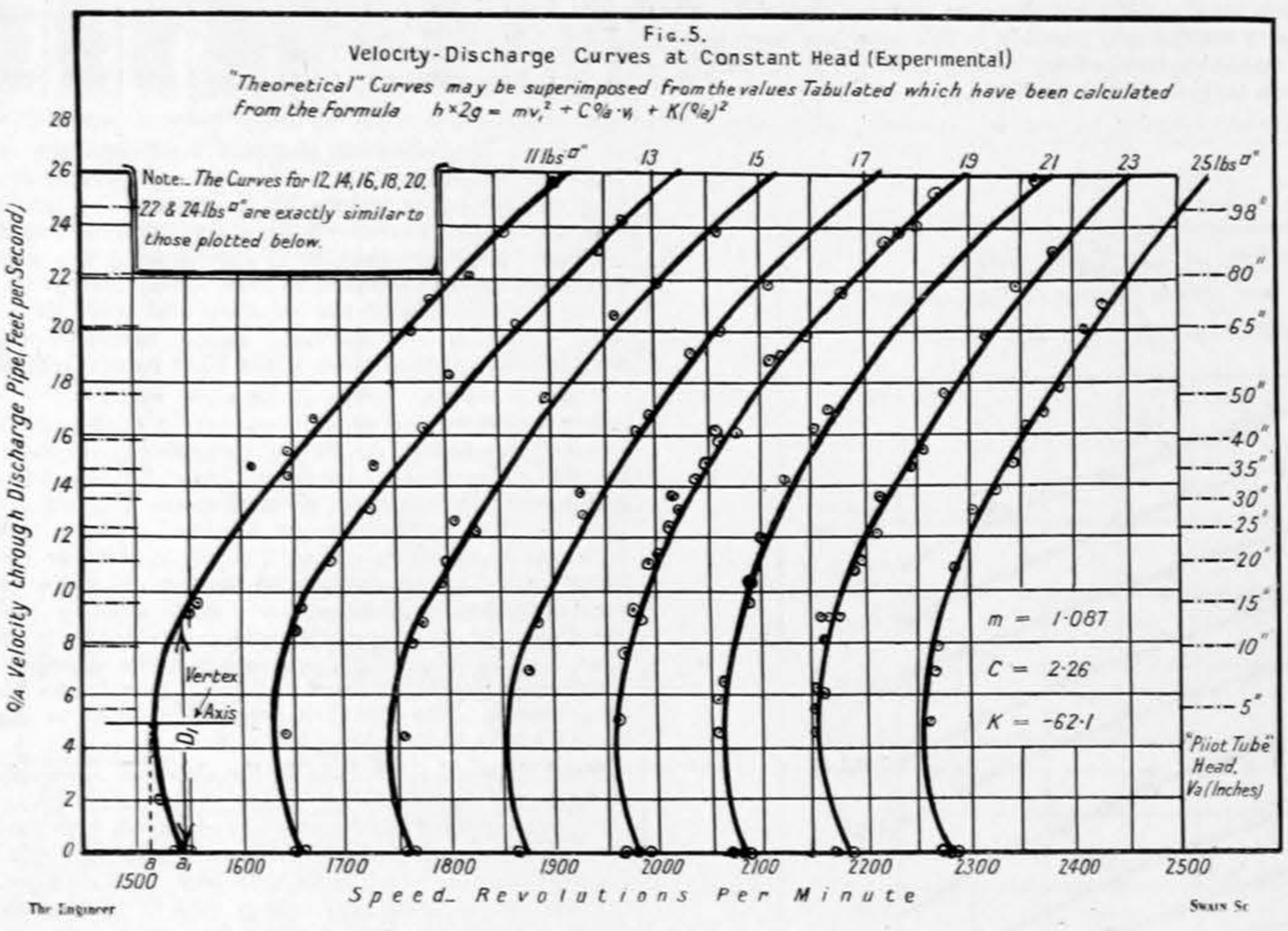
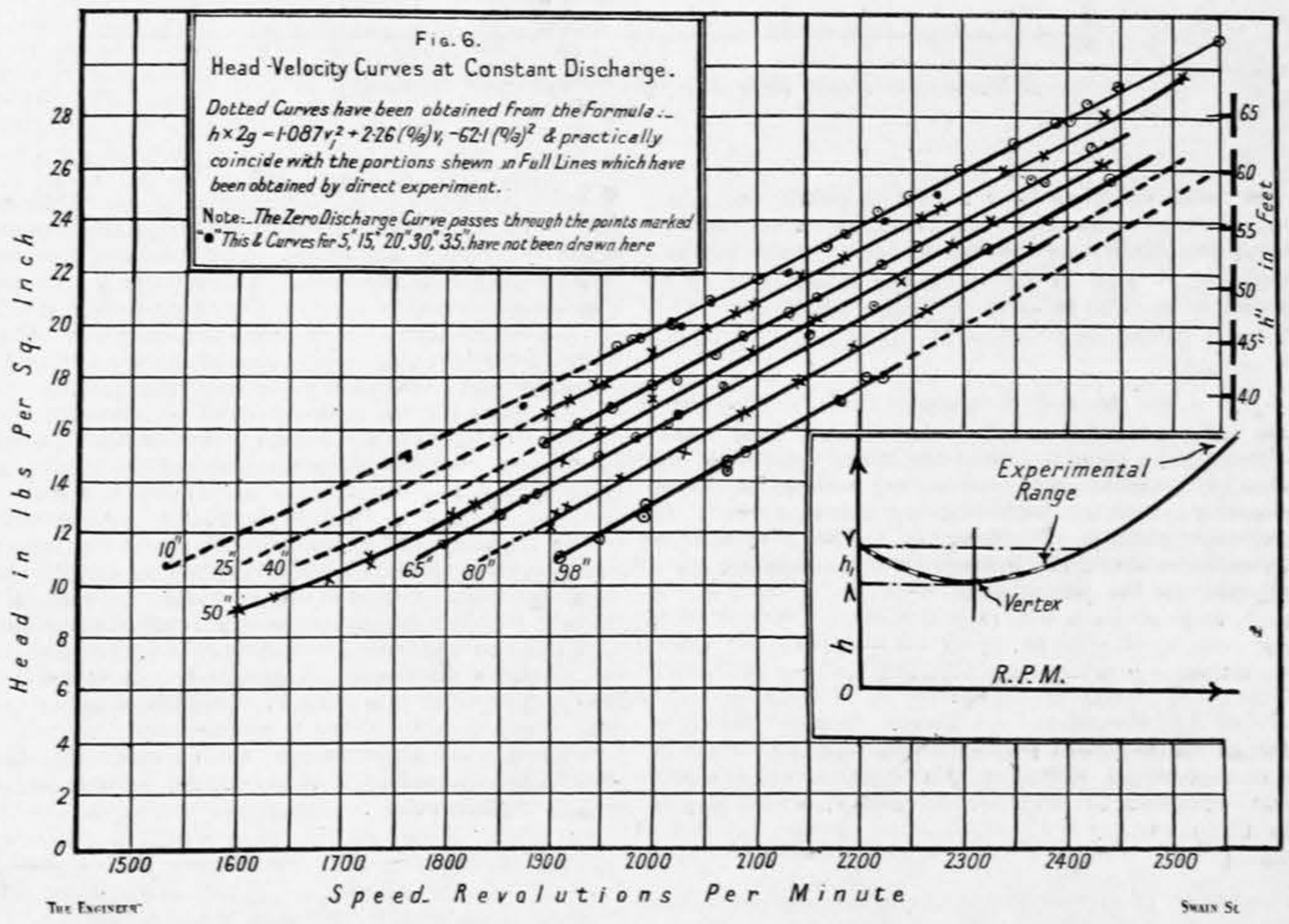



Fig. 6.
Head-Velocity Curves at Constant Discharge.




[Now (Actual head) = (Theoretical head) − (Head lost).

$$h = (V_1 \,.\, v_1/g) - (\text{losses 1, 2, 3, and 4})$$

$$= \frac{v_1\,(v_1 - u_1 \cot\rho)}{g} - \frac{(v - u\cot\theta)^2}{2g} - \left\{\frac{v_1 - u_1\,(\cot\alpha + \cot\rho)}{2g}\right\}^2 - \left\{\frac{s\,u_1^2}{2g} + \frac{t\,v_1^2}{2g}\right\} \div \frac{(k\,v_1 - n\,u_1)^2}{2g}$$

Now to obtain a parabolic expression for $h$ in terms of $u_1$ and $v_1$, we may write $u_1$ and $\theta$ for $u$ and $\rho$ respectively, by the introduction of suitable constant factors, since $\theta$ and $\rho$ are themselves constant, and $u$ is proportional to $u_1$, so that the expression reduces to—

$$2\,gh = m\,v_1^2 + C\,u_1 v_1 + K\,u_1^2 \,. \quad . \quad . \quad . \quad (5)$$

where $m$, C, and K, are constants, depending on the dimensions and design of any particular pump.

These constants can always be determined by solving the simultaneous equation given by three independent experiments on the pump, each giving an expression similar to (5).

In the particular case investigated the values of the constants were determined as follows:—

$h$ is the actual lift, or working head, of the pump in feet.
Q is the discharge in cubic feet per second.
$a$ is the normal area of water passages at the periphery of the wheel in square feet.
$v_1$ is the peripheral speed in feet per second.

Then $u_1$ becomes $Q/a$, so that

$$2g\,h = m v_1^2 + C\,(Q/a)\,v_1 + K\,(Q/a)^2 \,. \quad . \quad . \quad . \quad (D)$$

*Apparatus.*—The experiments described below were carried out at the Central Technical College Engineering Laboratories. The centrifugal pump is by Messrs. Mather and Platt, and is of the makers' standard type, having a normal capacity of 85 gallons per minute against a head of 35ft., and running normally at 2020 revolutions per minute. Driven through an ordinary flange coupling by an electric motor, it is of the "guide passage" type—a turbine pump—the general arrangement being indicated in Fig. 3. The number of vanes in the impeller is six, and the approximate angles at entry and exit respectively are $\theta = 5°$ and $\rho = 30°$. There are four guide blades—not shown—at an angle $\alpha = 3°$ to 5°. The suction pipe, which must not exceed 34ft. in height above water level, terminates in a foot valve K about 3in. from the bottom of the tank, to prevent backward flow of the water before starting. In starting up a pump any air remaining in the suction pipe must be replaced with water, either by filling through a suitable aperture, or, in the case of large pumps, by exhausting the air by means of a steam ejector after closing the delivery valve. On leaving the pump the water passes through a throttle valve V, just below which is fitted a pressure gauge G, which provides an imaginary head. The delivery pipe takes the form of an inverted U, and terminates about 8in. from the bottom of the tank, which contains about 20in. of water. Since the pump is not at water level, the additional head due to suction must be measured, and provision is made for this by the vacuum gauge $g$, fitted some 9in. past the bend in the suction pipe. This precaution is necessary to avoid the centrifugal head in the bend being included in the gauge reading.

to 2500 revolutions per minute, and of delivery pipe velocity 0ft. to 26ft. per second (0 to 177 gallons per minute).

The experimental points on eight typical curves only have been denoted. The mean curve in each case is very definitely outlined, and parabolic in form—see Fig. 5.

From the plotted curves C and K are now determined. For taking any two points, say, on the 20 lb. per square inch constant-head curve, whose co-ordinates are:—Speed 2049 and 2122 revolutions per minute, and $Q/a = 0.1995 \times Q/A = 2.485$ and 3.52ft. per second respectively, expression (D) becomes in the two cases—

$$2g\,(46.2) = 1.087\,(52.6)^2 + 52.6\,(2.485)\,C + (2.485)^2\,K$$
$$2g\,(46.2) = 1.087\,(54.5)^2 + 54.5\,(3.520)\,C + (3.520)^2\,K$$

From which $C = 2.47$ and $K = -58.8$.

The results show that C and K do not vary greatly, considering the wide range through which the experimental curves have been plotted, and that each solution is the result obtained from a pair of points not taken close together on the curves. Sixty independent solutions such as the above show that on the experimental curves

C varies from 1.80 to 2.81; mean of readings 2.26
K varies from − 50 to − 74.9; mean of readings − 62.1

Putting in the mean values of the constants as above (D) becomes—

$$64{\cdot}4\,h = 1{\cdot}087\,v_1^2 + 2{\cdot}26\,v_1\,Q/a - 62{\cdot}1\,(Q/a)^2 \quad . \quad (E)$$

From this expression, giving $h$ any definite fixed value, and assigning a value to one of the other unknowns, the second can be calculated, so obtaining a series of values connecting $v_1$ and $Q/a$ for the chosen constant head. In the solution of these equations, the following method is convenient:—Divide (D) throughout by $m$, and we have an equation of the general form:—

$$a_1 y^2 + b\,y + c = 0,$$

$$\text{that is } y = \frac{-b \pm \sqrt{b^2 - 4\,a_1 c}}{2a_1}.$$

In our case $a_1$ is I.

Assign values to Q/A convenient for plotting. Each of the corresponding values of $Q/a$ gives a value for $b$, which equals $2{\cdot}26\ Q/(1{\cdot}087\ a)$, and $c$, which equals $\frac{-62{\cdot}1}{1{\cdot}087}\left(\frac{Q}{a}\right)^2$, and the solution of each equation for $v_1$ is only a matter of substituting in the formula given above for $y$, which is identical with $v_1$. The speed in revolutions per minute, namely, $60\,v_1/1{\cdot}54$, is in each case plotted against the corresponding value of Q/A, and the values chosen for the latter are conveniently the same for each constant head curve so calculated from (E). The curves obtained in the above manner are found to agree so closely with the experimental curves already plotted that in most cases they are hardly to be distinguished from them.

A special point of note in these curves is the double value of the discharge possible throughout a range of speed $a\,a_1$—Fig. 5. The pump will not start up until the speed $O\,a_1$ has been exceeded; thereupon the discharge suddenly leaps to beyond $D_1$. On further opening the valve, $D_1$ increases, and the speed rises as the load is increased. On shutting down, the Pitot tube is seen to be in unstable equilibrium within the range of speed $a\,a_1$, and the least touch of the valve may give the double value of the discharge for that particular speed.

*Impending delivery.*—Denoting the critical peripheral speed—*i.e.*, the speed which is just sufficient to prevent downflow of water in the delivery pipe, the water being at rest in the impeller and in the suction pipe—by $V_c$, $h$ being the available head, $V_c$ should not greatly exceed $\sqrt{2\,g\,h}$, but is, of course, influenced by the frictional conditions and the shape of the blades. At low discharges the points are not generally so well in accordance with the regular outline of the curves as at the higher values, and this is probably due to discontinuity of action in the Pitot tube, caused by the pipe not running full. That such a condition is possible in this case has been proved by special investigations, details of which it is hardly of value to give in this article.

*Head velocity curves at constant discharge.*—The velocity head $V_a$ being maintained at constant values 0, 5, 10, 15, &c., to 98 inches, corresponding readings of the speed and head $h$ are noted. The readings are limited in some cases by the speed, in others by the gauge, so that the experimental limits differ for various discharges. For each discharge a curve of parabolic form is obtained experimentally—Fig. 6—the tangent to the vertex being parallel to the "speed" axis, again giving a double value to the speed for the range of head $h_1$, although this is outside the experimental range. The thirteen curves so determined from 162 independent experiments (the range of head being 9 lb. to 31 lb. per sq. in., and of speed 1600 to 2500 R.P.M.) could, of course, be utilised for determining C and K, using the mean value of $m$ already obtained. It is more convenient, however, to superimpose the curves calculated from expression (E) for these experimental discharges, in order to determine how nearly they coincide. This might be done by proceeding with expression (E) at the constant discharges chosen, in a similar manner to that employed in the case of constant head. A more direct method is to cut the "constant head" curves with horizontal lines representing the constant discharges, reading off the values of the speed for every head, tabulating the values thus:—

| Discharge through delivery pipe. (Q/A) in inches of water (Pitot tube) | Head in pounds per square inch. 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | Speed—Revs. per min. |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 1535 | 1590 | 1648 | 1704 | 1760 | 1817 | 1875 | 1930 | |
| 5 | 1520 | 1575 | 1631 | 1688 | 1744 | 1800 | 1857 | 1913 | |
| 10 | 1530 | 1586 | 1644 | 1699 | 1754 | 1810 | 1866 | 1922 | |
| 15 | 1547 | 1605 | 1662 | 1717 | 1770 | 1826 | 1880 | 1936 | |
| 20 | 1574 | 1630 | 1685 | 1740 | 1794 | 1847 | 1898 | 1954 | |
| 25 | 1598 | 1650 | 1703 | 1758 | 1813 | 1865 | 1915 | 1970 | |
| 30 | 1622 | 1673 | 1723 | 1777 | 1832 | 1883 | 1934 | 1985 | |
| 35 | 1647 | 1695 | 1745 | 1800 | 1852 | 1902 | 1953 | 2003 | |
| 40 | 1670 | 1718 | 1768 | 1820 | 1870 | 1920 | 1970 | 2020 | |
| 50 | 1713 | 1762 | 1809 | 1862 | 1910 | 1956 | 2006 | 2055 | |
| 65 | 1775 | 1820 | 1867 | 1915 | 1963 | 2010 | 2059 | 2110 | |
| 80 | 1835 | 1883 | 1930 | 1975 | 2020 | 2065 | 2115 | 2165 | |
| 98 | 1915 | 1958 | 2002 | 2049 | 2090 | 2139 | 2184 | 2228 | |

| Discharge through delivery pipe. (Q/A) in inches of water (Pitot tube) | Head in pounds per square inch. 19 | 20 | 21 | 22 | 23 | 24 | 25 | Speed—Revs. per min. |
|---|---|---|---|---|---|---|---|---|
| 0 | 1981 | 2030 | 2080 | 2130 | 2180 | 2228 | 2278 | |
| 5 | 1965 | 2015 | 2065 | 2112 | 2158 | 2207 | 2254 | |
| 10 | 1975 | 2020 | 2071 | 2120 | 2166 | 2213 | 2259 | |
| 15 | 1987 | 2033 | 2081 | 2130 | 2180 | 2224 | 2269 | |
| 20 | 2003 | 2050 | 2095 | 2144 | 2193 | 2239 | 2285 | |
| 25 | 2017 | 2062 | 2110 | 2158 | 2206 | 2255 | 2300 | |
| 30 | 2032 | 2078 | 2125 | 2174 | 2221 | 2270 | 2317 | |
| 35 | 2048 | 2092 | 2140 | 2189 | 2235 | 2285 | 2332 | |
| 40 | 2063 | 2108 | 2156 | 2203 | 2250 | 2301 | 2347 | |
| 50 | 2098 | 2145 | 2187 | 2235 | 2282 | 2330 | 2375 | |
| 65 | 2150 | 2193 | 2235 | 2278 | 2323 | 2372 | 2416 | |
| 80 | 2205 | 2243 | 2283 | 2325 | 2370 | 2415 | 2460 | |
| 98 | 2265 | 2303 | 2343 | 2383 | 2423 | 2463 | 2505 | |

For any experimental constant discharge, the calculated or "theoretical" curve is obtained directly by plotting corresponding values of $h$ and Q/A as tabulated. The above table also serves for the plotting of "theoretical" curves of constant head discharge, if the constant discharge curves should have been drawn first.

The coincidence of the experimental with the calculated curves is very marked. But, as before, occasional discontinuity in the action of the Pitot tube is indicated.

*Head discharge curves at constant speed.*—The regulating resistances being adjusted during each experiment to obtain a constant reading of a sensitive speed indicator, a series of seventeen curves has been obtained from 185 independent experiments, giving a range of speed of from 1625 to 2408 revolutions per minute, of head 12 lb. to 29 lb. per square inch, and of Q/A 0ft. to 24ft. per second. These curves are parabolic, with the tangent to the vertex parallel to the discharge axis, and again a double value of the discharge for the same head between the limits of head 0 $h$ and 0 $h_1$—Fig. 7—is obtained, the unstable condition being quite noticeable during the course of the experiments. The low discharges again point to discontinuity in the Pitot tube.

The "theoretical" curves for the above are conveniently plotted in a similar way to those for constant discharge, namely, by cutting the constant head curves with vertical lines at the speeds chosen, and reading off the values of the discharge for every head, tabulating and plotting.

These curves agree very closely with those obtained by direct experiment, almost coinciding with them in the majority of cases.

*Efficiency curves (electrical).*—These are of interest as a very complete test of the performance of the pump. The power required to drive the motor light at all speeds is constant; the same applies to driving the pump without water, the total losses in the motor—friction, eddy current, and hysteresis—being the same for all speeds. Sets of curves have been plotted, and from these—not given here—the efficiency of the pump under any conditions may be found.

*General conclusions.*—From the above, it is clear that the same parabolic expression for the lift of the pump gives curves which agree very closely with the curves obtained by independent experiments over the ranges indicated above. This expression may be termed the *Characteristic Equation* of the pump.

The above test has been a severe one, and it has seemed reasonable to suppose that, within limits, the same form of expression will apply to other pumps of a similar type.

It has been applied successfully to the following cases:—A centrifugal pump tested by Mr. Livens—"Proceedings," Institution of Mechanical Engineers, 1903—having a wheel 19.5in. diameter $\rho$ about 13° and $\theta = 81°$, which running at 550 revolutions per minute gave an efficiency of 71 per cent. when delivering 1600 gallons per minute against a head of 25ft. The characteristic equation is found to be $1.18\,v_1^2 + 3\,u_1 v_1 - 142\,u_1^2 = 2\,g\,h$.

Again, for a turbine pump having six vanes ($\theta = 5°$ and $\rho = 30°$) and four guide vanes ($\alpha = 3° -$), where the wheel diameter is 2·5 times the discharge pipe diameter, the characteristic equation is:—

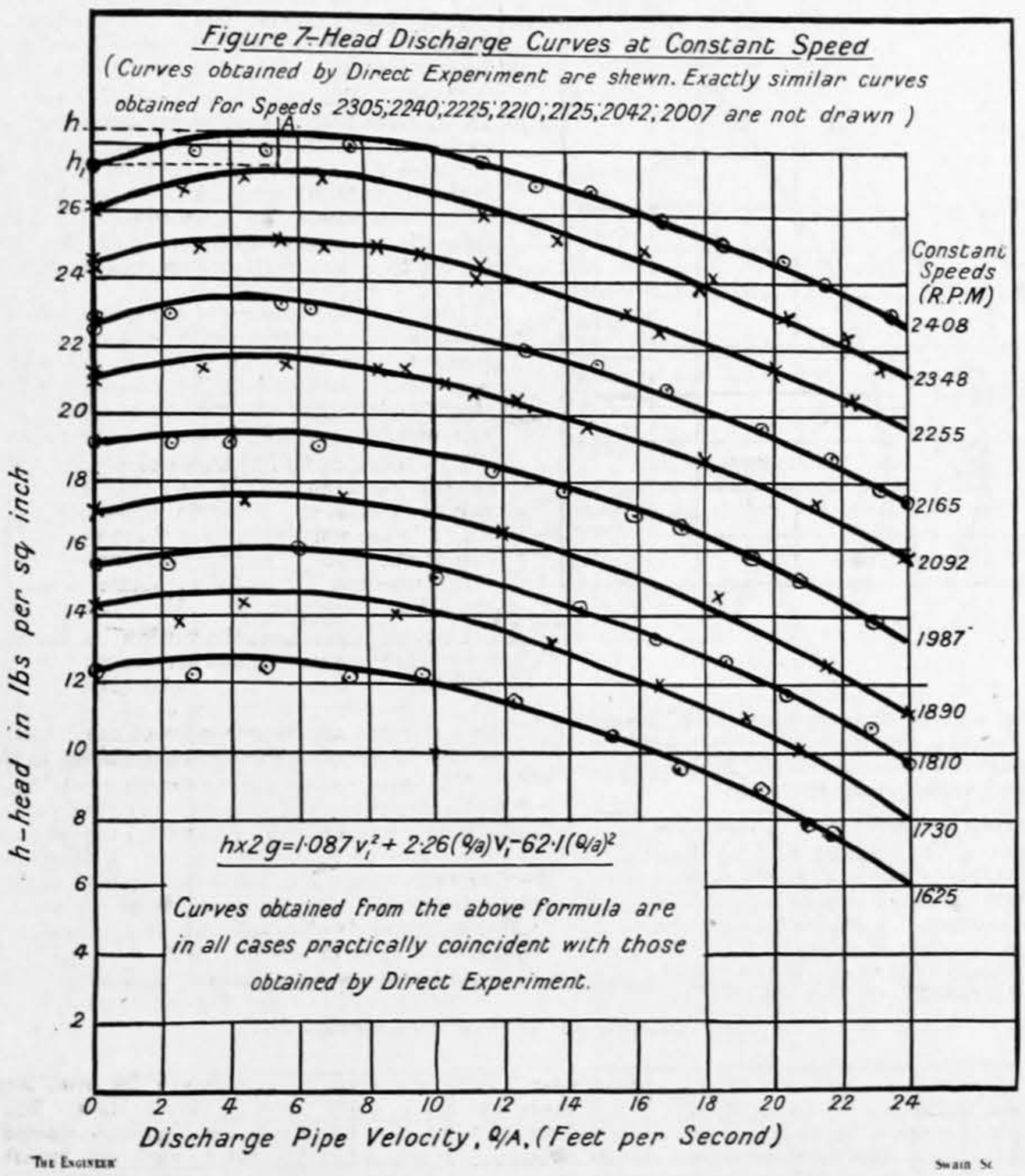
$$0{\cdot}84\,v_1^2 + 48{\cdot}3\,u_1 v_1 - 587\,u_1^2 = 2\,g\,h.$$

In the above cases $v_1$ and $u_1$ are the peripheral speed, and the radial velocity of flow at exit from the wheel—*i.e.*, $Q/a$—in feet per second respectively, $h$ the lift in feet. For other particulars see "Hydraulics" (Lea). The results obtained from the test of a Mather and Platt high-lift turbine pump—see "Hydraulics and its Applications," page 618, Gibson, 1908—delivering 2200 gallons per minute at 1100 revolutions per minute against a head of 140ft., promise from the curves shown a result similar to that of the smaller pump here tested, but no details are forthcoming. The efficiency of this pump rises to 70 per cent.

It is probable that in the small pump tested above the losses are more exaggerated than they would be in larger pumps.

The smoothness of finish and accuracy of the vane angles are important features of pumps by continental makers in general, the reduction of friction by this means being very considerable. The pump on which the above described experiments have been made is not finely finished.

It would be of great interest in future experiments to determine the range of practical application of the characteristic equation in the case of larger pumps, but from the above results and applications there seems little doubt that this method of stating the performance of a pump under known or tried conditions, and thence forecasting with fair accuracy its performance under untried conditions, can be advantageously and easily adopted in most practical cases.



## THE EFFICIENCY OF ELECTRIC POWER STATIONS.

In the generation of electric power, or more correctly speaking, in the transformation of the heat energy in coal into electrical energy, excellent opportunities are afforded for observing the inefficiency of the process. In order to sell electric power it is necessary to measure it accurately, and having done so, knowing the amount of fuel consumed, it is easy to arrive at what has been lost in the processes of transformation.

An American engineer, in referring to the boiler plant of the traction company which works the street car system of Cleveland, Ohio, recently said that the thermal efficiency of that plant was approximately 8 per cent. By this he meant that out of every 100 tons of coal burned the energy of but 8 tons was delivered to the switchboard in the form of electricity. As a matter of fact, 8 per cent. is a fair figure for some of the largest and best equipped power stations at present in operation. It has been estimated—by Mr. Hobart, we believe—that the average overall efficiency of existing British steam electric stations is from 3.5 to 4.5 per cent. The thermal efficiency of a generating station may be defined by saying that it is the ratio of the heat units supplied to the bus bars to the heat units in the coal. A kilowatt hour or unit is equivalent to 3412.66 British thermal units, so that we may write thermal efficiency equals

$$\frac{3412.66 \times 100}{\text{pounds of coal per unit} \times \text{calorific value.}}$$

It is interesting to calculate the thermal efficiencies of different stations and to endeavour to discover the reason for the varying results, but the main trouble lies in the collection of the necessary data. To take a single case, in one of the stations in this country, during a period of twelve months 10,217,158 units were generated and 18,417 tons of coal were consumed. Thus 4.02 lb. of coal were consumed in generating a unit. The estimated mean calorific value of the fuel was 12,500 British thermal units, so that the thermal efficiency of that particular station was $\frac{3412.66 \times 100}{4.02 \times 1250} = 6.78$ per cent.

During the year ending June 30th, 1904, the output of the Berlin Electricity Works was 113 million units, which were supplied from a number of distributed power stations. The overall thermal efficiency for those stations during that period works out at 9.6 per cent. In the following year, when the output had risen to 141 million units, the efficiency was 10 per cent., and in the year 1906, when the load reached 167 million units, the efficiency only rose to 10.3 per cent. Thus it will be seen that even with an enormous output such as that the thermal efficiency, though high in comparison with that of some plants, is at the same time in reality low. In the foregoing it will be observed that the units considered are those delivered to the bus bars of the station, and not to the consumers, and, therefore, the transmission losses have not been taken into account.

If we try to analyse the losses in a generating station by fixing a certain efficiency for the steam raising plant, another for the engines or turbines, and so on, it will be found that unless these assumed efficiencies are fixed low it will not be possible to get them to add up to a figure corresponding with that calculated as above. The actual result obtained by the formula will always seem too low. This, however, is a very natural result when it is remembered that the plant is only running at its full output during a portion of the time, and it is, therefore, somewhat difficult to estimate the average efficiency of each constituent. But that which adds to this discrepancy by a considerable amount is the question of banking. In the large lighting stations, and particularly during the winter months, when bad fogs are liable to come on with practically no warning, the quantity of coal used for banking purposes has a very appreciable effect upon the total consumption, and therefore upon the overall thermal efficiency. But quite apart from such questions as these, it is well known that under the best conditions an efficiency of much more than 11 per cent. cannot be expected.

From tests carried out on a large number of generating stations in America the various losses are estimated as follows:—Loss in ashes and leakage, 6 per cent.; heat lost in chimney, 22 per cent.; that delivered to auxiliaries and losses from pipes, 7.4 per cent.; main and auxiliary exhaust, 58.7 per cent.; and minor losses 1.47 per cent., giving a total of 95.57 per cent. Of this loss 5 per cent. is returned by the feed-water heater, so that the overall thermal efficiency becomes 9.43 per cent. Different investigators have naturally obtained slightly varying results, but where the discrepancy comes in is generally fairly evident, and, all things considered, the net results are not far apart.

Occasionally engineers are reminded that we are wasting our coal with enormous rapidity, and that a heat engine is essentially uneconomical. The unscientific public becomes alarmed; but when the newspaper announcement goes on to state that there is ample coal for at least another hundred years the story becomes less exciting. One of the greatest helps in the way of saving coal, although, unfortunately, not possible to a great extent in this country, is the utilisation of water power. In America, on the other hand, where they are exceptionally wealthy in this respect, the reduction in the coal consumption is enormous. This is brought to light in a statement made by Mr. L. B. Stillwell in a paper which he read before the American Institute of Electrical Engineers in May of this year. During the year 1908, he states, the plants of the Niagara Falls Power Company delivered an output of 560,000,000 units. Had this output been generated by large modern central stations using steam power the consumption of coal would have approximated 2000 tons per day. Were the users of Niagara power dependent to-day upon their own individual steam plants they would use in the aggregate not less than 3000 tons of coal per day—in other words, more than 1,000,000 tons per annum. If this power were replacing steam as used under average conditions in the manufacturing cities, instead of being used for the most part in supplying power to a comparatively small number of consumers using large amounts of power, it is estimated that it would replace and save nearly 2,000 000 tons of coal per annum. Whilst in this country we can never hope to benefit to an appreciable extent from natural sources of power we do, and have done for years, looked forward to improvements in the efficiency of our prime movers. It is not due to lack of energy on the part of English engineers, or indeed of engineers in any other part of the globe, that more economical results have not been obtained. No subject has, or in all probability ever will, receive greater attention, and yet to-day it is by no means easy to see where further improvements in the steam plant is to come from. In the gas engine we place great hopes, for in this direction the view is not so misty. That the thermal efficiency is higher all the world knows; that this type of engine will become still more economical is probable, and that the gas engine stations already in operation show an appreciably higher overall thermal efficiency than the steam stations was clearly shown in the paper recently read before the Institution of Electrical Engineers by Messrs. Andrews and Porter.

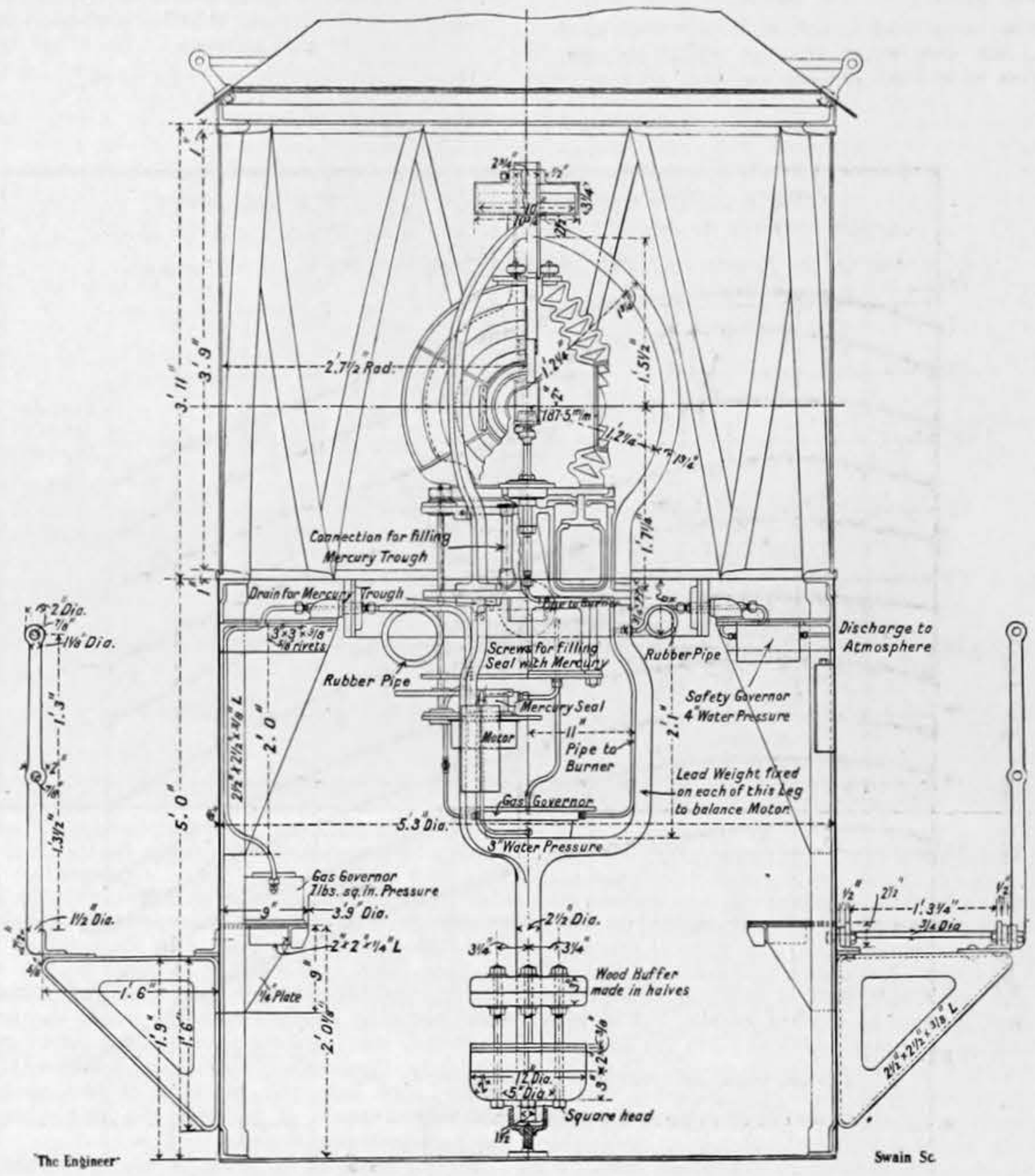



Fig. 1—DETAILS OF THE OPTICAL APPARATUS

## UNWATCHED FLASHING GAS-LIGHTED BOAT.

Our readers will be aware that for a number of years now there have been stationed on the river Thames, and at numerous points round our coasts, flashing or occulting lights exhibited from gas buoys. The light in these has been produced by means of a fixed dioptric lens having an oil gas burner, and the occulting or flashing of the light has been brought about by means of Pintsch's regulator, which can be adjusted to turn the gas on and off at stated intervals with wonderful accuracy. The necessary gas is contained under pressure in the body of the buoy, and the light is being continuously lit and extinguished automatically day and night. We shall have something more to say regarding these buoys later on; but, meanwhile, we turn to a further development.

The Corporation of Trinity House, in whose hands is entrusted the lighting of the coasts and channels of England and Wales, have for some time been experimenting in the direction of obtaining something in between these buoys and the lightship proper. What has been aimed at has been the provision of a flashing light produced by a revolving lens in place of the fixed lenses used on gas buoys, thereby increasing the power of the light by condensing it into revolving beams, without the necessity of having men stationed on board the vessel.

After mature consideration Sir Thomas Matthews, engineer-in-chief to the Trinity House, decided to advise the Corporation to construct a vessel similar to, but considerably smaller than, an ordinary lightship. This proposal having been approved, the vessel was built and provided with a lantern carried on a structure which gave the focal plane of the lenses a height of 26ft., and the light a range of visibility of ten miles. In this lantern was fitted an automatically driven pair of lenses, which were illuminated by a constantly burning Argand burner receiving its supply of oil gas from large reservoirs contained in the hull of the vessel. On her completion the boat was anchored, for experimental purposes, off Southend for about a month, and gave every satisfaction; and afterwards, for a more severe trial in open water, was placed off the North Goodwin light vessel, during which time and whilst being towed back to Blackwall the mechanism worked most efficiently. We were recently courteously invited by the Trinity House to inspect it, and are permitted by them to reproduce the accompanying engravings, Figs. 1 to 4, and to give the following description of the boat.

As will be seen from the engravings, the hull has something the shape of a lifeboat. Its total length is 65ft., its beam 18½ft., and its depth 10½ft. The lantern is carried on a four-legged steel structure erected amidships. There are two holds—one forward and one aft—and each contains two gasholders each having a capacity of 375 cubic feet. These receivers, when fully charged with oil gas, contain sufficient for keeping the light in action for about 100 days.

The lantern is 5ft. 3in. in diameter, and the light gives a flash of 5100 candle-power intensity at intervals of ten seconds. The revolving mechanism, which is shown in Figs. 1 and 2, is exceedingly ingenious. The gas in the

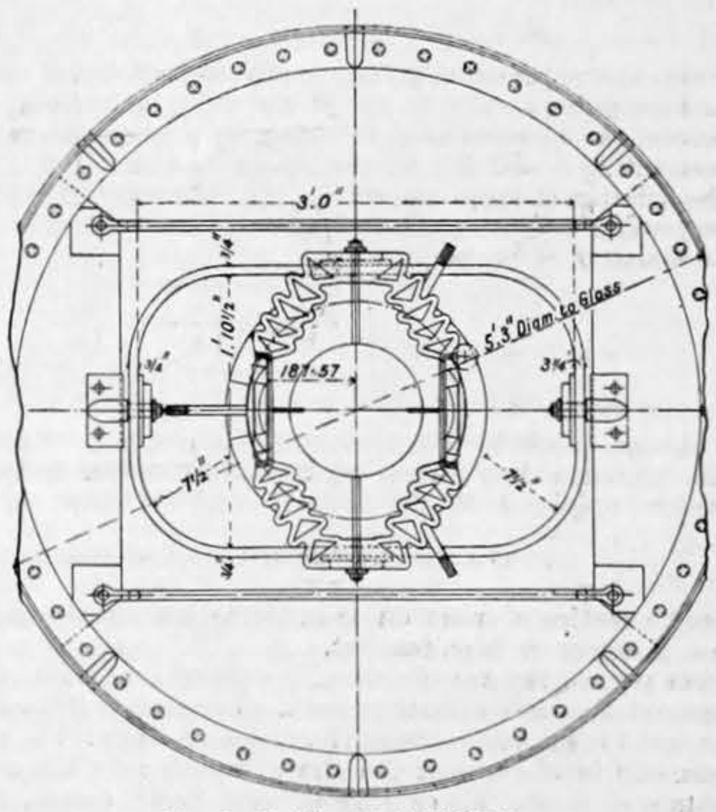



Fig. 2—PLAN OF LANTERN

reservoir holders is compressed to 7½ atmospheres. This, of course, is too high a pressure at which to work the burner, and the gas is consequently first passed through a governor or pressure-reducing valve, which delivers it at a pressure of 7 lb. on the square inch. This governor is shown in the engraving, Fig. 1. It is fixed to the side of the lantern, and from a rigid pipe connected to it is taken a flexible rubber connection to

# UNWATCHED FLASHING GAS-LIGHTED BOAT

SIR THOMAS MATTHEWS, TRINITY HOUSE, ENGINEER



the apparatus. Before it passes to the burner, the gas is taken to a small three-cylinder motor, in which the cylinders are arranged at 120 deg. apart. The cylinders are ¾in. in diameter, and are single-acting. They all work on to one crank, the shaft of which is connected to the turntable of the lens by toothed gearing. The turntable is carried in a mercury bath, and there are ball bearings at the top and bottom of the carriage. The whole mechanism is so beautifully made and adjusted that the power developed by the expansion of the gas in the three cylinders of the motor is sufficient not only to revolve the lenses, but to do so at an absolutely accurate rate. We had an opportunity of observing this for ourselves, and the experiment was not carried out in the workshop, but on board the vessel itself, and with the mechanism just as it had come out of its unwatched trial of one month down the river. A sensitive governor is provided, which acts by putting a brake on the mechanism should there be any tendency to go too fast.

There are several points in connection with the mechanism which call for remark. The first is that the gas, as it is exhausted from the cylinders, is burnt in the light. It is delivered from the cylinders into the case containing them, this case being hermetically closed, the mechanism spindle passing through a mercury sealed gland. From the case it is led to a cylindrical reservoir, this being provided in order to counteract any tendency to pulsation which there might be owing to the discharge of the cylinders of the motor. From this reservoir the gas passes to the low-pressure side of the governor and thence to the burner. The high-pressure side of the governor is connected with the feed-pipe to the motor, and the governor is set to give a pressure of 3in. of water on the burner, and will admit gas to make up that pressure should the exhaust from the motor be insufficient. It will also automatically supply the full quantity of gas to the burner in the event of the motor stopping, thus maintaining a light in the apparatus, although the beam in this case would be stationary. In case anything should occur by which the pressure on the burner rose above 3in., a further safety governor is provided. Connection is made to it through a flexible rubber pipe, and the function of this governor is to exhaust the excess of gas into the atmosphere through the discharge pipe shown.

As will be seen from Fig. 2 the apparatus is carried on double gimbals, so that, no matter how the vessel may roll, the lamp is always vertical. The trunnions of the gimbals work in ball bearings, and the whole mechanism is so accurately adjusted that it responds to the slightest motion of the vessel. A weighted rod is provided to act as a pendulum, and to prevent undue motion. On it is carried a wood buffer which can come into contact with a wood fender carried round the inside of the lantern. The balance is so arranged that an oscillation from one side of the lantern to the other occupies a period of five seconds.

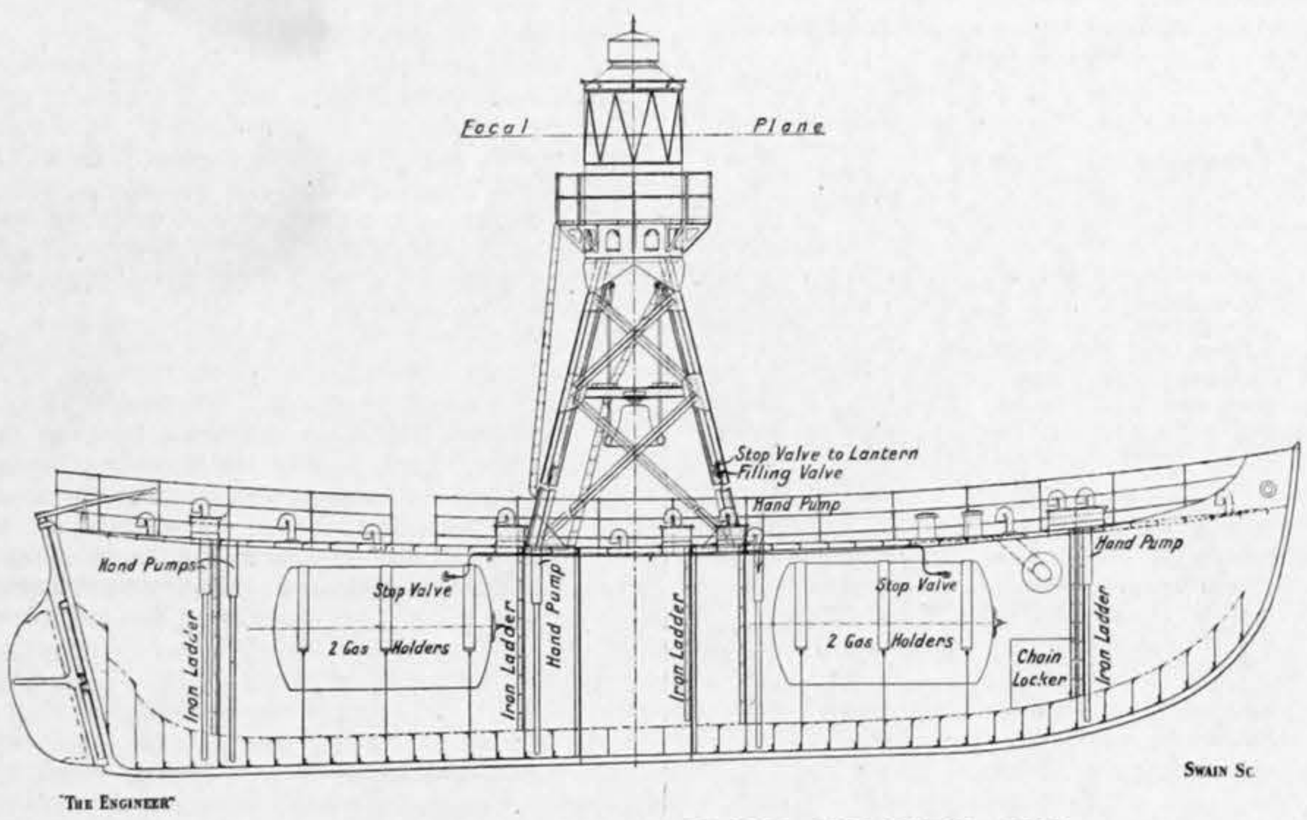



Fig. 3—LONGITUDINAL SECTION OF THE GAS-LIGHTED BOAT

The gas burner consumes 4 cubic feet of gas per hour, and as the light is in action continuously day and night this represents a no inconsiderable amount of gas in the course of the year. In order to reduce this consumption Sir Thomas Matthews has been experimenting for some considerable time with the use of incandescent inverted mantles, and has been very successful with them as applied to buoys, obtaining not only a largely increased illumination but a very decided decrease in gas consumption. It is proposed to adapt this system for use with the unwatched light vessel described above. If this were done, so great is the saving of gas that it would be necessary to fill only one of the four reservoirs with gas. The remainder might be filled with compressed air for driving the motor. The life of the mantle varies to some extent, but as far as experience has gone it is quite long enough to permit a period of, say, a month to elapse between inspections. The adoption of incandescent inverted mantles as contemplated would practically triple the intensity of the beam of light, while considerably reducing the consumption of gas. The Corporation of Trinity House are, moreover, quite sanguine that they may soon be able to apply this system of dioptric apparatus to light vessels generally, in lieu of the present catoptric method of illumination, which would prove a further stride of the utmost importance. The illuminant, however, in this case would be incandescent oil.

Then too—to recur to the subject of the gas-lighted boat—a further improvement will probably be added by means of an arrangement for automatically cutting off the gas supply to the mantle between sunrise and sunset. The principle of this device is that of a graduated cam which can turn on and shut off the gas at greater or less intervals, according to the variation in the length of day with the time of year. A pilot light would always be burning, of course; but this would consume a comparatively small amount of gas. With all these appliances the unwatched boat would look after itself for long periods, lighting up the burner when it got dark, and extinguishing it when it got light, and giving a regular flashing light during the hours of darkness.

Nor is this the full extent of the proposed automatism of the vessel. The hull has been constructed with a well, designed to accommodate an automatic submarine bell-signalling apparatus. This at present has not been fitted, but we understand that so successful have been the trials with the automatic apparatus of the Submarine Signal Company on the Nab buoy in the Trinity House service, that it is practically certain that advantage will be taken of the forethought in providing for the addition of one of these. In this case, with everything working well—and we see no reason whatever why it should not—the unwatched light vessel might take the place of some of the watched vessels, and much saving of expenditure be thus effected. As we saw the vessel, the fog signalling equipment consisted of a 6 cwt. bell, which was suspended in the superstructure, and was sounded, through the motion of the boat, by four hammers in the upper part of the superstructure. Our engraving shows this bell with its clappers in position.

The whole of the lighting apparatus in connection with the vessel, with the exception of the lenses, which were supplied by Chance Bros. and Co., of Birmingham, has been constructed at the Trinity House Engineering workshops at Blackwall.

We may add that the hull of the boat was built by H. and C. Grayson, Limited, of Liverpool.

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The following information is from the report by the British Vice-Consul at Emden (Mr. W. H. M. Sinclair) on the trade of that district in 1908, which will shortly be issued:—An undertaking which will be of interest has been initiated near Aurich with Government assistance. Works are being erected with a view to utilising peat, of which a vast supply is available, for the generating of electricity. The Government will, it is reported, require a supply of some 2,000,000 kilowatts yearly in connection with the harbour at Emden.

## THE RHEIMS AERONAUTICAL MEETING.

No. I.

THE official commencement of the Rheims aeronautical meeting now being held under the management of the Aero Club of France took place last Sunday. Throughout the previous week the aeronauts who had entered for the different competitions comprised in the programme had spent much time in the adjusting and testing of their machines and getting used to the conditions of flight imposed on them by the rules of the meeting. These rules add some new difficulties to those which already attend successful flight, but while doing so they call for the solution of problems which must be overcome before we can seriously consider aerial traffic and transportation.

Hitherto it has been found most suitable to make flights either in the early morning or late evening, as experience shows that at these time the atmospheric conditions are most likely to be such as to render the attempts successful. By the rules drawn up for the Rheims meeting it is made obligatory that no official start in any of the competitions be made before 10 a.m. and none later than 7 p.m.

The restrictions laid on starting from the ground work also for the ultimate progress of the art, and early in the week one aeronaut was disqualified, as far as the attempt in question is concerned, for occupying too much time in leaving the ground.

With regard to the path of flight the competitors are bound to follow the track laid out on the plains of Betheny. This track is rectangular in shape, and measures 10 kilometres to the lap. At the corners so-called pyramids have been erected to mark the course, while about half-way down one of the shorter sides accommodation has been provided for the judges and timekeepers. At this point also the starting and finishing posts are situated, and, on the outer side of the course, stands for spectators, garages, and manœuvring grounds for the aeroplanes are provided.

The programme for the week contains six principal events, for which substantial monetary prizes will be given. Although the direct scientific results will probably be of little value, since it is not for the accumulation of such data that the meeting is being held, there can be no doubt that the various competitions which have been arranged will test thoroughly the capabilities of the different types of aeroplanes at present in existence. Thus, the speed, endurance, and passenger carrying capabilities of the machines will be tested, and, in addition, a competition has been arranged in which the altitude to which the aeroplane can reach is taken as the point to be contested. There are three distinct competitions for speed—the Gordon Bennett International Cup Race of 20 kiloms., the Prix de Vitesse of 30 kiloms., and the Tour de Piste of 10 kiloms.; while the Grand Prix, which is exciting the largest amount of interest after the Gordon Bennett Cup, will be given as the reward for the greatest endurance. So far eleven entries have been received for the International race, but of these it would seem five only are likely to take part in this event, which has been set down on the programme for to-morrow (Saturday). Of the entrants likely to participate, three will be Frenchmen, one will represent this country, and the United States will contribute the fifth. As might be expected, the majority of the aeronauts at Rheims this week are French, and the Aero Club of France has found it necessary to institute eliminating trials to determine their choice of three representatives.

Where the success of the meeting is so entirely at the mercy of the chances of Nature it is necessary to economise the favourable moments in the meteorological conditions. To this end it has been decided that, wherever possible, a competitor may be held as having competed in several events with the same flight. The passenger and altitude competitions are, however, to be kept separate in this respect from each other and the rest, while the Gordon Bennett race is likewise a separate event.

When the meeting opened on Sunday morning at 10 o'clock the state of the weather was far from being satisfactory; but, despite the wind and rain, the committee expressed a desire that the Gordon Bennett elimination trials should be proceeded with if possible. In compliance with this request several aeronauts attempted to make a start, but up till mid-day all these, with the exception of one by M. Lefebvre, ended in failure. M. Lefebvre, on a Wright biplane, set out intending to complete the three laps required for the Prix de Vitesse, but after accomplishing $1\frac{3}{4}$ laps he was forced to descend, the cause not being stated. He was, however, entitled under the ruling mentioned above to enter this as an attempt for the Tour de Piste, and his official time for the 10-kilom. lap of this competition has been given as 8 min. $58\frac{4}{5}$ sec. During the afternoon all attempts had to be completely abandoned on account of the high wind, but towards six o'clock in the evening the atmospheric conditions improved somewhat, and in a short time several aeronauts were on their machines. Some of these succeeded in flying the 30 kiloms. for the Prix de Vitesse. From the particulars of these and other results, which we give below, it will be seen that M. Lefebvre's morning performance remained unexcelled. Thus the first day passed without any exceptional results being recorded, although sufficient was done to enable the committee to select two of the French competitors as their representatives for the Gordon Bennett race. Their choice fell on MM. Lefebvre and Blériot, while M. Latham's name was provisionally indicated as that of the third, the final decision being held over until the results of the succeeding days could be compared.

On Monday the weather had improved to a certain extent, although the state of the wind was still such as to give the officials and competitors cause for anxiety. As on the previous day, the flights attempted in the morning were on the whole unsuccessful. In the afternoon, however, several good performances were recorded, the most notable of which was M. Paulhan's flight of 49½ kiloms. To accomplish this he remained in the air for 70 minutes. He had earlier in the day carried out a flight of 57 minutes' duration, and thus he made a double entry for the Grand Prix. M. Blériot, on his 50 horse-power Antoinette, succeeded shortly afterwards in establishing a new record for the 10 kiloms., reducing the time taken by M. Lefebvre on the previous day by $16\frac{2}{5}$ seconds. This, in turn, was quickly improved upon by Mr. Curtiss, the American representative, who flew over the 10-kilom. lap in 8 min. $35\frac{2}{5}$ sec., which remained as the best performance so far for the Tour de Piste.

Tuesday morning was entirely devoid of attempts, and it was not until nearly five in the afternoon that the first flight of the day was undertaken, as the weather again was unfavourable. The proceedings about this time were witnessed by President Fallières and other ministers, who had travelled to Rheims expressly for the purpose.

M. Paulhan again distinguished himself, and despite the strong wind blowing, completed the three laps for the Prix de Vitesse in 38 min. 12 sec. M. Latham immediately afterwards set out on a similar course, and succeeded in accomplishing the distance in 30 min. 2 sec., although a twentieth part of this will be added on as a penalty for not finishing a previous flight. Meanwhile M. Blériot had flown away on the single lap journey for the Tour de Piste, and, flying low, broke the record made by Curtiss on the previous day by doing the 10 kiloms. in 8 min. $4\frac{2}{5}$ sec. No other flights calling for special mention were made during the day.

The weather conditions on Wednesday morning were likewise of a nature to forbid any attempts at flight. About 3 o'clock in the afternoon several aeronauts brought their machines to the starting point, but none succeeded in getting off. Shortly before 4 M. Paulhan made a start in the Grand Prix contest, and was immediately followed by M. Latham. The latter, however, had only accomplished one round when he came back to earth again. At the end of Paulhan's second round, M. Fournier, on a Voisin biplane, set out to follow him, but only succeeded in flying a short distance, when he was caught by a gust of wind and fell heavily to earth. In addition to the entire wreck of his machine, he was himself stunned. Meanwhile Paulhan continued on his course, and it was soon apparent that he was likely to create a record for both time and distance. His flight was keenly watched, and towards the end all others were given up, even his rival aeronauts lending him their encouragement. On his eleventh circuit of the course, it was announced that he had beaten the world's record for duration of flight, which was made a few weeks ago by Sommer, who, on a Farman biplane, remained in the air 2 h. 27 min. In the middle of his fourteenth circuit Paulhan was seen to be descending, and it was learned that his petrol supply had become exhausted. He had, however, easily established a record for both time and distance, having remained in the air for 2 h. 43 min. 24 sec., during which time he flew a distance of 131 kilometres—about 82 miles.

This notable performance was practically the only event of the day, other aeronauts being on the whole unfortunate.

The table appended is necessarily incomplete, the more notable flights only having been entered, and the figures given are provisional, as the final results have not yet been issued. Three of the machines are illustrated on page 218.

*Speeds and Distances at Rheims.*

References:—G.P. = Grand Prix. P.V. = Prix de Vitesse. T.P. = Tour de Piste.

| Date. | Competition. | Aeronaut. | Machine. | Distance 10 kiloms. to the lap | Time. |
|---|---|---|---|---|---|
| | | | | | m. s. |
| Aug. 22 | T.P. | Lefebvre ... | Wright ... ... | 1 lap | 8 $58\frac{4}{5}$ |
| ,, | ,, | Tissandier ... | ,, ... ... | ,, | 9 $26\frac{1}{5}$ |
| ,, | ,, | De Lambert... | ,, ... ... | ,, | 9 $33\frac{3}{5}$ |
| ,, | ,, | Latham... ... | Antoinette ... | ,, | 9 47 |
| ,, | ,, | Paulhan ... | Voisin ... ... | ,, | 10 50 |
| ,, | ,, | Sommer ... | Farman ... ... | ,, | 11 $24\frac{2}{5}$ |
| ,, | ,, | Cockburn ... | ,, ... ... | ,, | 11 44 |
| ,, | ,, | Bunan Varilla | Voisin ... | ,, | 13 $8\frac{1}{5}$ |
| ,, | P.V. | Lefebvre ... | Wright ... .. | 3 laps | 29 2 |
| ,, | ,, | Paulhan ... | Voisin ... ... | ,, | 32 $49\frac{3}{5}$ |
| ,, | ,, | De Lambert... | Wright ... ... | ,, | 29 2 |
| ,, | ,, | Tissandier ... | ,, ... ... | ,, | 28 $59\frac{1}{5}$ |
| Aug. 23 | G.P. | Paulhan .. | Voisin ... ... | 49½ km. | — |
| ,, | T.P. | Curtiss ... ... | Herring-Curtiss | 1 lap | 8 $35\frac{2}{5}$ |
| ,, | ,, | Blériot ... ... | Blériot ... ... | ,, | 8 $42\frac{3}{5}$ |
| Aug. 24 | P.V. | Paulhan ... | Voisin ... ... | 3 laps | 38 12 |
| ,, | T.P. | Blériot ... ... | Blériot .. ... | 1 lap | 8 4 |
| ,, | P.V. | Latham ... | Antoinette ... | 3 laps | 30 2 |
| Aug. 25 | G.P. | Paulhan .. | Voisin ... ... | 131 km. | 163 24 |

## ELECTROLYSIS.

THE restrictions imposed by the Board of Trade have compelled engineers in this country to pay great attention to the bonding of rails on our electric traction systems, and it is thanks to these restrictions that the troubles arising from electrolysis have been reduced to their present low standard. The resistance of the return-circuit of an electric tramway is made up of the rails themselves and the bonds connecting them together. If this resistance is large, the current on its way back to the power-house will take up another path, provided, of course, that it can find one of sufficiently low resistance. Thus, as many engineers have often found to their sorrow, instead of the current returning to the power-house or sub-station by way of the rails, some of it finds its way back through the earth, or more correctly speaking, through things which are buried in the earth. Gas pipes, water mains, lead-covered cables, &c., are all more or less good conductors of electricity, and it is well known that with badly bonded rails they will readily act as such. It is equally well known that whenever current passes from a pipe or cable to the ground, or to another pipe or cable, corrosion of the metal takes place, holes and pittings are produced, causing leaky pipes, rotting away the lead covering on telephone and other cables, and so giving rise to a great amount of inconvenience, expense, and annoyance. The corrosion may be slow or it may be rapid, depending on the strength of the stray current. It is for good reason, therefore, that the Board of Trade requires that a continuous record be kept of the difference in potential between the point of the uninsulated return furthest from and nearest to the power station. Should at any time the difference of potential exceed 7 volts steps must be taken to reduce it below that limit. The usual method of reducing the drop at times of heavy loads is by means of a negative or return wire booster, which may be regarded as a pump for pumping back the current to the station. There are other requirements of the Board of Trade which have to be complied with, but we need not enter into them here; our object is merely to emphasise the importance of these restrictions, and to draw attention to what has happened at Winnipeg in consequence of no such rules being in force.

In January last the Board of Control of Winnipeg engaged Professor L. A. Herdt, of the McGill University, to report upon the electrical conditions existing in the city, particularly in connection with the return current of the Winnipeg Electric Railway Company's system and its connection with the Government telephone cable system, and to submit recommendations dealing with improvements of the present state of affairs, so that electrolysis or fire risks, if such existed, might be eliminated. His report, which has recently been issued, shows what a large amount of damage can be done to water pipes, &c., with badly bonded rails and a high resistance return circuit due to other causes. The Winnipeg Street Railway Company has two plants in the city. One of them is a steam plant, which is kept in reserve, while the other, which furnishes the whole of the electric current for the street railway, receives its power from a hydro-electric plant on the Winnipeg River. At times the current taken by the railway, reaches 9000 ampères, but the average current is 6000 ampères. It appears that the return circuit of practically the whole system is abnormally imperfect, and that the soil in the city has a remarkably low resistance, so that in order to prevent leakage currents a very small drop in the rail return would be necessary.

According to a report of the city electrician electrolytic action has mainly taken place in six districts. Lengths of water pipe and lead-covered cables taken from those districts have been examined, and there appears to be no doubt that the holes and breaks in them have been caused by electrolysis. The damage in four districts is believed to be due to the very bad condition of the bonding. The condition of which may be judged when it is stated that in one place, where the road bed is unpaved, the bond wires, which are No. 0 B and S soft copper wire, with bonding cap terminals, gave pressure drop readings equivalent to that of rails from 20ft. to 60ft. long. In this country nearly all specifications call for 98 per cent. conductivity in the bonds, and this is generally obtained. At some parts the bonds are uncovered, and many of these have been found to be broken altogether. Professor Herdt states that in another district the rails are bonded to the water pipes, and the heavy water mains in this street carry a large part of the current, until it reaches a point where the stray currents pass into the telephone cables, which are bonded to the negative bus bars of the sub-station, and also to the intricate network of mains and service pipes lying in another district. It seems that in their efforts to stop electrolysis a great deal has been done in the way of bonding water and gas mains direct to the rails. Indeed, one is led to suppose from the report that these gas and water mains, and the telephone cables, act just as much as return conductors as the rails themselves, or possibly even more so.

The practice of bonding the tracks to water and gas pipes, while affording local protection, has undoubtedly encouraged leakage currents, and there appears good reason to believe that the electrolysis troubles have been intensified to a great extent by adopting this practice. Professor Herdt, in his report, calls attention to this, and recommends that the practice be abandoned. A great number of American engineers appear to place reliance on this practice of relieving mains from electrolysis at badly affected places, but they seem to overlook the fact that it is inviting the current to leave the rails and take to the pipes, and it often gives rise to electrolytic action at the joints. The conditions of things is well brought out in a paragraph having reference to a test which was made in the basement of a building where a recording ammeter was connected between a water main and telephone cable. At one time 50 ampères were recorded and the water pipe was positive to the telephone cables.

In addition to the imperfect condition of the bonding in the greater part of the city, the general design of the system also appears to add materially to the electrolysis trouble. It is obvious that not only must the rails be well bonded, but that they themselves should be of ample section to carry whatever return current they may be called upon to deal with. And no less important is the question of low resistance return feeders, which should take the current from the rails at various points. But at Winnipeg the conditions in these respects are anything but ideal. Between the rails, which are 70 lb. and 90 lb., there is a 500,000 circular mil cable which is cross-bonded to the track. Readings taken along the line between the high-pressure hydrants and domestic water pipes show these positive to the rails. As a matter of fact, throughout the whole centre of the city this condition is met. At one point the tracks are bonded to return feeders of a total sectional area equal to 6,848,000 circular mils. The drop of potential between this point and the negative bus bars, if these carried the railway current

altogether, would reach 12 volts at times. The distance is approximately 1200ft.; in other words, the drop of potential from these tracks to the station is one volt per 100ft., which is, of course, excessive. Other return feeders are bonded to the tracks at different points, but they are of comparatively small section, and little current can be carried by them.

The remedies for the trouble are naturally very evident. Professor Herdt, in drawing up his recommendations, has undoubtedly given sound advice, which if acted upon will, we feel sure, remove the unpleasant state of affairs at present existing at Winnipeg. First he recommends the erection of sub-stations at different points, with a view to diminishing the amount of current to be returned through the rails in the centre of the city. Proper re-bonding of all tracks that show defect, and special bonding and cross-bonding at intersections, is urged upon the company, and also a system of inspection of track returns. It is satisfactory to learn that the company has placed an order for electrical machinery, which will be erected in three new sub-stations, and which will reduce very largely the amount of current through the rails now very much overloaded. Its desire quickly to remedy matters is also evident from the fact that the company has now in operation a bonding car for electrically brazing copper bonds on the rail joints. The amount of copper in the return feeders will have to be increased, and it seems that the cost of removing electrolysis troubles from Winnipeg will amount to something considerable.

## BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

The annual meeting of the British Association for the Advancement of Science opened on Wednesday at Winnipeg, Manitoba. This is the third occasion on which the Dominion of Canada has witnessed the convention of the members, previous meetings having been held at Montreal and Toronto in 1884 and 1897 respectively. The meetings are being held in the buildings of Manitoba University, while other colleges and halls are being utilised for reception and other purposes. Sir J. J. Thomson is the president this year, and on the opening day delivered his address, part of which is given below.

### ADDRESS BY PROFESSOR SIR J. J. THOMSON, M.A., LL.D., D.Sc., F.R.S., President.

Twenty-five years ago a great change was made in the practice of the British Association. From the foundation of our Society until 1884 its meetings had always been held in the British Isles; in that year, however, the Association met in Montreal, and a step was taken which changed us from an insular into an Imperial Association. For this change, which now I think meets with nothing but approval, Canada is mainly responsible. Men of science welcome it for the increased opportunities it gives them of studying under the most pleasant and favourable conditions different parts of our Empire, of making new friends; such meetings as these not only promote the progress of science, but also help to strengthen the bonds which bind together the different portions of the King's dominions.

This year, for the third time in a quarter of a century, we are meeting in Canada. As if to give us an object lesson in the growth of Empire, you in Winnipeg took the opportunity at our first meeting in Canada in 1884 to invite our members to visit Manitoba and see for themselves the development of the Province at that time. Those who were fortunate enough to be your guests then as well as now are confronted with a change which must seem to them unexampled and almost incredible. Great cities have sprung up, immense areas have been converted from prairies to prosperous farms, flourishing industries have been started, and the population has quadrupled. As the President of a scientific association I hope I may be pardoned if I point out that even the enterprise and energy of your people and the richness of your country would have been powerless to effect this change without the resources placed at their disposal by the labours of men of science.

The eminence of my predecessors in the chair at the meetings of the British Association in Canada makes my task this evening a difficult one. The meeting at Montreal was presided over by Lord Rayleigh, who, like Lord Kelvin, his colleague in the chair of Section A at that meeting, has left the lion's mark on every department of physics, and who has shown that, vast as is the empire of physics, there are still men who can extend its frontiers in all of the many regions under its sway. It has been my lot to succeed Lord Rayleigh in other offices as well as this, and I know how difficult a man he is to follow.

The President of the second meeting in Canada—that held in 1897 at Toronto—was Sir John Evans, one of the men who, like Boyle, Cavendish, Darwin, Joule, and Huggins, have, from their own resources and without the aid derived from official positions or from the universities, made memorable contributions to science; such men form one of the characteristic features of British science. May we not hope that, as the knowledge of science and the interest taken in it increase, more of the large number of men of independent means in our country may be found working for the advancement of science, and thereby rendering services to the community no less valuable than the political, philanthropic, and social work at which many of them labour with so much zeal and success?

I can, however, claim to have some experience of, at any rate, one branch of Canadian science, for it has been my privilege to receive at the Cavendish Laboratory many students from your universities. Some of these have been holders of what is known as the 1851 scholarships. These scholarships are provided from the surplus of the Great Exhibition of 1851, and are placed at the disposal of most of the younger universities in the British Empire, to enable students to devote themselves for two or three years to original research in various branches of science. I have had many opportunities of seeing the work of these scholars, and I should like to put on record my opinion that there is no educational endowment in the country which has done or is doing better work.

I have had, as I said, the privilege of having as pupils students from your universities as well as from those of New Zealand, Australia, and the United States, and have thus had opportunities of comparing the effect on the best men of the educational system in force at your universities with that which prevails in the older English universities. Well, as the result, I have come to the conclusion that there is a good deal in the latter system which you have been wise not to imitate. The chief evil from which we at Cambridge suffer and which you have avoided is, I am convinced, the excessive competition for scholarships which confronts our students at almost every stage of their education. You may form some estimate of the prevalence of these scholarships if I tell you that the colleges in the University of Cambridge alone give more than £35,000 a year in scholarships to undergraduates, and I suppose the case is much the same at Oxford. The result of this is that preparation for these scholarships dominates the education of the great majority of the cleverer boys who come to these universities, and indeed in some quarters it seems to be held that the chief duty of a schoolmaster, and the best test of his efficiency, is to make his boys get scholarships. The preparation for the scholarship too often means that about two years before the examination the boy begins to specialise, and from the age of sixteen does little else than the subject, be it mathematics, classics, or natural science, for which he wishes to get a scholarship; then, on entering the university, he spends three or four years studying the same subject before he takes his degree, when his real life work ought to begin. How has this training fitted him for this work? I will take the case in which the system might perhaps be expected to show to greatest advantage, when his work is to be original research in the subject he has been studying. He has certainly acquired a very minute acquaintance with his subject—indeed, the knowledge possessed by some of the students trained under this system is quite remarkable, much greater than that of any other students I have ever met. But though he has acquired knowledge, the effect of studying one subject, and one subject only, for so long a time is too often to dull his enthusiasm for it, and he begins research with much of his early interest and keenness evaporated. Now there is hardly any quality more essential to success in research than enthusiasm. Research is difficult, laborious, often disheartening. The carefully designed apparatus refuses to work, it develops defects which may take months of patient work to rectify, the results obtained may appear inconsistent with each other and with every known law of Nature, sleepless nights and laborious days may seem only to make the confusion more confounded, and there is nothing for the student to do but to take for his motto "It's dogged as does it," and plod on, comforting himself with the assurance that when success does come, the difficulties he has overcome will increase the pleasure—one of the most exquisite men can enjoy—of getting some conception which will make all that was tangled, confused, and contradictory, clear and consistent. Unless he has enthusiasm to carry him on when the prospect seems almost hopeless and the labour and strain incessant, the student may give up his task and take to easier, though less important, pursuits.

I am convinced that no greater evil can be done to a young man than to dull his enthusiasm. In a very considerable experience of students of physics beginning research, I have met with more—many more—failures from lack of enthusiasm and determination than from any lack of knowledge or of what is usually known as cleverness.

This continual harping from an early age on one subject, which is so efficient in quenching enthusiasm, is much encouraged by the practice of the colleges to give scholarships for proficiency in one subject alone. I went through a list of the scholarships awarded in the University of Cambridge last winter, and though there were 202 of them, I could only find three cases in which it was specified that the award was made for proficiency in more than one subject.

The premature specialisation fostered by the preparation for these scholarships injures the student by depriving him of adequate literary culture, while when it extends, as it often does, to specialisation in one or two branches of science, it retards the progress of science by tending to isolate one science from another. The boundaries between the sciences are arbitrary, and tend to disappear as science progresses. The principles of one science often find most striking and suggestive illustrations in the phenomena of another. Thus, for example, the physicist finds in astronomy that effects he has observed in the laboratory are illustrated on the grand scale in the sun and stars. No better illustration of this could be given than Professor Hale's recent discovery of the Zeeman effect in the light from sun spots; in chemistry, too, the physicist finds in the behaviour of the whole series of reactions illustrations of the great laws of thermodynamics, while if he turns to the biological sciences he is confronted by problems, mostly unsolved, of unsurpassed interest. Consider for a moment the problem presented by almost any plant—the characteristic and often exquisite detail of flower, leaf, and habit—and remember that the mechanism which controls this almost infinite complexity was once contained in a seed perhaps hardly large enough to be visible. We have here one of the most entrancing problems in chemistry and physics it is possible to conceive.

Again, the specialisation prevalent in schools often prevents students of science from acquiring sufficient knowledge of mathematics; it is true that most of those who study physics do some mathematics, but I hold that, in general, they do not do enough, and that they are not as efficient physicists as they would be if they had a wider knowledge of that subject. There seems at present a tendency in some quarters to discourage the use of mathematics in physics; indeed, one might infer, from the statements of some writers in quasi-scientific journals, that ignorance of mathematics is almost a virtue. If this is so, then surely of all the virtues this is the easiest and most prevalent.

I do not for a moment urge that the physicist should confine himself to looking at his problems from the mathematical point of view; on the contrary, I think a famous French mathematician and physicist was guilty of only slight exaggeration when he said that no discovery was really important or properly understood by its author unless and until he could explain it to the first man he met in the street.

But two points of view are better than one, and the physicist who is also a mathematician possesses a most powerful instrument for scientific research with which many of the greatest discoveries have been made; for example, electric waves were discovered by mathematics long before they were detected in the laboratory. He has also at his command a language clear, concise, and universal, and there is no better way of detecting ambiguities and discrepancies in his ideas than by trying to express them in this language. Again, it often happens that we are not able to appreciate the full significance of some physical discovery until we have subjected it to mathematical treatment, when we find that the effect we have discovered involves other effects which have not been detected, and we are able by this means to duplicate the discovery. Thus James Thomson, starting from the fact that ice floats on water, showed that it follows by mathematics that ice can be melted and water prevented from freezing by pressure. This effect, which was at that time unknown, was afterwards verified by his brother, Lord Kelvin. Multitudes of similar duplication of physical discoveries by mathematics could be quoted.

I have been pleading in the interests of physics for a greater study of mathematics by physicists. I would also plead for a greater study of physics by mathematicians in the interest of pure mathematics.

The history of pure mathematics shows that many of the most important branches of the subject have arisen from the attempts made to get a mathematical solution of a problem suggested by physics. Thus the differential calculus arose from attempts to deal with the problem of moving bodies. Fourier's theorem resulted from attempts to deal with the vibrations of strings and the conduction of heat; indeed, it would seem that the most fruitful crop of scientific ideas is produced by cross-fertilisation between the mind and some definite fact, and that the mind by itself is comparatively unproductive.

I think, if we could trace the origin of some of our most comprehensive and important scientific ideas, it would be found that they arose in the attempt to find an explanation of some apparently trivial and very special phenomenon; when once started the ideas grew to such generality and importance that their modest origin could hardly be suspected. Water vapour we know will refuse to condense into rain unless there are particles of dust to form nuclei; so an idea before taking shape seems to require a nucleus of solid fact round which it can condense.

I have ventured to urge the closer union between mathematics and physics, because I think of late years there has been some tendency for these sciences to drift apart, and that the workers in applied mathematics are relatively fewer than they were some years ago. This is no doubt due to some extent to the remarkable developments made in the last few years in experimental physics on the one hand, and in the most abstract and metaphysical parts of pure mathematics on the other. The fascination of these has drawn workers to the frontiers of these regions who would otherwise have worked nearer the junction of the two. In part, too, it may be due to the fact that the problems with which the applied mathematician has to deal are exceedingly difficult, and many may have felt that the problems presented by the older physics have been worked over so often by men of the highest genius that there was but little chance of any problem which they could have any hope of solving being left.

But the newer developments of physics have opened virgin ground which has not yet been worked over, and which offers problems to the mathematician of great interest and novelty—problems which will suggest and require new methods of attack, the development of which will advance pure mathematics as well as physics.

I have alluded to the fact that pure mathematicians have been indebted to the study of concrete problems for the origination of some of their most valuable conceptions; but, though, no doubt, pure mathematicians are in many ways very exceptional folk, yet in this respect they are very human. Most of us need to tackle some definite difficulty before our minds develop whatever powers they may possess. This is true for even the youngest of us, for our school boys and school girls, and I think the moral to be drawn from it is that we should aim at making the education in our schools as little bookish and as practical and concrete as possible.

I once had an illustration of the power of the concrete in stimulating the mind which made a very lasting impression upon me. One of my first pupils came to me with the assurance from his previous teacher that he knew little and cared less about mathematics, and that he had no chance of obtaining a degree in that subject. For some time I thought this estimate was correct, but he happened to be enthusiastic about billiards, and when we were reading that part of mechanics which deals with the collision of elastic bodies I pointed out that many of the effects he was constantly observing were illustrations of the subject we were studying. From that time he was a changed man. He had never before regarded mathematics as anything but a means of annoying innocent undergraduates; now, when he saw what important results it could obtain, he became enthusiastic about it, developed very considerable mathematical ability, and, though he had already wasted two out of his three years at college, took a good place in the mathematical tripos.

It is possible to read books, to pass examinations without the higher qualities of the mind being called into play. Indeed, I doubt if there is any process in which the mind is more quiescent than in reading without interest. I might appeal to the widespread habit of reading in bed as a prevention of insomnia as a proof of this. But it is not possible for a boy to make a boat or for a girl to cook a dinner without using their brains. With practical things the difficulties have to be surmounted, the boat must be made water-tight, the dinner must be cooked, while in reading there is always the hope that the difficulties which have been slurred over will not be set in the examination.

I think it was Helmholtz who said that often in the course of a research more thought and energy were spent in reducing a refractory piece of brass to order than in devising the method or planning the scheme of campaign. This constant need for thought and action gives to original reasearch in any branch of experimental science great educational value even for those who will not become professional men of science. I have had considerable experience with students beginning research in experimental physics, and I have always been struck by the quite remarkable improvement in judgment, independence of thought and maturity produced by a year's research. Research develops qualities which are apt to atrophy when the student is preparing for examinations, and, quite apart from the addition of new knowledge to our store, is of the greatest importance as a means of education.

It is the practice in many universities to make special provision for the reception of students from other universities who wish to do original research or to study the more advanced parts of their subject, and considerable numbers of such students migrate from one university to another. I think it would be a good thing if this practice were to extend to students at an earlier stage in their career; especially should I like to see a considerable interchange of students between the universities in the Mother Country and those in the Colonies.

I am quite sure that many of our English students, especially those destined for public life, could have no more valuable experience than to spend a year in one or other of your universities, and I hope some of your students might profit by a visit to ours.

I can think of nothing more likely to lead to a better understanding of the feelings, the sympathies, and, what is not less important, the prejudices, of one country by another, than by the youths of those countries spending a part of their student life together. Undergraduates as a rule do not wear a mask either of politeness or any other material, and have probably a better knowledge of each other's opinions and points of view—in fact, know each other better than do people of riper age. To bring this communion of students about there must be co-operation between the universities throughout the Empire; there must be recognition of each other's examinations, residence, and degrees. Before this can be accomplished there must, as my freind Mr. E. B. Sargant pointed out in a lecture given at the McGill University, be co-operation and recognition between the universities in each part of the Empire. I do not mean for a moment that all universities in a country should be under one government. I am a strong believer in the individuality of universities, but I do not think this is in any way inconsistent with the policy of an open door from one university to every other in the Empire.

It has usually been the practice of the president of this Association to give some account of the progress made in the last few years in the branch of science which he has the honour to represent.

I propose this evening to follow that precedent, and to attempt to give a very short account of some of the more recent developments of physics, and the new conceptions of physical processes to which they have led.

The period which has elapsed since the Association last met in Canada has been one of almost unparalleled activity in many branches of physics, and many new and unsuspected properties of matter and electricity have been discovered. The history of this period affords a remarkable illustration of the effect which may be produced by a single discovery; for it is, I think, to the discovery of the Röntgen rays that we owe the rapidity of the progress which has recently been made in physics. A striking discovery like that of the Röntgen rays acts much like the discovery of gold in a sparsely populated country; it attracts workers who come in the first place for the gold, but who may find that the country has other products, other charms, perhaps even more valuable than the gold itself. The country in which the gold was discovered in the case of the Röntgen rays was the department of physics dealing with the discharge of electricity through gases, a subject which, almost from the beginning of electrical science, had attracted a few enthusiastic workers, who felt convinced that the key to unlock the secret of electricity was to be found in a vacuum tube. Röntgen, in 1895, showed that when electricity passed through such a tube, the tube emitted rays which could pass through bodies opaque to ordinary light, which could, for example, pass through the flesh of the body, and throw a shadow of the bones on a suitable screen. The fascination of this discovery attracted many workers to the subject of the discharge of electricity through gases, and led to great improvements in the instruments used in this type of research. It is not, however, to the power of probing dark places, important though this is, that the influence of Röntgen rays on the progress of science has mainly been due; it is rather because these rays make gases, and, indeed, solids and liquids, through which they pass, conductors of electricity. It is true that before the discovery of these rays other methods of making gases conductors were known, but none of these was so convenient for the purposes of accurate measurement,

The study of gases exposed to Röntgen rays has revealed in such gases the presence of particles charged with electricity; some of these particles are charged with positive, others with negative electricity.

The properties of these particles have been investigated; we know the charge they carry, the speed with which they move under an electric force, the rate at which the oppositely charged ones recombine, and these investigations have thrown a new light, not only on electricity, but also on the structure of matter.

We know from these investigations that electricity, like matter, is molecular in structure, that just as a quantity of hydrogen is a collection of an immense number of small particles called molecules, so a charge of electricity is made up of a great number of small charges, each of a perfectly definite and known amount.

Helmholtz said in 1880 that in his opinion the evidence in favour of the molecular constitution of electricity was even stronger than that in favour of the molecular constitution of matter. How much stronger is that evidence now, when we have measured the charge on the unit and found it to be the same from whatever source the electricity is obtained. Nay, further, the molecular theory of matter is indebted to the molecular theory of electricity for the most accurate determination of its fundamental quantity, the number of molecules in any given quantity of an elementary substance.

The great advantage of the electrical methods for the study of the properties of matter is due to the fact that whenever a particle is electrified it is very easily identified, whereas an uncharged molecule is most elusive; and it is only when these are present in immense numbers that we are able to detect them. A very simple calculation will illustrate the difference in our power of detecting electrified and unelectrified molecules. The smallest quantity of unelectrified matter ever detected is probably that of neon, one of the inert gases of the atmosphere. Professor Strutt has shown that the amount of neon in one-twentieth of a cubic centimetre of the air at ordinary pressures can be detected by the spectroscope; Sir William Ramsay estimates that the neon in the air only amounts to one part of neon in 100,000 parts of air, so that the neon in one-twentieth of a cubic centimetre of air would only occupy at atmospheric pressure a volume of half a millionth of a cubic centimetre. Whan stated in this form the quantity seems exceedingly small, but in this small volume there are about ten million million molecules. Now the population of the earth is estimated at about fifteen hundred millions, so that the smallest number of molecules of neon we can identify is about 7000 times the population of the earth. In other words, if we had no better test for the existence of a man than we have for that of an unelectrified molecule we should come to the conclusion that the earth is uninhabited. Contrast this with our power of detecting electrified molecules. We can by the electrical method, even better by the cloud method of C. T. R. Wilson, detect the presence of three or four charged particles in a cubic centimetre. Rutherford has shown that we can detect the presence of a single $\alpha$ particle. Now the $\alpha$ particle is a charged atom of helium; if this atom had been uncharged we should have required more than a million million of them, instead of one, before we should have been able to detect them.

We may, I think, conclude, since electrified particles can be studied with so much greater ease than unelectrified ones, that we shall obtain a knowledge of the ultimate structure of electricity before we arrive at a corresponding degree of certainty with regard to the structure of matter.

We have already made considerable progress in the task of discovering what the structure of electricity is. We have known for some time that of one kind of electricity—the negative—and a very interesting one it is. We know that negative electricity is made up of units all of which are of the same kind; that these units are exceedingly small compared with even the smallest atom, for the mass of the unit is only $\frac{1}{1700}$th part of the mass of an atom of hydrogen; that its radius is only $10^{-13}$ centimetre, and that these units, "corpuscles" as they have been called, can be obtained from all substances. The size of these corpuscles is on an altogether different scale from that of atoms; the volume of a corpuscle bears to that of the atom about the same relation as that of a speck of dust to the volume of this room. Under suitable conditions they move at enormous speeds which approach in some instances the velocity of light.

The discovery of these corpuscles is an interesting example of the way Nature responds to the demands made upon her by mathematicians. Some years before the discovery of corpuscles it had been shown by a mathematical investigation that the mass of a body must be increased by a charge of electricity. This increase, however, is greater for small bodies than for large ones, and even bodies as small as atoms are hopelessly too large to show any appreciable effect; thus the result seemed entirely academic. After a time corpuscles were discovered, and these are so much smaller than the atom that the increase in mass due to the charge becomes not merely appreciable, but so great that, as the experiments of Kaufmann and Bucherer have shown, the whole of the mass of the corpuscle arises from its charge.

We know a great deal about negative electricity; what do we know about positive electricity? Is positive electricity molecular in structure? Is it made up into units, each unit carrying a charge equal in magnitude, though opposite in sign, to that carried by a corpuscle? Does, or does not, this unit differ, in size and physical properties, very widely from the corpuscle? We know that by suitable processes we can get corpuscles out of any kind of matter, and that the corpuscles will be the same from whatever source they may be derived. Is a similar thing true for positive electricity? Can we get, for example, a positive unit from oxygen of the same kind as that we get from hydrogen?

For my own part, I think the evidence is in favour of the view that we can, although the nature of the unit of positive electricity makes the proof much more difficult than for the negative unit.

In the first place, we find that the positive particles—"canalstrahlen" is their technical name—discovered by our distinguished guest, Dr. Goldstein, which are found when an electric discharge passes through a highly rarefied gas, are, when the pressure is very low, the same, whatever may have been the gas in the vessel to begin with. If we pump out the gas until the pressure is too low to allow the discharge to pass, and then introduce a small quantity of gas and restart the discharge, the positive particles are the same whatever kind of gas may have been introduced.

I have, for example, put into the exhausted vessel oxygen, argon, helium, the vapour of carbon tetrachloride, none of which contain hydrogen, and found the positive particles to be the same as when hydrogen was introduced.

Some experiments made lately by Wellisch, in the Cavendish Laboratory, strongly support the view that there is a definite unit of positive electricity independent of the gas from which it is derived; these experiments were on the velocity with which positive particles move through mixed gases. If we have a mixture of methyl-iodide and hydrogen exposed to Röntgen rays, the effect of the rays on the methyl-iodide is so much greater than on the hydrogen, that, even when the mixture contains only a small percentage of methyl-iodide, practically all the electricity comes from this gas, and not from the hydrogen.

Now, if the positive particles were merely the residue left when a corpuscle had been abstracted from the methyl-iodide, these particles would have the dimensions of a molecule of methyl-iodide; this is very large and heavy, and would therefore move more slowly through the hydrogen molecules than the positive particles derived from hydrogen itself, which would, on this view, be of the size and weight of the light hydrogen molecules. Wellisch found that the velocities of both the positive and negative parcels through the mixture were the same as the velocities through pure hydrogen, although in the one case the ions had originated from methyl-iodide, and in the other from hydrogen; a similar result was obtained when carbon tetrachloride or mercury-methyl was used instead of methyl-iodide. These and similar results lead to the conclusion that the atom of the different chemical elements contains definite units of positive as well as of negative electricity, and that the positive electricity, like the negative, is molecular in structure.

The investigations made on the unit of positive electricity show that it is of quite a different kind from the unit of negative, the mass of the negative unit is exceedingly small compared with any atom, the only positive units that up to the present have been detected are quite comparable in mass with the mass of an atom of hydrogen; in fact, they seem equal to it. This makes it more difficult to be certain that the unit of positive electricity has been isolated, for we have to be on our guard against it being a much smaller body attached to the hydrogen atoms which happen to be present in the vessel. If the positive units have a much greater mass than the negative ones, they ought not to be so easily deflected by magnetic forces when moving at equal speeds; and in general the insensibility of the positive particles to the influence of a magnet is very marked; though there are cases when the positive particles are much more readily deflected, and these have been interpreted as proving the existence of positive units comparable in mass with the negative ones. I have found, however, that in these cases the positive particles are moving very slowly, and that the ease with which they are deflected is due to the smallness of the velocity, and not to that of the mass. It should, however, be noted that M. Jean Becquerel has observed in the absorption spectra of some minerals, and Professor Wood in the rotation of the plane of polarisation by sodium vapour, effects which could be explained by the presence in the substances of positive units comparable in mass with corpuscles. This, however, is not the only explanation which can be given of these effects, and at present the smallest positive electrified particles of which we have direct experimental evidence have masses comparable with that of an atom of hydrogen.

A knowledge of the mass and size of the two units of electricity, the positive and the negative, would give us the material for constructing what may be called a molecular theory of electricity, and would be a starting point for a theory of the structure of matter; for the most natural view to take, as a provisional hypothesis, is that matter is just a collection of positive and negative units of electricity, and that the forces which hold atoms and molecules together, the properties which differentiate one kind of matter from another, all have their origin in the electrical forces exerted by positive and negative units of electricity, grouped together in different ways in the atoms of the different elements.

As it would seem that the units of positive and negative electricity are of very different sizes, we must regard matter as a mixture containing systems of very different types, one type corresponding to the small corpuscle, the other to the large positive unit.

Since the energy associated with a given charge is greater, the smaller the body on which the charge is concentrated, the energy stored up in the negative corpuscles will be far greater than that stored up by the positive. The amount of energy which is stored up in ordinary matter in the form of the electrostatic potential energy of its corpuscles is, I think, not generally realised All substances give out corpuscles, so that we may assume that each atom of a substance contains at least one corpuscle. From the size and the charge on the corpuscle, both of which are known, we find that each corpuscle has $8 \times 10^{-7}$ ergs of energy; this is on the supposition that the usual expressions for the energy of a charged body hold when, as in the case of a corpuscle, the charge is reduced to one unit. Now, in one gramme of hydrogen there are about $6 \times 10^{23}$ atoms, so if there is only one corpuscle in each atom, the energy due to the corpuscles in a gramme of hydrogen would be $48 \times 10^{16}$ ergs, or $11 \times 10^{9}$ calories. This is more than seven times the heat developed by one gramme of radium, or than that developed by the burning of five tons of coal. Thus we see that even ordinary matter contains enormous stores of energy; this energy is fortunately kept fast bound by the corpuscles; if at any time an appreciable fraction were to get free, the earth would explode and become a gaseous nebula.

The matter of which I have been speaking so far is the material which builds up the earth, the sun, and the stars, the matter studied by the chemist, and which he can represent by a formula; this matter occupies, however, but an insignificant fraction of the universe, it forms but minute islands in the great ocean of the ether, the substance with which the whole universe is filled.

The ether is not a fantastic creation of the speculative philosopher; it is as essential to us as the air we breathe. For we must remember that we on this earth are not living on our own resources; we are dependent from minute to minute upon what we are getting from the sun, and the gifts of the sun are conveyed to us by the ether. It is to the sun that we owe not merely night and day, springtime and harvest, but it is the energy of the sun, stored up in coal, in waterfalls, in food, that practically does all the work of the world.

How great is the supply the sun lavishes upon us becomes clear when we consider that the heat received by the earth under a high sun and a clear sky is equivalent, according to the measurements of Langley, to about 7000 horse-power per acre. Though our engineers have not yet discovered how to utilise this enormous supply of power, they will, I have not the slightest doubt, ultimately succeed in doing so; and when coal is exhausted and our water-power inadequate, it may be that this is the source from which we shall derive the energy necessary for the world's work. When that comes about, our centres of industrial activity may perhaps be transferred to the burning deserts of the Sahara, and the value of land determined by its suitability for the reception of traps to catch sunbeams.

This energy, in the interval between its departure from the sun and its arrival at the earth, must be in the space between them. Thus this space must contain something which, like ordinary matter, can store up energy, which can carry at an enormous pace the energy associated with light and heat, and which can, in addition, exert the enormous stresses necessary to keep the earth circling round the sun and the moon round the earth.

The study of this all-pervading substance is, perhaps, the most fascinating and important duty of the physicist.

On the electro-magnetic theory of light, now universally accepted, the energy streaming to the earth travels through the ether in electric waves; thus practically the whole of the energy at our disposal has at one time or another been electrical energy. The ether must, then, be the seat of electrical and magnetic forces. We know, thanks to the genius of Clerk Maxwell, the founder and inspirer of modern electrical theory, the equations which express the relation between these forces, and although for some purposes these are all we require, yet they do not tell us very much about the nature of the ether.

The interest inspired by equations, too, in some minds is apt to be somewhat Platonic; and something more grossly mechanical—a model, for example, is felt by many to be more suggestive and manageable, and for them a more powerful instrument of research, than a purely analytical theory.

Is the ether dense or rare? Has it a structure? Is it at rest or in motion? are some of the questions which force themselves upon us.

Let us consider some of the facts known about the ether. When light falls on a body and is absorbed by it, the body is pushed forward in the direction in which the light is travelling, and if the body is free to move it is set in motion by the light. Now it is a fundamental principle of dynamics that when a body is set moving in a certain direction, or, to use the language of dynamics acquires momentum in that direction, some other mass must loose the same amount of momentum; in other words, the amount of momentum in the universe is constant. Thus, when the body is pushed forward by the light some other system must have lost the momentum the body acquires, and the only other system available is the wave of light falling on the body; hence we conclude that there must have been momentum in the wave in the direction in which it is travelling. Momentum, however, implies mass in motion. We conclude, then, that in the ether through which the wave is moving there is mass moving with the velocity of light. The experiments made on the pressure due to light enable us to calculate this mass, and we find that in a cubic kilometre of ether carrying light as intense as sunlight is at the surface of the earth, the mass moving is only about one-fifty-millionth of a milligramme. We must be careful not to confuse this with the mass of a cubic kilometre of ether; it is only the mass moved when the light passes through it; the vast majority of the ether is left undisturbed by the light. Now, on the electro-magnetic theory of light, a wave of light may be regarded as made up of groups of lines of electric force moving with the velocity of light; and if we take this point of view we can prove that the mass of ether per cubic centimetre carried along is proportional to the energy possessed by these lines of electric force per cubic centimetre, divided by the square of the velocity of light. But though lines of electric force carry some of the ether along with them as they move, the amount so carried, even in the strongest electric fields we can produce, is but a minute fraction of the ether in their neighbourhood.

This is proved by an experiment made by Sir Oliver Lodge in which light was made to travel through an electric field in rapid motion. If the electric field had carried the whole of the ether with it, the velocity of the light would have been increased by the velocity of the electric field. As a matter of fact, no increase whatever could be detected, though it would have been registered if it had amounted to one-thousandth part of that of the field.

The ether carried along by a wave of light must be an exceedingly small part of the volume through which the wave is spread. Parts of this volume are in motion, but by far the greater part is at rest; thus in the wave front there cannot be uniformity, at some parts the ether is moving, at others it is at rest—in other words, the wave front must be more analogous to bright specks on a dark ground than to a uniformly illuminated surface.

The place where the density of the ether carried along by an electric field rises to its highest value is close to a corpuscle, for round the corpuscles are by far the strongest electric fields of which we have any knowledge. We know the mass of the corpuscle, we know from Kaufmann's experiments that this arises entirely from the electric charge, and is therefore due to the ether carried along with the corpuscle by the lines of force attached to it.

A simple calculation shows that one-half of this mass is contained in a volume seven times that of a corpuscle. Since we know the volume of the corpuscle as well as the mass, we can calculate the density of the ether attached to the corpuscle; doing so, we find it amounts to the prodigious value of about $5 \times 10^{10}$, or about 2000 million times that of lead. Sir Oliver Lodge, by somewhat different considerations, has arrived at a value of the same order of magnitude.

Thus around the corpuscle ether must have an extravagant density: whether the density is as great as this in other places depends upon whether the ether is compressible or not. If it is compressible, then it may be condensed round the corpuscles, and there have an abnormally great density; if it is not compressible, then the density in free space cannot be less than the number I have just mentioned.

With respect to this point we must remember that the forces acting on the ether close to the corpuscle are prodigious. If the ether were, for example, an ideal gas whose density increased in proportion to the pressure, however great the pressure might be, then if, when exposed to the pressures which exist in some directions close to the corpuscle, it had the density stated above, its density under atmospheric pressure would only be about $8 \times 10^{-16}$, or a cubic kilometre would have a mass less than a gramme; so that instead of being almost incomparably denser than lead, it would be almost incomparably rarer than the lightest gas.

I do not know at present of any effect which would enable us to determine whether ether is compressible or not. And although at first sight the idea that we are immersed in a medium almost infinitely denser than lead might seem inconceivable, it is not so if we remember that in all probability matter is composed mainly of holes. We may, in fact, regard matter as possessing a bird-cage kind of structure in which the volume of the ether disturbed by the wires where the structure is moved is infinitesimal in comparison with the volume enclosed by them. If we do this, no difficulty arises from the great density of the ether; all we have to do is to increase the distance between the wires in proportion as we increase the density of the ether.

(*To be continued*).

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ACCORDING to the *Nachrichten für Handel und Industrie* (Berlin) of July 29th, the city authorities of Belgrade are arranging to enlarge the drinking-water system, to defray the cost of which a loan will be issued. The intention is to build a reservoir on an elevation near Belgrade, in order to get the requisite pressure for taking the water to the city.

METEOROLOGICAL REPORT FOR 1908-9.—The report of the Astronomer Royal states that during the twelve months ended April 30th last the highest temperature in the shade was 84.0 deg. on July 3rd. The lowest temperature recorded was 12.1 deg. on December 30th. During the winter there were 54 days on which the temperature fell below 32.0 deg., being two less than the average number. The mean daily horizontal movement of the air in the year was 266 miles, which is 16 miles below the average of the preceding 41 years. The greatest recorded daily movement was 776 miles on February 3rd, and the least 36 miles on January 28th. The greatest recorded pressure of the wind was 16.2 lb. on the square foot on September 9th, and the greatest hourly velocity 43 miles on November 23rd and February 3rd. The number of hours of bright sunshine recorded was 1752 out of 4458 hours during which the sun was above the horizon. As contributing to this exceptionally high proportion, it may be mentioned that in three of the months—October, November, and April—the amount registered was the highest for those months, reaching in April a percentage of 60 for the first time in any month, and in three other months—June, January, and February—the amount registered was the second highest for those months. The rainfall for the year was 22 60in., being 1.52in. less than the average of the 65 years 1841-1905. The number of rainy days—0.005in. or over—was 155. The mean temperature for the year 1908 was 49.8 deg., or 0.2 deg. above the average for the 65 years 1841-1905.

DREDGING PLANT FOR THE PORT OF PARA.—Last month (July) there sailed from the Clyde, bound for the Port of Para, Brazil, a powerful bucket dredger named Andre Reboucas, constructed by Messrs. Lobnitz and Co., of Renfrew, for the Port of Para. This dredger was ordered as recently as March 11th, the keel was laid on April 11th and the vessel ready for trial on July 9th, thus being completely manufactured and delivered within four months from the time of passing the order and creating a record in rapidity of construction for this class of vessel. The dredger is of the non-propelling type, very stiffly and powerfully constructed for dredging to a depth of 46ft. below water level in hard material. The 600 horse-power dredging engines are situated high up near the top tumbler, and their gearing is designed in so simple a manner that one may say they practically act directly upon the buckets, and thus work with the greatest possible efficiency in dealing with hard material. The huge shaft of the tumbler over which the buckets turn at the top is of solid steel 19½in. in diameter, similar to that of the great dredger Peluse, owned by the Suez Canal Company. All the gear wheels have their teeth machine cut from the solid steel. Three large vertical sided hopper barges were built at the same time by Messrs. Lobnitz and Co., Renfrew, Scotland, to serve this dredger, which will be used by the contractors, Messrs. S. Pearson and Son, Limited, of Westminster, together with the existing large self-propelling bucket dredger, two large suction dredgers, and other floating plant in connection with the important new port works under construction at Para.

# POWER SIGNALLING ON THE GREAT WESTERN RAILWAY

McKENZIE AND HOLLAND, LIMITED, WESTMINSTER, ENGINEERS

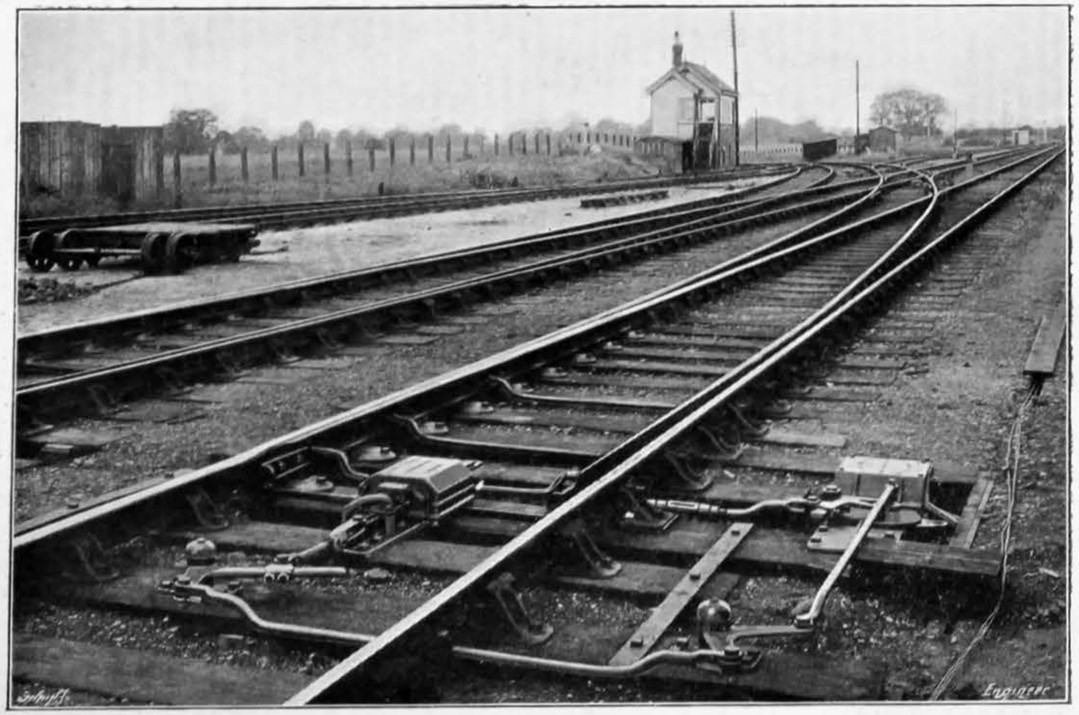
*(For description see page 215)*



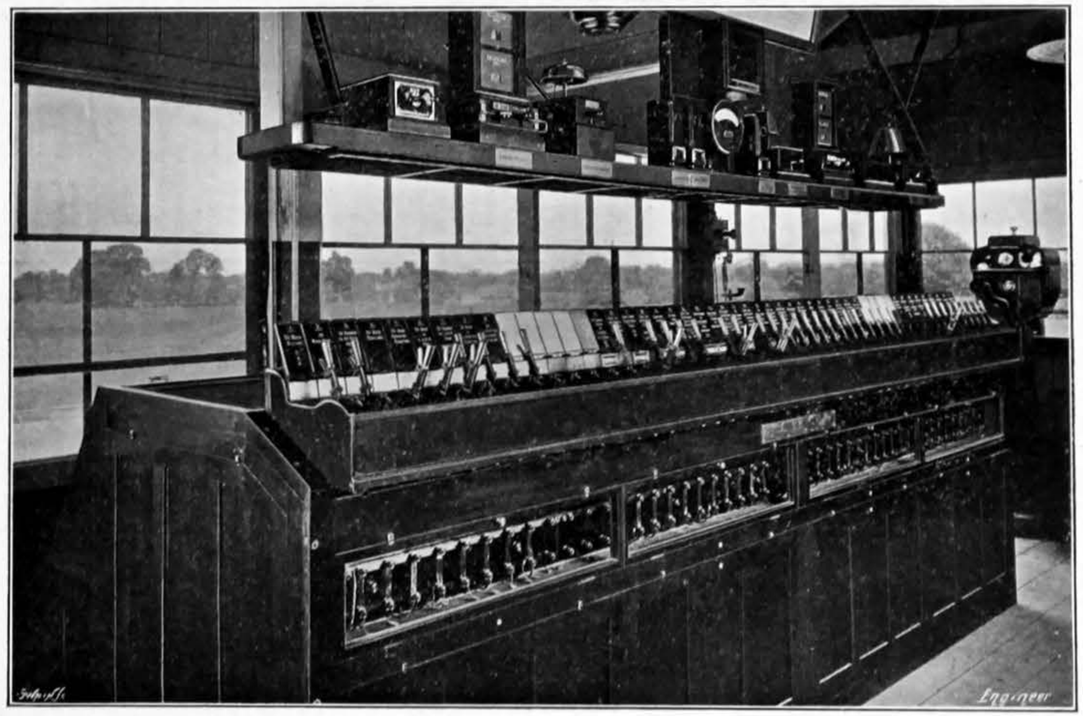
YARNTON SIGNAL BOX



FACING POINT



TRAILING POINTS



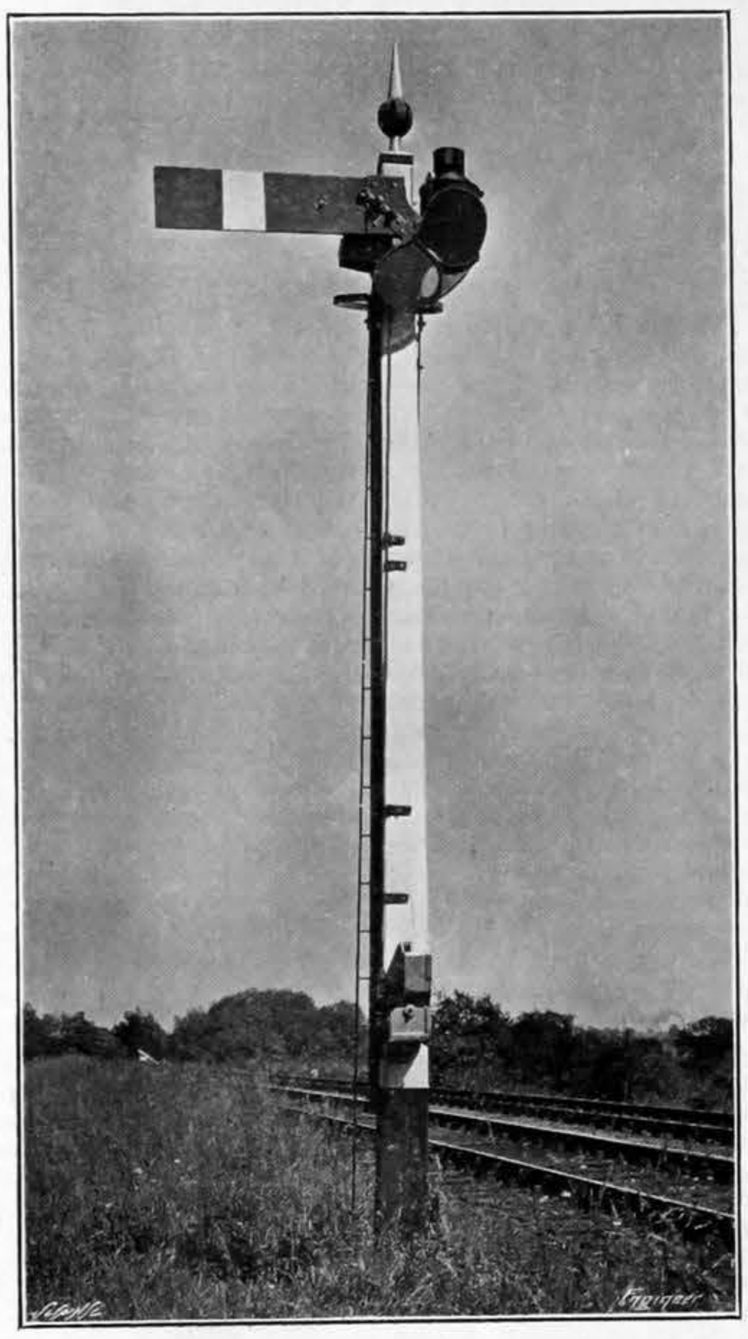
INTERIOR OF YARNTON SIGNAL BOX

## THE LATEST SYSTEM OF POWER RAILWAY SIGNALLING.

THERE has recently been brought into use at Yarnton, near Oxford, on the Great Western Railway, an all-electric power-signalling plant which contains some novel features.

The locking frame—page 214—contains fifty levers, of which seven are spare. These levers are of the usual miniature type employed in power systems, but they differ from most of the others in that the lever can be pulled fully over, and point levers can also be put fully to normal at one stroke instead of there being a pause in the middle of the movement. This pause, it should be noted, arises through a check lock that stops the lever after it has travelled sufficiently far to switch in the electrical or other power to operate the points. This lock is taken out of the lever by power over a return wire or pipe from the points. The return current flows as soon as, but not before, the points are in their altered position, and—if facing points—duly plunged and locked. Unless and until, therefore, the lever has done its work the check lock cannot be withdrawn, and this not only gives an intimation to the signalman that the work is not done, but, as the lever is not fully over, the sympathetic levers—such as a siding signal following the opening of some siding points—cannot be pulled until all is in order. This "return indication," whilst very useful, is apt to spoil the otherwise beneficial effects of power signalling, in that the signalman has to pause in the middle of moving a lever.

In the new frame at Yarnton there is no such check lock, and the signalman is able to pull over the levers in the same way as in a mechanically-operated frame, but much quicker



ELECTRICALLY-OPERATED SIGNAL

and with no exertion, of course; but the safeguards afforded by the "return indication" are to be found here, though they are provided in another way. These consist of electrical circuits to the corresponding signals, which are not completed until the point lever has done its work. There is also what is known as "constant detection" of the points, and this causes any signal at once to be thrown to danger, or, if already at danger, to be kept there, should any points such a signal applies to become damaged in any way. In order that the signalman may know how the "return indication" is, there is provided behind each point lever a visual indication with three screens—"normal," "wrong," "reversed."

Two views on page 214 show the lay out at facing points and trailing points respectively. The only difference lies in the fact that the former has a facing point locking bar. For each there is a plunger working through the casting seen in the "four-foot" into a divided stretcher rod. In this casting are the circuit controller—whereby the current is cut off when the points are over—the detectors, and return-indication circuits.

Above is a view of a signal. Signals are operated by a motor having a combined electric clutch gear and holding-off coil, and the signal goes on without rotating the motor or its gear wheels, and all risk of the latter jamming is eliminated.

The exterior of the signal-box is also shown. Opposite to it is a small power-house containing a 10 horse-power oil engine connected to a generator, which supplies the necessary current for two batteries of 60 cells. Sufficient power is provided by charging three to four hours twice a week.

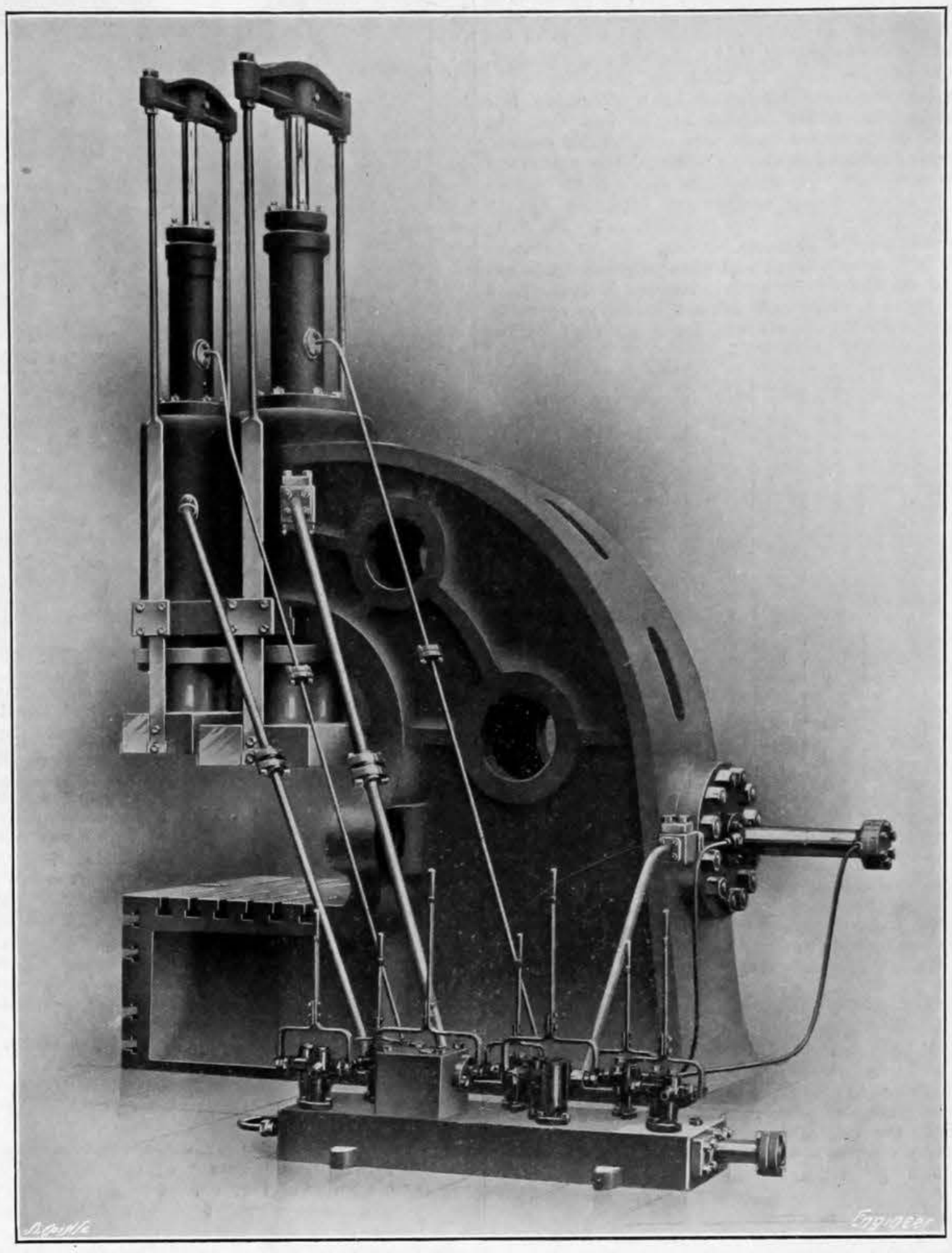
The work has been carried out by McKenzie and Holland, Limited, of Victoria-street, Westminster, and Worcester.

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ADMIRALTY COURSES OF INSTRUCTION.—The Secretary of the Admiralty announces that courses of instruction for officers will be held as follows:—Signals (Portsmouth), short course for Lieutenants, R.N., 2nd to 23rd October, 1909; short course for R.N.R. Officers, 23rd October to 6th November, 1909. Physical Training (Portsmouth), short course for Lieutenants, R.N, Captains and Lieutenants, R.M., and Warrant Officers, R.N., 11th October to 11th December, 1909. Gunnery and Torpedo, short course for R.N.V.R. Officers, 9th to 22nd October, 1909.

## HYDRAULIC FORGING PRESS

HENRY BERRY AND CO., LIMITED, LEEDS, ENGINEERS



## A NEW HYDRAULIC FORGING PRESS.

A NEW and powerful hydraulic forging press has recently been completed by Henry Berry and Co., Limited, of Leeds, for a foreign Government. It will be seen from the accompanying engraving that the frame is of the "overhung" type, and is in one piece, with the table and cylinders. Three cylinders are embodied in the design of the machine, two of these being vertical and one horizontal. Of the vertical cylinders, one can exert a total pressure of 500 tons, while the other gives 100 tons. The horizontal cylinder is capable of exerting a force of 250 tons, the stroke of all three cylinders being 2ft. Each of the vertical cylinders has attached to it a separate draw-back cylinder. To economise the consumption of high-pressure water, the 500-ton vertical and the horizontal cylinders are fitted with means whereby the rams may be brought up to the work by, and the cylinders filled with low-pressure water taken from a supply contained in an overhead tank. Thus, the high-pressure supply is only called upon to provide energy for doing the useful work of the press. The table is 4ft. square, and is provided on the top and front side with the customary slots for the bolts holding down the work, or, as may be sometimes desired, securing an extension to the front of the table.

The body of the press, which is made of Siemens-Martin cast steel, has formed on it, in line with the horizontal cylinder, two lugs which will be found of use in the manipulation of some jobs, such as tube staving. A set of Berry's patented working valves mounted on a stand, having inlet and outlet connections common to all the valves, is supplied with the press, and is placed near it, so that the operator has a good view of the work on the table.

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## MILITARY TRACTORS IN GERMANY.

IT may not be generally known that in order to promote the construction and use of heavy motor vehicles, with a view to these being available for the use of the army in the event of war, the German Parliament voted the sum of £40,000 as subsidies for this purpose in the Budget year of 1908-09, and the sum similarly appropriated for 1909-10 has been increased to £50,000. The State subsidy amounts to £200 towards the production of the tractor and £50 per annum towards the cost of maintenance. It is not quite clear whether the makers receive the total of these two sums, or whether they are awarded the former on the fulfilment of certain conditions, thus leaving the annual grant for the benefit of the purchasers of the lorries, but it is highly probably that the allocations are divided in the latter manner, and thus assist both the manufacturer and the users. As a result of the trials of heavy motor vehicles which took place in 1908, subsidies were granted to 11 engineering firms as makers, and the number of tractors concerned was 158, of which 88 were in the possession of breweries, 8 were employed in connection with agriculture, 7 were used by motor vehicle working companies, 6 by brickyards, and 5 by mining undertakings, whilst the remainder were distributed over a large number of industries.

The military authorities, after the trials which took place in 1908, decided to make further experiments this year under more exacting conditions and extending over many days. A route comprising a round trip between Berlin and Stuttgart, of a total distance of 1458 miles, was mapped out for trials under war conditions, and the tests took place between April 26th and May 21st, in conjunction with the international competition organised by the Imperial Automobile Club and the Association of Motor Vehicle Manufacturers. The coincidence of the two events proved to be an unsatisfactory arrangement, and it is improbable that a repetition will occur in the future, whilst the early period of the year chosen for the trials was also unfortunate, owing to the fact that the principal works of repairs to the roads were in progress, as is customary at the season, and this was not without influence upon the running of the vehicles.

The trials, which were extended over a considerably longer period than in the case of the preceding so-called subsidy experiments, lasted 27 days, of which 20 days were occupied in travelling, and 17 heavy vehicles participated and were submitted by the firms of Argus, Bussing, Eisenach, Nacke, Lloyd, Gaggenau, Soest, Daimler, Durkopp, Ehrhardt, Mulag, and the Norddeutsche Automobile Gesellschaft. Of these twelve firms, those of Argus, Ehrhardt and Soest had not previously become entitled to subsidies, and the entrance of their vehicles was intended to qualify for this position, whilst the other nine firms sought to test on a long endurance trial the results of the improvements which they had introduced. The trials were conducted and supervised by the military motor car division, as represented by 5 officers, 6 non-commissioned officers and 62 men, and the *personnel* placed at disposal by the makers accommodated themselves to the military requirements.

The route of 1458 miles was formed partly of level road, partly hilly and partly of a mountainous character with long and heavy gradients up to 13 per cent., and the varying conditions of the road surface placed considerable demands both on the vehicles and the drivers. Notwithstanding these matters, and with the exception of the Soest tractor—which was withdrawn by the firm on the first day of the outward journey—all the vehicles returned to Berlin at the proper time on May 21st. The departures were made every day at 6 a.m., and the arrivals always took place before darkness set in. A pause of from one to two hours was made at mid-day, and the work of replenishing fuel and attention to engines and vehicles had to be completed in one hour, soldiers rendering assistance to the representatives of the makers. The control of the fuel consumption in the case of each tractor was exercised by the officers appointed for the purpose.

The vehicles were divided into two columns for the purpose of securing better supervision, the intervening distance being 1 kilom., whilst a distance of from 33ft. to 66ft. was

to be arranged between the vehicles. It was, however, found necessary to alter this arrangement on certain days, particularly from Frankfort-on-the-Main, in consequence of the raising of a large amount of dust, and the intervals between the tractors had to be increased to 660ft. and over. In addition to this, the authorities had largely—as, for instance, in the Bavarian Palatinate—prescribed longer distances between the vehicles, and this naturally extended the length of the column. The whole distance of 1458 miles was accomplished, including the mid-day stops, in 218 hours' travelling, or at the average rate of about 6 7 miles an hour. This low rate might be surprising, having regard to the fact that the average speed in the earlier trials was considerably greater, but it is largely explained by the condition of the roads and the regulations made by the authorities, specially in connection with the international competition organised by the Imperial Automobile Club, as already mentioned. The daily stages were calculated at 72 miles, although longer distances were travelled on certain days; and the greatest distance was accomplished on the fifteenth day between Stuttgart and Tauberbischofsheim, which is 86 miles. The following table, which is taken from the *Kolnische Zeitung*, gives particulars of the tractors engaged in the trials:—

| | Normal number of revolutions. | Nominal horse-power. | Weight in kilogrammes | Class of fuel. | Total consumption in gallons throughout the trials |
|---|---|---|---|---|---|
| Argus | 800 | 30 | 4076 | Light benzine | 303 |
| Bussing | 850 | 28 | 4255 | Benzol | — |
| Daimler I. | 800 | 35 | 4050 | ,, | 277 |
| Daimler II. | 800 | 35 | 4050 | ,, | 298 |
| Durkopp I. | 800 | 38 | 4303 | ,, | 323 |
| Durkopp II. | 800 | 38 | 4480 | ,, | 311 |
| Ehrhardt I. | 850 | 36 | 4100 | ,, | 366 |
| Ehrhardt II. | 850 | 35 | 4100 | ,, | 307 |
| Eisenach | 800 | 35 | 4250 | ,, | 317 |
| Mulag I. | 750 | 35 | 3980 | Heavy benzine | 340 |
| Mulag II. | 750 | 35 | 3980 | ,, | 356 |
| Nacke | 850 | 37 | 4346 | Benzol | 307 |
| Norddeutsche Automobile I. | 850 | 40 | 4200 | ,, | 307 |
| Norddeutsche Automobile II. | 850 | 40 | 4200 | ,, | 284 |
| Lloyd | 800 | 35 | 4443 | Light benzine | 377 |
| Soest | 800 | 30 | — | — | — |
| Gaggenau | 850 | 35 | 4314 | Heavy benzine | 249 |

It is necessary to explain that the Bussing tractor, of which no particulars are given respecting the fuel consumption, was only driven to Stuttgart, as the vehicle had been sold to the Hanover brick works, and had to be delivered; and that the name Mulag is an abbreviation of Motoren und Lastwagen Actien Gesellschaft, of Aix-la-Chapelle. The width of the tractors between the outside wheels ranged from 5ft. to 5.9ft., the military authorities having specified that the width should not exceed 6.56ft. The use of benzol and benzine as fuel is a result of the endeavours made by the military authorities to promote the use of native products so as to render the country more independent of imports from abroad, and by the end of the present year they will have about 300 heavy vehicles at disposal as a consequence of the increased subsidy granted in the current financial year.

## ORE PROCESS AT THE OPEN-HEARTH PLANT OF THE DNEPROVSKY WORKS, SOUTH RUSSIA.

By M. PAVLOFF.

MUCH attention has been paid, in technical literature, to the ore process as conducted at the Yurievsky Works, South Russia, the records of some consecutive heats made in the Yurievsky open-hearth furnaces being described in German by R. Genzmer, C. Dichmann, and T. Naske, whose articles have been reproduced in many French and English journals.

Trusting that the results obtained at the Dneprovsky Iron and Steel Works, where the ore process is practised on a large scale, will also be of interest, the author presents the following table, to which it will be sufficient to add a short explanation.

*Results of Operation of the Open hearth Furnace No. 6, Dneprovsky Iron and Steel Works, Russia, April*, 1909.

| | Per month = 5 weeks = 28 working days | Per week. | Per day of 24 hours. | Per 100 of metal charged. | Per 100 of good steel ingots. |
|---|---|---|---|---|---|
| Number of heats made | 100 | 20 | 3.63 | — | — |
| Charged— | Tons. | Tons. | Tons. | Tons. | Tons. |
| Molten iron | 3832.22 | 766.44 | 139.00 | 91.47 | 92.07 |
| Solid iron | 104.55 | 20.91 | 3.79 | 2.49 | 2.51 |
| Steel scrap | 239.10 | 47.82 | 8.67 | 5.71 | 5.74 |
| Additions (ferro-mangan.) | 13.76 | 2.75 | 0.50 | 0.33 | 0.33 |
| Total metal charged | 4189.63 | 837.92 | 151.96 | 100.00 | 100.65 |
| Used— | | | | | |
| Ore | 876.39 | 175.28 | 31.79 | 20.92 | 21.07 |
| Dolomite | 203.94 | 40.79 | 7.40 | 4.87 | 4.90 |
| Limestone | 432.42 | 86.52 | 15.69 | 10.33 | 10.39 |
| Coal | 824.47 | 164.89 | 29.90 | 19.68 | 19.81 |
| Received— | | | | | |
| Steel in good ingots | 4162.73 | 832.55 | 151.00 | 99.36 | 101.00 |
| Steel in scrap | 135.04 | 27.20 | 4.93 | 3.25 | 3.27 |
| Total steel received | 4298.77 | 859.75 | 155.93 | 102.61 | 103.27 |

The iron, taken in a molten state from the mixer, is produced by smelting red hematites of Krivoi Rog with small proportions of mill cinder, open-hearth and Bessemer slag, and has the following composition:—Carbon about 3·75 per cent.; silicon from 0·7 per cent. to 1·8 per cent., and on an average per month, 1·35 per cent.; manganese from 1·2 per cent. to 2·1 per cent., and 1·82 on an average; sulphur about 0·05 per cent., and phosphorus ranges between 0·40 per cent. and 0·15 per cent.

A very rich portion of Krivoi Rog hematites, used in a lumpy state as an oxidising agent, contains 3 per cent. of silica, 1·0 per cent. of alumina, and about 93 per cent. of iron oxide—that is, 65 per cent. of Fe; other constituents may be found in negligible quantities.

The shed for the basic open-hearth furnaces in which the process is conducted is represented in detail by side elevation and three sections on the tables 46 and 47 of the author's album of open-hearth furnaces; but it must be mentioned here that the roof—to prevent the rapid corrosion during the boiling—at the present is placed higher, the distance between the bottom and roof being made 8ft. 3in.

Three furnaces, working with ore process and having the bed surface 30ft. 2in. by 10ft., may be rated as 32-ton ones; but they run with metallic charges of from 40½ to 43 tons.

In spite of the deep metal bath thus obtained, the average duration of one heat was, in April, 6 h. 30 min., thanks to the powerful oxidation performed by the ore. Thirty minutes were needed for the bed repairing, 34 min. for charging solid iron and scrap, 63 min. for charging molten iron by three ladles, thus leaving 4 h. 20 min. for the smelting and boiling periods.

The fuel consumption, shown in the above table, may be called low, taking into consideration the quality of coal used; the latter often contains 12 per cent. of ash and 6 per cent. of moisture.

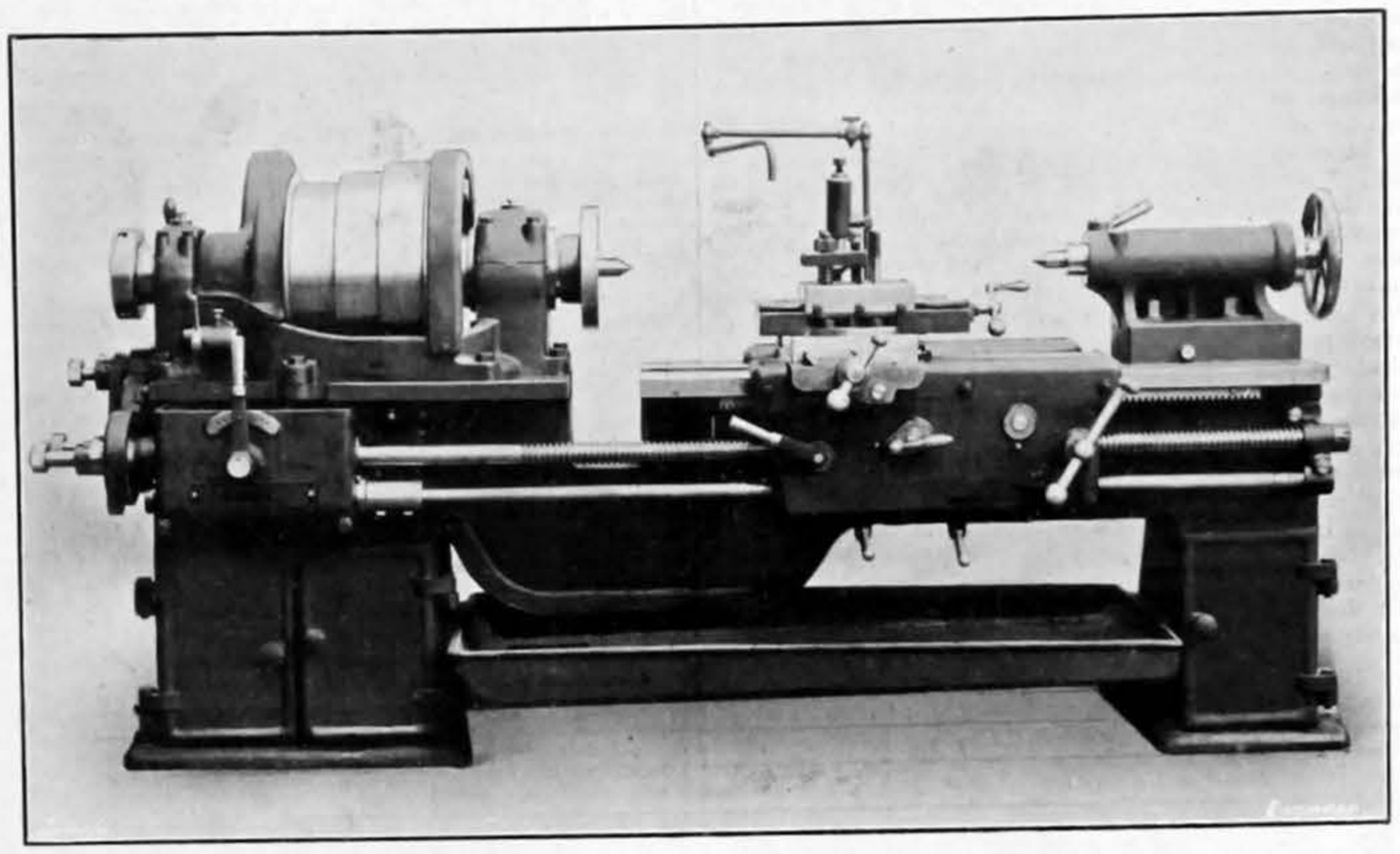
The amount of a single addition used—that is, ferro-manganese—was also small, thanks to the high percentage of manganese in the iron treated.

As to the amount of scrap produced, it appears to be somewhat large, but its quantity is explained by the fact that a very large number of ingots must be poured from one heat, because each ingot, being of 6½in. by 6½in. in section, weighs only 325 lb.

In conclusion, it may be added that about 80 per cent. of iron introduced into the bath by the ore is reduced by the open-hearth process as conducted at the Dneprovsky Works.

## 8½-INCH GAP LATHE

COLCHESTER LATHE COMPANY, COLCHESTER, ENGINEERS



## 8½-INCH CENTRE SCREW-CUTTING LATHE.

THIS lathe, illustrated above, has been designed by its makers, the Colchester Lathe Company, to obtain a maximum amount of power at all spindle speeds. The headstock is fitted with a three-speed cone to take a 3½in. belt; the largest size step is 18in. diameter and the smallest 14⅜in. The spindle, which has a 2⅝in. hole right through it, runs in adjustable parallel phosphor bronze bearings, the thrust being taken by a ball bearing against the rear housing. All the wheels are enclosed in guards. The reverse motion is fitted inside the headstock, and is arranged to be worked by a small lever, thus rendering it unnecessary to use a locking nut. Two back gears are provided, the ratio being 3.3 to 1 and 10.85 to 1. Countershaft speeds are 370 and 205, which give the following spindle speeds:—

| | | | | | |
|---|---|---|---|---|---|
| 451 | 370 | 303 | 250 | 205 | 167 |
| 137 | 113 | 92 | 76 | 62 | 51 |
| 42 | 34 | 28 | 23 | 19 | 15.5 |

The special features claimed for this lathe as being those by which its great cutting powers are obtained are as follows:—First, the size of cone, viz., 14⅜in., 16⅝in., and 18in. diameter for 3½in. belt. Attention is called to the fact that if, say, a cutting speed of 70ft. per minute is required the back gear giving a reduction of 3.3 is used from 2½in. diameter up to 5in. diameter inclusive, and the 10.85 reduction from 5 upwards. Secondly, the loose headstock is very massive and is held down by two bolts. The spindle is ground, and the centre is adjustable sideways for taper turning. Thirdly, the bed is of strong box section and has square edges. The standards of the bed form change wheel and tool cabinets, each wheel having its own place and being easily accessible. Fourthly, the saddle has a long bearing surface. Fifthly, all the gearing in the apron is carried on double bearings, the rack pinion being cut from the solid and supported underneath the rack. Sixthly, that the feeds are positive and fool-proof; and lastly, that no friction clutches are used, and the screw-cutting, sliding, and surfacing motions can only be used singly. The gear-box gives three rates of feed—8, 16, and 32 cuts per inch. The leading screw is ¼in. pitch. The following are the principal particulars of the tool:—Bed, 16½in. wide by 12½in. deep; front spindle bearing, 5in. diameter by 7¼in. long; the speed cone, 18in., 16⅝in., 14⅜in. diameter for 3½in. belt, ratio of gearing 3.3 to 1 and 10.85 to 1, will swing over saddle 12in. diameter; admits between centres with 8ft. bed, 3ft.; approximate weight with 8ft. bed, 50 cwt. The lathe is supplied with catch plate, face-plate, stationary stay, and travelling stays; 22 change wheels, spanners, trough, pump, and piping. This latter is part of the design, and is made telescopic.

## LITERATURE.

### SHORT NOTICES.

*Electrical Installations.* By Rankin Kennedy. London: Caxton Publishing Company, Limited, Clun House, Surrey-street, Strand, W.C. A new edition, revised and enlarged, in five volumes. Price 7s. 6d. net per volume.—The appearance of this new and revised edition clearly indicates that the work is in demand among a certain section interested in electrical engineering. Students, amateurs, and others desirous of knowing just a little about practically everything met with in the various branches of the electrical profession, and who do not wish to be troubled with much theory, will find that the work suits them admirably. To those, however, who find it necessary to deal with things quantitatively, the work does not so much appeal. The highly coloured illustrations, the cardboard models of machines and apparatus which are to be found in the front of each book, coupled with the absence of mathematics, all serve to make the volumes attractive to young readers, and should at least stimulate a desire for more thorough and advanced knowledge. Many new illustrations have been included in this second edition, and, on the whole, the work is fairly well up to date, although too much attention and space is devoted to antiquated designs. The author would have done much better had he deleted a great portion of the historical matter and used the space for more fully describing the machines and apparatus now in use.

*Sanitation and Sanitary Engineering.* By W. P. Gerhard. New York: Published by the author.—The author of the present volume does not state for what class of readers he intends his book, nor does a perusal of it help one to arrive at a decision in the matter. It is difficult to say whether he means it to be a popular account of the work of the sanitary engineer, or a more or less scientific treatise on the subject. If the former be the correct view, we cannot refrain from expressing the opinion that he has under-estimated the intelligence of his readers; if the latter, then the book cannot be recommended as authoritative. Dealing first with the profession and practice of sanitary engineering, he catalogues a list of such operations as are to be seen daily in the streets of any large town, and dismisses them without any remark of importance. The work of the sanitary engineer in time of epidemics, war, and sudden calamities is discussed in the second chapter, a history of sanitation from 1850 to 1900 in the third—which is, perhaps, the most valuable part of the book—an account of the sanitation of Greater New York is given in the fourth, while the fifth is a translation of an article on the corresponding conditions in Russia, the author being indebted for this to a German medical journal of 1896.

*Principles of Reinforced Concrete Construction.* By F. E. Turneaure and E. R. Maurer. New York: John Wiley and Sons. Price 15s. net.—This book, which is a second and considerably enlarged edition, treats of the principles of mechanics underlying the design of reinforced concrete, and in the earlier chapters the results of many experiments are given which will assist in the establishment of coefficients and working stresses. While in the first five chapters the more or less theoretical side of the subject is dealt with, the sixth consists of a convenient collection of formulæ and diagrams, which will prove of great value as a source of reference to designers. The remaining chapters, five in number, treat of the use of the material in various structures, such as arches, retaining walls, chimneys, &c. Some typical examples of the types of structures discussed are given, and throughout the book numerous clear diagrams and sketches are inserted.

*Elementary Mechanics of Solids and Fluids.* By A. C. Jones and C. H. Blomfield. London: Edward Arnold. Price 4s. 6d.—The importance of a thorough understanding of the more elementary parts of dynamics and hydrostatics at the very outset of an engineer's career is now too well recognised to need emphasising. In the present volume there will be found a satisfactory treatment of the subjects, and it should prove of use to many classes of readers—first-year students, and to workmen whose duty brings them into touch with, and necessitates a knowledge of, some of the fundamental results of physical science, in particular. An elementary knowledge of mathematics is assumed as already among the acquirements of the student, but it will be found that the authors have treated their subject with discernment, and laid stress on those parts which experience has shown are likely to cause especial difficulty to the beginner.

## RAILWAY MATTERS.

THE Canadian Railway Commission has issued an order compelling every railway in Canada to have the whole of its right-of-way properly fenced in by January 1st, 1911. The order states that the fence must be of a minimum height of 4ft. 6in., and gates must be provided at every farm crossing. At every level highway crossing there must be adequate cattle guards. The width of approaches to level crossings must be 20ft. on concession and main roads and 16ft. on side and bush roads.

ACCORDING to the *Railway Times*, the Great Eastern Railway Company will close to passengers on and after October 1st next, the Churchbury, Forty Hill, and Theobald's Park stations on the Cheshunt branch of the system, owing to the competition of the electric tramway cars. The district will continue to be served by the adjacent stations on the Enfield Town and Cambridge main lines, namely, Lower Edmonton, Bush Hill Park, Enfield Town, Ponder's End, Brimsdown, Enfield Lock, Waltham Cross, and Cheshunt.

THE Mexico North-Western Railway Company has acquired the Rio Grande Sierra Madre and Pacific Railroad, extending from El Paso Terrazas, 160 miles. By constructing about 160 miles of line to effect a connection between the Sierra Madre and Pacific and the Chihuahua and Pacific, which were purchased some time since, the Mexico North-Western will get an outlet for its timber through Chihuahua on the Mexican Central, as well as through El Paso, Tex., on its own line. The management, it is said, proposes to build this connection next year.

THE *Nachrichten für Handel und Industrie* (Berlin) of July 31st announces, on the authority of the German Consul in Valparaiso, that the concession for the construction and working of a railway from the Bay of Camarones to the Bolivian frontier, which was previously granted to Salvador Izquierdo, Ramiro Sanches, and Rodolfo Rothstein, and afterwards withdrawn, has now been transferred to the Comunidad Chilcaya y Ferrocarril de Camarones. It appears also that the same company has applied to the Bolivian Government for a concession in respect of a railway from Chilcaya to Oruro.

THE circular railway which serves some portions of Berlin and its suburbs was the scene of a curious accident on Thursday, August 19th. An iron tower on the premises of the Imperial Gas Company at Schoneberg, which are skirted by the line, collapsed shortly before midday, just as a train was passing by. The tower was about 280ft. high, and was intended for the storage of material for a new gasometer. The fragments in their fall wrecked the last compartment of the passing train. One person was severely injured, while four others were slightly hurt. Traffic on the railway line was subsequently restored.

THERE has recently been considerable activity in the building of inter-urban lines in Mexico, and it has been announced that an American syndicate is planning a new line from the city of Guaymas to the suburban towns of Aurora, San Jose, De Guaymas, and Empalme. This road will be about 16 miles long. There is also a Canadian syndicate in the field, and it is planning a line between Mexico City and Puebla. The proposed line runs between the two volcanoes, Popocatepetl and Ixtaccihuatl, and parts of it will lie above the winter snow line. Power for its operation will be obtained from the electric plant of the Mexican Light and Power Company at Necaxa.

THE Western Railways of France have obtained authority from the Government to electrify their lines. A beginning is to be made with the lines which run from the St. Lazare Station in Paris to Argenteuil and Saint-Germain-en-Laye. Special tracks will be laid, so that the service can be effected without any interference with the steam-driven trains. Sub-stations will be erected which will supply continuous current at 600 volts. It is anticipated that from twelve to twenty trains, composed of a maximum of six double carriages 20 m. long, can be run per hour. The permanent way, the equipment of line, &c., will cost £1,160,000; the rolling stock and converter stations, £800,000; interest on capital and other expenditure bringing the total amount to £2,280,000 for the 33.5 kiloms. of the line to be constructed.

THE £1,230,000 which is to be spent by the Transvaal Government on railways will be divided up as follows:—The Selati line is to be bought for £300,000, and the following new railways constructed:—An extension of the Pretoria-Pietersburg Railway from Pietersburg to a point near Bandolier Kop, a distance of 64 miles, at a cost of £250,000; a railway from Welverdiend Station to near Lichtenburg, with a westerly extension from a point near Treurfontein, a distance of 154 miles, at a cost of £400,000; an extension from Ermelo to Piet Retief, 72 miles long, at a cost of £255,000; a line from Geduld Station, *vid* Benoni, to a junction with the Germiston-Ermelo Railway at a point 8¼ miles east of Germiston, distance 13 miles, at a cost of £75,000; a line, being an extension of the Komati-Selati Railway, to a point near the Great Letaba River, distance 150 miles, at a cost of £250,000.

AT last, states a consular report, the celebrated circular railway round Moscow, which has been in construction for so many years, and has cost so many millions of roubles, has been completed and opened. The results, however, have been anything but satisfactory. Firstly, as regards passenger traffic, owing to the high fares and even more owing to the stations being often built in the middle of fields without any means of getting to them, the line has proved a complete failure. The number of passengers was absolutely ridiculous, a few dozen per month, and in the autumn it was decided to suspend passenger traffic. Affairs are but little better as concerns goods traffic. Owing to the exceptionally high and unsatisfactory tariff, every merchant who can possibly manage it avoids using the line for transporting his wares. In a word, the line has in no way fulfilled the expectations of the Government, which financed the undertaking. Seeing that affairs are in a hopeless state, the Government are going to revise the tariff, when possibly the line may begin to exercise the influence hoped for by the constructors.

A REPORT presented to the Board of Trade upon the accidents which occurred on railways in the United Kingdom during the year 1908 shows that during the year 1043 persons were killed and 7984 injured by accidents due to the running of trains or the movement of railway vehicles, the average figures for the previous ten years being 1155 killed and 7036 injured. During the year no passengers lost their lives in accidents to trains in which they were travelling, and the number injured—283—is very low compared with previous years. The average numbers for the past ten years have been 21 killed and 626 injured. So far as the records extends, there has only been one previous year, 1901, in which no passengers were killed in train accidents. In the class of accidents caused by the movement of trains and railway vehicles exclusive of train accidents, 102 passengers were killed and 2242 injured, the corresponding averages for the ten years previous being 120 killed and 1784 injured. The casualties to passengers in this class largely arise from the carelessness of the passengers themselves. Of servants of railway companies and contractors, 376 were killed and 5976 injured. In this class of accidents the number killed shows a large decrease compared with the average for the previous ten years. In addition to accidents caused by the running of trains and the movement of railway vehicles, a large number of accidents unconnected with railway working occurred on railway premises. Accidents of this kind accounted for the death of 85 persons and injury to 20,501. The bulk of these accidents were due to misadventure, and comparatively few could be attributed to preventable causes.

## NOTES AND MEMORANDA.

ACCORDING to a parliamentary return of last Tuesday, the number of applications received from all countries for British patents from January 1st to July 31st last totalled 17,869, compared with 16,303 in the corresponding period of last year. Of the applications received during the first seven months of this year, 1735 were from Germany, 1579 from the United States, 560 from France, 192 from Austria-Hungary, and 118 from Canada.

THE loftiest chimney in the world, states the *Scientific American*, was recently put into service at the large smelting works at Great Falls, Mont., where it will serve to carry off the gases from the greater part of the large plant. The chimney, which is built of brick, is said to be 506ft. in height above the ground. The flue includes a dust chamber in which vertically-hung wires serve to take out the dust from the smoke. The dust is removed from the wires by shaking mechanism and falls in hoppers in the floor, from which it is loaded into cars in a pit below.

IN a printed reply to a question addressed to the President of the Board of Trade by Mr. Tyson Wilson, Mr. Tennant gives the value of the machinery imported into and exported from the United Kingdom during the years 1906, 1907, and 1908. The tables show that the total imports in 1906 amounted to £5,126,972; in 1907 to £5,311,681; and in 1908 to £4,552,904. Deducting re-exports, the net imports in the three years were £3,663,732, £3,878,911, and £3,452,361. Against these figures were to be set the total exports of machinery manufactured in the United Kingdom, which in 1906 amounted to £28,440,481; in 1907 to £34,293,955; and in 1908 to £33,594,796.

THE British Consul at Stockholm, Mr. M. Villiers, in his annual report for 1908, says that it is now claimed that a commercially economical method of smelting iron ore by electricity is now in operation in Sweden, by which it is hoped that with the aid of the vast water power of the country its enormous mineral deposits of ore may be smelted without the importation of so much coal or such a consumption of charcoal. The cost of producing a ton of pig iron in this electric furnace is estimated to be about £1 12s. In addition, the life of the furnace will, it is stated, be considerably longer than that of a blast furnace. It is claimed that the product of the electric furnace is of excellent quality.

THE introduction of labour-saving machinery on the farm has been one of the principal features of the modern revolution in agriculture, and has been rendered necessary by the difficulty of getting sufficient help. Few contrivances are more interesting than the milking machine. A lengthy test has been made at the Wisconsin Agricultural Experiment Station, and is recorded in Bulletin No. 173. The machine worked more quickly and more cheaply than a man; it yielded a cleaner milk, which therefore kept better, and, finally, was shown to have no injurious effect on the udders or the general health of the animals. The machine, of course, requires proper attention and careful working to get the best results, but proved decidedly economical in herds of thirty cows or more. There are already signs that the agricultural labourer of the next generation will be, in the main, an engineer.

A 30IN. cast iron water main laid on a timber trestle in Devereaux-street, Philadelphia, was lowered last autumn to low concrete piers by the Bureau of Water, in connection with the grading of the street. The section lowered had a total length of about 1100ft., and the trestle was 27ft. high. The supply was shut off and the pipe cut into two sections, each approximately 550ft. long, so that the work was done in two successive operations. The trestle was of a simple two-post type, the bents being cross-braced and having diagonal bracing running longitudinally from bent to bent. A gallows frame was erected on top of each bent over the first half of the pipe to be lowered, and was fitted with a screw long enough to reach to the final resting place of the pipe. The screw was held by a nut, bearing on the top of the gallows frame, and having two handles. The lower end of the screw was attached to a strap passing under the pipe. Two men were placed at each screw, and the entire 550ft. of pipe lowered simultaneously.

A SMART piece of work was recently carried out by the Knowles Oxygen Company, Limited, Walsall-street, Wolverhampton, at Pearson's Furnaces, Netherton, where, owing to an accident, the crank shaft of a large vertical blowing engine had broken. Amongst other damage the piston-rod had been bent in such a manner that it seemed impossible to remove it from the cylinder. However, the Knowles Oxygen Company, by means of an oxy-hydrogen blow-pipe, cut off the piston-rod, which was about 7in. in diameter, close to the gland of the cylinder. The work was one of particular difficulty, because the cut had to be made overhead, close under the large cylinder cover, and at a considerable height from the ground, with the result that the burning metal, while the work was being done, showered down on the men and their wooden staging, and made it impossible for the shaft to be cut through at one operation. In spite of this, and that it was, we understand, the first attempt of the kind the men had ever made, the work only occupied thirty-five minutes from start to finish.

IT is frequently useful to have at hand approximate figures for the relative space occupied by the different departments of an engineering works. In a recent paper before the Glasgow Technical College Scientific Society Messrs. G. H. Gibson and A. Home-Morton give the following apportionment of covered area:—Pattern shop, 4 per cent.; foundry, 25 per cent.; machine shop, 35 per cent.; erecting and fitting shop, 20 per cent.; testing shop, 5 per cent.; stores and tool-room, 11 per cent. We presume that the figure for the pattern shop does not include pattern stores. The same gentlemen have analysed the cost records of a number of engineering and other factories, and find the average distribution of cost to be:—Labour, 37 per cent.; material, 52 per cent.; power, 3 per cent.; and other costs, 8 per cent. As might be anticipated, considerable variations from the average were found. It will be noted how small the cost of power is, and it is unfortunate that manufacturers by their policy of secrecy make it impossible for most factory costs to be discussed in a logical manner. If such discussions were usual considerable economies would certainly be effected, to the advantage of everybody.

AN invention which, after expert testing, has been pronounced a valuable addition to the means of combating bacterial disease, is reported from Chemnitz. It is a highly lustrous paint, applied to all surfaces in the ordinary way, with a basis of white lead or zinc white. Its chief value is for disinfecting, and it is prepared and sold more specifically for use in rooms, &c where it is desired to combat pathogenic germs. German Officials have made exhaustive tests of the germicidal properties of "vitralin" under varying conditions. The results may be briefly summarised as follows:—When in contact with the vitralin coating the bacilli of tuberculosis (as found in saliva) are completely destroyed in three days. Diphtheria bacilli require five hours, typhoid bacilli eight hours, and those of pus from six to thirteen hours. No lethal effect could be observed upon the spores of anthrax, even when the contact lasted thirty days, although a distinctly retarding influence upon the development of the spores was noticed. Control experiments carried on simultaneously with surfaces covered with ordinary oil colours, whitewash, &c., showed either no germicidal power or a much less degree of efficacy. Direct sunlight renders the lethal action much more rapid than does diffused daylight. The investigator came to the conclusion that the specific disinfectant property of vitralin results from the oxidation of the linseed oil, which forms an important constituent of this paint.

## MISCELLANEA.

ENERGETIC efforts are being made in Logrono to bring to a successful issue the proposed extensive scheme for the construction of the "Victoria and Alfonso" dam works in Lodosa. The cost is estimated at 9,863,000 pesetas (about £352,250), and the work will involve the irrigation of an area covering about 74,000 acres, which will benefit five districts in the province of Logroño, eight in Navarre, and twelve in Saragossa.

A SERIES of comparative tests on the case-hardening power of various gases, the results of which were communicated by Olsen and Weiffenback at the recent Brooklyn meeting of the American Institute of Chemical Engineers, have shown that the case-hardening effect of carbon monoxide is greater than that of acetylene or methane. It is stated that the carbon monoxide process has been applied to commercial case-hardening, and that a patent covering it has recently been taken out in France.

THE new airship school which is being constructed at Friedrichshafen is nearing completion, and will be opened in October. The majority of the pupils there will be young cadets, who are obliged to bind themselves for a course of instruction for two years. Provision is also being made, however, for the instruction of senior officers, naval men, and military engineers. The Government's subsidy has been supplemented by the generosity of well-known industrial firms, and Count Zeppelin will present the school with a balloon, and steam launches, as well as motor cars, are to be used for following the flights of airships.

A SERIOUS high-tension accident occurred on Wednesday of last week at Olginate, a small village on the river Adda, near Lake Como. This place is supplied by overhead wires with electric current at 3000 volts from a water-power station in the neighbourhood. It appears that during a thunderstorm one of the overhead high-tension wires fell, and came into contact with the low-tension distributing mains, which are also carried overhead. The result was that the house fittings were all charged to the higher potential, and many persons were injured while attempting to switch off the current. It is said that twelve people were killed, and nearly thirty badly injured. There was considerable panic, which was increased by the fact that the lights were all extinguished.

As already announced, the Cunard Company has determined to make Fishguard a port of call for passengers and mails. The service will be started by the Mauretania, now on her way across the Atlantic, and she is expected to arrive on Monday morning next. The Great Western Railway Company is using every endeavour to make the new arrangement a success, and it is thought highly probable that a service of special trains will be run direct from Fishguard to Dover for the convenience of passengers travelling direct to the Continent. An experimental train will meet the first boat. At first, at any rate, the liners will not come alongside the quay at Fishguard; but the mails and passengers will be removed by tender. The vessels will then proceed to Liverpool.

SOME interesting experiments are being conducted by the South Park Commissioners of Chicago in the lighting of the boulevards under their control. Several different types of lamps have been installed on temporary posts in order that the comparative illuminating effect may be observed and a determination made of how high the lamps should be hung and how far apart, and similar considerations. The lamps under test or about to be tested include incandescent gas lamps, enclosed arcs, magnetite arcs, flaming arcs, and incandescent tungsten lamps. The commissioners hope to obtain valuable data, both as regards illumination and economy, from these trials, the latter being an important factor, as it is estimated that 1,000,000 kilowatt hours per annum will be required for the lighting of Grant Park alone.

RECENTLY the Lords Commissioners of the Admiralty had under their consideration the question of the emoluments of officers of the Royal Marines appointed to the charge of wireless telegraphy stations, and, as a consequence, they came to the conclusion that the extra responsibility imposed upon these officers merited additional remuneration. The final result is that his Majesty, by an Order in Council, has just sanctioned the grant of an allowance of two shillings and sixpence a day to officers of the Royal Marines when appointed to the charge of wireless telegraphy stations. In addition, there is to be a further allowance of one shilling a day in lieu of a servant to these officers while they are employed on telegraphic duty. The new allowances are to take effect as from November 14th, 1908, and they are to be in addition to the full pay of the officers employed.

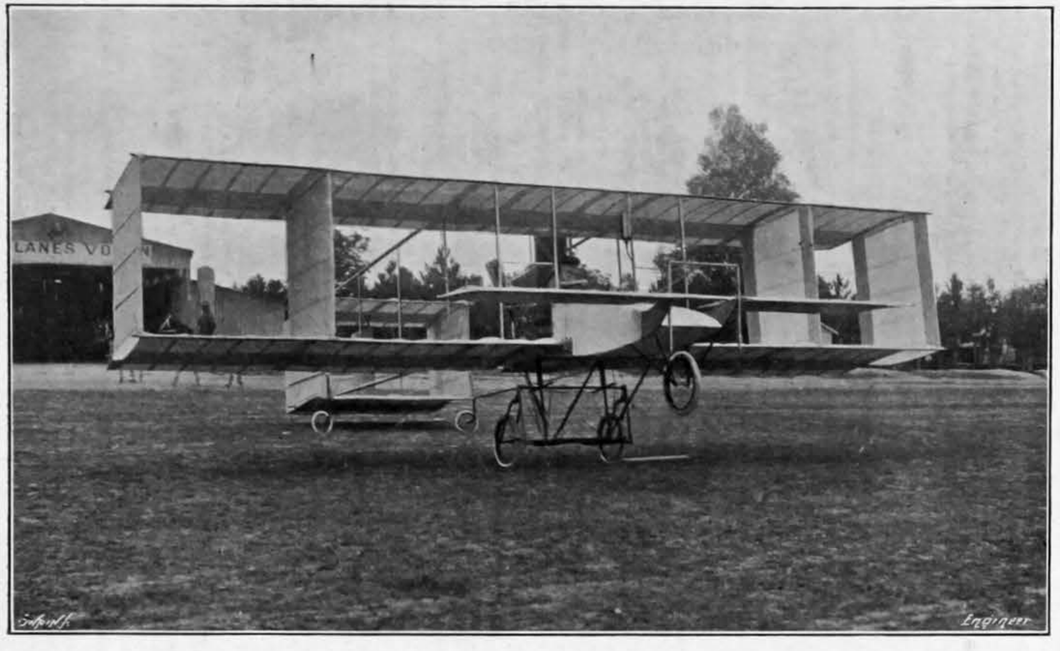
IT has been decided, after an experiment extending over two years in the Place de la République, one of the busiest squares in Paris, to adopt the method for the laying of wood pavement which has been thus tested, along the entire length of the Rue de Rivoli. The process in question, which is the invention of M. Managnan, consists in a preliminary treatment of the wood blocks to give them the qualities of suppleness and strength. The wood is heated to a temperature of 80 deg. Cent. in a special bath, containing alkaline, carbonates, and wood tar. By this treatment it loses 20 per cent. of water and 10 per cent. of solid matters of various kinds, and there remains a timber, the density of which has been increased by 40 or 50 per cent. The new material prepared in this way avoids the necessity of repairs for two years at least, which, in Paris, entail a cost of not less than 1s. 3d. per square metre annually.

IT is reported that the Transvaal Government have extensive improvements in hand with the telegraph and telephone services all over the colony, which will make it one of the best equipped in the world. It is suggested to link up every town, and main trunk lines are to be carried to every point where the railway lines cross the border, with a view to their ultimate extension to the coast ports when the other colonies are ready. It is regarded as certain that the Union Government will find telephonic communication between Cape Town and Pretoria absolutely essential. The scheme contemplates connections with farmhouses as well as the establishment of call offices at convenient centres. It is estimated that the coast extensions will cost £250,000. A concentrator has already been installed in Johannesburg to enable messages between minor offices to pass direct to their destination, without any necessity for taking off and re-transmission at central stations as heretofore.

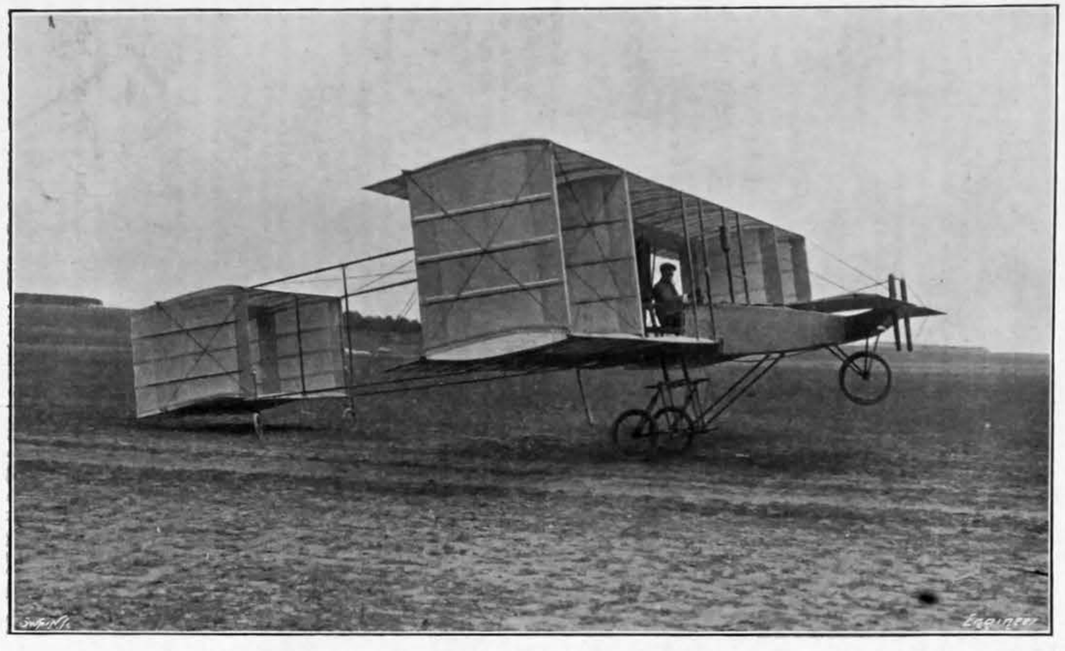
THE text was issued last Tuesday of the Bill presented by Mr. M'Kenna to make better provision respecting naval establishments in British possessions. The memorandum of the measure states that the Colonial Fortifications Act, 1877, authorised the transfer by Order in Council to the Governor of a colony of "any fortifications, works, buildings, or land in the colony held in trust for the defence of that colony." Provisional arrangements have been made with Canada for the transfer to the Canadian Government of the naval establishments at Halifax and Esquimalt, but these arrangements cannot be carried into effect without legislative sanction, the naval establishments not being works "held in trust for the defence of the colony." The present Bill proposes to give the necessary legislative sanction to these arrangements, and to any proposals of a similar nature which may be made in the future. The transfer can be made upon such conditions and subject to such reservations as may be specified in the Order in Council, and, consequently, there is full power to make it a condition that the establishments shall be kept in a state of efficiency, and that the right of user for his Majesty's navy should be preserved.

# AEROPLANES AT THE RHEIMS AERONAUTICAL MEETING

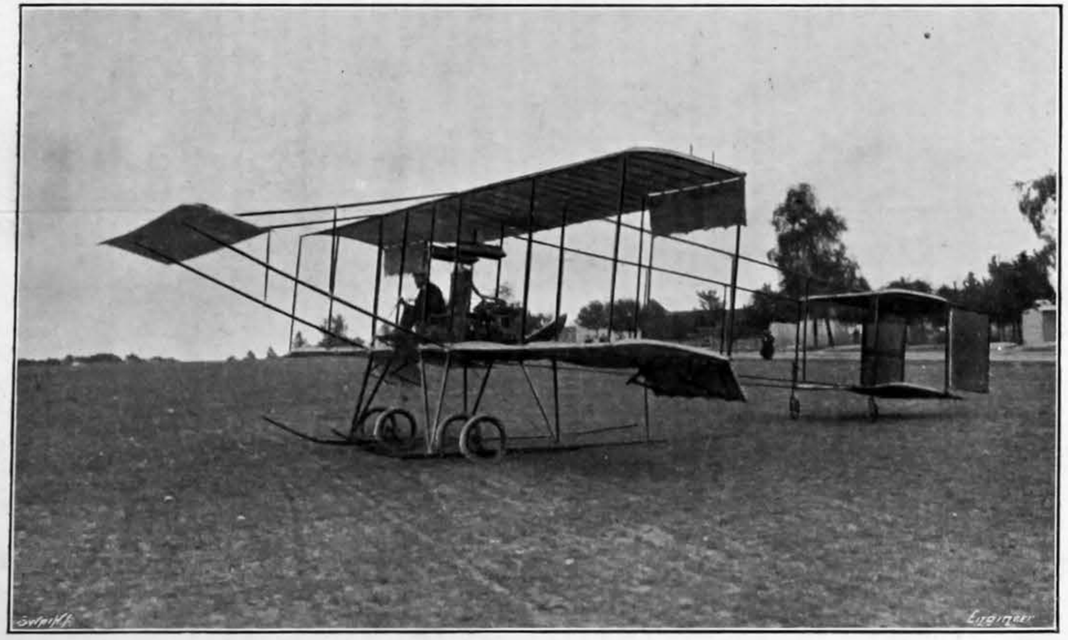
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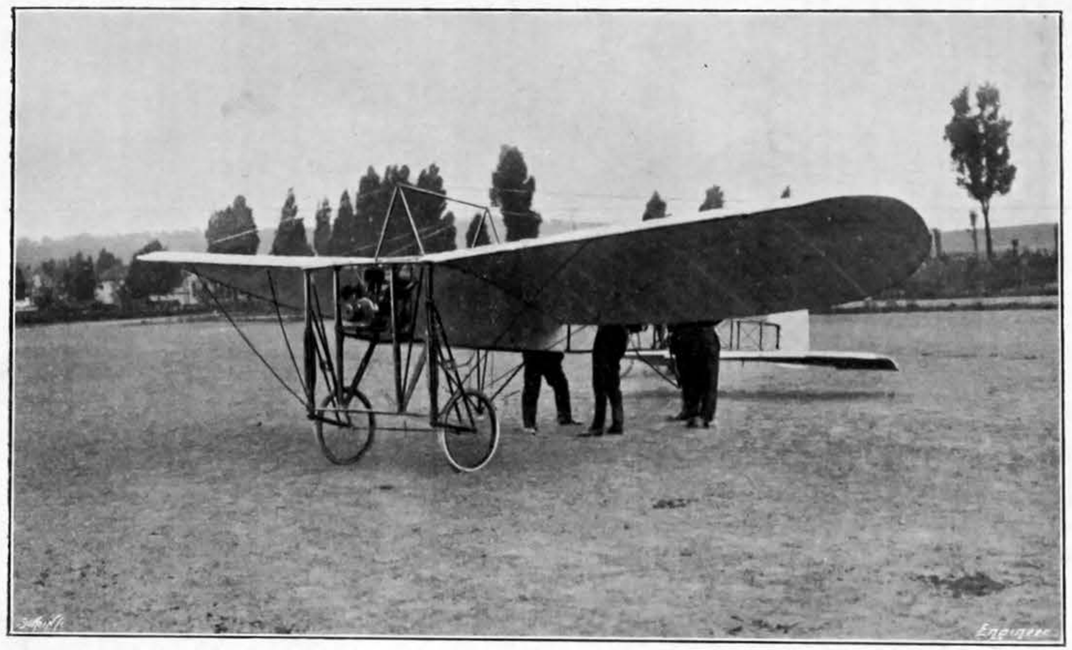
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## TO CORRESPONDENTS.

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# THE ENGINEER.

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### Aeroplane Development in France.

ONE of the reasons for the success of the French in following up new lines of research is probably to be found in the fact that they often allow themselves to be influenced by imagination rather than by the practical aspect of the problems they are trying to solve. In some cases data are so entirely lacking, that it is impossible to reduce the problem to a scientific basis before undertaking a vast amount of experimental work. In other words, the experimenter has to take the materials he has in hand and "worry through" with them until he has evolved his machine in something like a practical form. It was so in the case of the motor car, which at first was so crude as to excite the ridicule of everyone not possessing the saving grace of imagination. Apparently the same influence is at work in the evolution of the aeroplane, which is arousing so much interest on the other side of the Channel. The meeting at Rheims this week is a case in point. Capital to an almost unlimited extent has been raised to make this ancient city a centre of the aeronautical movement, and while, of course, the science of aeronautics would not be given this support unless there was some hope of corresponding business advantages, it must be admitted that the risks of failure are so great as to make this expenditure something more than an investment. Many towns and centres are trying to identify themselves in the same way with aeronautics, and are offering encouragement that has probably never been accorded to any other movement.

Seeing that makers of aeroplanes are still working more or less in the dark, it may be interesting to deal briefly with the ideas which are influencing our French friends in evolving a satisfactory type of flying machine. These ideas have always been entirely cpposed to those of the American school, in the sense that speed is considered an essential factor in mechanical flight. By the application of the cellular principle Voisin and other makers, and, to a less extent, the Wrights, have sought to obtain an automatic stability with relatively low engine powers, thereby allowing of the use of more trustworthy engines; but it is to be remarked that, following the example of the Wrights, the French makers of bi-planes have been modifying their apparatus, and rely more upon stability by bending the planes, and are employing higher powered engines. For the moment nothing practical has been done in the way of designing aeroplanes which will preserve their stability when being driven slowly. According to French experimenters, the stability of the aeroplane, in the present state of the art, must depend upon the speed at which it is propelled. However skilful a pilot may be in bending the planes, there is always a danger of air currents turning over apparatus designed upon existing principles unless they are opposed by the speed at which the machine is travelling. It is argued that with a high enough velocity the aeroplane can travel in any winds. Until quite recently the bi-plane had the reputation of being a relatively slow machine. For this reason a special impetus was given to the monoplane, which in France is regarded as essentially a speed apparatus, and during the past few months it has certainly shown to advantage. Nevertheless, the whole question seems to be one of engines and propellers, and in recent trials there has appeared to be little to choose between the two types of apparatus, although it may be assumed that as higher speeds are attained the lower resistance will give an advantage to the monopolane. It is to be hoped that some of these points will be elucidated at the Rheims meeting. Obviously an aeroplane cannot remain stationary in the air and travel at very low speeds; and although interesting experiments have been carried out with machines of the helicopter type, the difficulties in the way of providing sufficient power to raise the apparatus are so great that the principle has been abandoned by experimenters until the science of aviation has made greater headway. Until this system can be developed search will still continue for the aeroplane which will rise from the ground at as obtuse an angle as possible. It cannot become practical so long as it is obliged to run along the ground or be propelled by dropped weights. This necessitates conditions of surface for starting that it is not always easy to find. Some builders of aeroplanes are trying to solve this problem by varying the inclination of the propeller so that the pressure may be directed as much as possible under the planes for lifting. As research is thus confined to the simple type of apparatus, which relies for its sustentation upon gliding as opposed to lifting, the only way of increasing the carrying power of the machine is to increase its speed. The area cannot be enlarged unduly without necessitating much higher power, and with this power the same sustaining force can be obtained with smaller planes at greater speeds. M. Soreau has calculated that with its present surface increased by only 10 per cent. a bi-plane of the Farman type can carry a ton, including, of course, the machinery, when travelling at three times the present speed—that is to say, at from 110 to 125 miles per hour. As, however, the increase of resistance offered to the aeroplane varies as the square of the velocity, there is obviously a critical speed which would prove dangerous to the existing type of apparatus, and to attain the speeds necessary for carrying good loads the aeroplane would need to be of much stronger construction. Besides the design and the assembling of the planes, there is also the question of the motor, which at present offers the greatest difficulty to aeroplane makers. For the moment they have no alternative between an imperfect special type of aeroplane engine and the ordinary petrol motor modified to meet the special conditions. Under the impression that a minimum weight was absolutely essential to success in mechanical flight, builders of special engines with eight or more cylinders have in some cases been cutting the weight so fine as seriously to impair the reliability of the engine. The majority of troubles with aeroplanes arise from this cause. Monoplanes are usually fitted with these specially light engines, and few of them have been able to remain in the air, except under especially favourable conditions, for any great length of time. Experimenters with bi-planes have for the most part returned to the ordinary type of petrol engine, and as this limitation of motive power has necessitated a great deal of attention being given to the efficiency of the propeller, the shortcomings of the motor, in the present stage of aeroplane construction, have not been without their advantages. The performances of bi-plane apparatus fitted with such engines have certainly been more consistent. If speeds of 100 miles an hour and more are to be attained it can only be done with special engines which may be evolved from some of the types now being built, and as all the engine builders in France are now giving attention to specially light and powerful motors for aviation work, there is every reason for hoping that considerable progress will be made in this branch of aeroplane engineering at an early date.

Although there is undoubtedly a future for the aeroplane, it is probable that a considerable time will elapse before it develops into anything like a practical machine. The remarkable performances that have been accomplished from time to time are to be attributed mainly to the patience and courage of the men who have driven the machines. They have waited their opportunities when everything was in their favour, and it is because these opportunities are so rare that there are so few long-distance flights. On the first day of the Rheims meeting only a few succeeded in making flights between the squalls of rain and wind, some of them coming to grief mainly through irregularities of the engine, and it was only when the sun had set, and the wind died down to a perfect calm, that competitors tried their machines one after the other until there were eight apparatus in the air at the same time. On subsequent occasions competitors were more fortunate, but it was a common observation that the aeroplane was still the slave of the wind.

### Higher Mathematics and the Engineer.

As long as the battle for existence rages education will be a subject of undying interest, and we need make no apology for a few comments on part of the address which was delivered on Wednesday last at Winnipeg by the President of the

British Association. Sir J. J. Thomson, as a Cambridge professor, has had unrivalled opportunities of studying the effects of education upon young men of all nationalities, and he is able to speak with authority upon the faults and virtues of our present system. It must, however, be borne in mind that he himself has made the great reputation he enjoys in the fields of pure science, and it is desirable that all who read his words should be reminded that between pure science and ordinary work-a-day engineering a great gulf is fixed, which is only now and again traversed by the more gifted spirits on one side or the other. The pure scientist is rarely interested in the financial aspects of the problems he sets himself to solve; he is frequently independent of time, and he always comes to his task fitted with a peculiar mind—a gift of the gods—and a particular form of training. The work-a-day scientist, be he engineer, electrician, or chemist, has to make a living by the production of articles directly useful to man or by the prosecution of routine humdrum essential work. He is interested deeply and intimately in all the very things that the pure scientist cares nothing about. To him the financial value of his work is of far greater interest than its scientific value, and science is very truly and accurately his handmaid rather than his goddess. Whereas the pure scientist finds beatitude in her presence alone, the working scientist bustles her hither and thither with very little respect, and the only assistance he asks from her is that she will show him the means of making more money out of his engine, dynamo, waterworks, or what not. Both men have their sphere of usefulness, and it ill becomes either to reproach the other with shortcomings. But it is wholly impossible for the two ever to effect a complete amalgamation in a single brain, and we are convinced that as a whole better work is done by the two acting in complementary capacities to each other than by attempting such a union.

Sir J. J. Thomson speaks throughout the address which we are considering of physics, but he nowhere tells us what he wishes to imply by the term. In many schools and colleges physics mean sound, light, and heat, but we are certain that the President of the British Association takes a far wider view. Apart from the fact that he would of necessity include all those theories on the constitution of matter which are collected under the head of the new physics, he, no doubt, will permit us to number the practical applications of heat and the strength of materials upon which nearly the whole progress of the modern world rests. If we are right in regarding his use of the word in this light, then many of his observations apply as directly to the engineer as they do to the pure scientist, and whilst we can only commend many of them—as, for example, his remarks on the dangers of specialisation at an early age, and the disadvantages of scholarships, to the attention of our readers as the opinions of a man who has had unsurpassed opportunities of judging—one at least of the others we must be permitted to criticise. Sir J. J. Thomson writes:—"Again the specialisation prevalent in schools often prevents students of science from acquiring sufficient knowledge of mathematics. It is true that most of those who study physics do some mathematics, but I hold that, in general, they do not do enough, and that they are not as efficient physicists as they would be if they had a wider knowledge of that subject. There seems at present a tendency in some quarters to discourage the use of mathematics in physics. Indeed, one might infer, from the statements of some writers in quasi-scientific journals, that ignorance of mathematics is almost a virtue." If we are to take this as a blow directed at the many thousands of engineers who do not consider a very advanced mathematical training necessary to welfare in their profession, then we say that its force depends entirely upon the point of view. For scientific engineering a profound knowledge of mathematics is necessary; for ordinary engineering, and for what Sir J. J. Thomson would no doubt call quasi-scientific engineering advanced mathematics are not only wholly unnecessary, but they are apt to become an actual danger. Nearly all problems in engineering can be solved by the application of a great deal of common sense, plenty of experience, and a few simple mathematical operations. There are very few, if any, problems in practical engineering which do not surrender to the simplest mathematics once the conditions are fully understood. The difficulty is not so much in solving the problem as in stating it clearly, and if there is any aspect of mathematics that needs development in schools and colleges more than another, it is the ability to see precisely what is wanted, to know what is aimed at, and the road by which it is to be attained. Whether that is taught by a study of the higher mathematics or not we leave professors to say. But what "quasi-scientific journals" mean when they say that too much weight is laid upon mathematical knowledge by teachers is that the machinery and apparatus of the higher mathematics are not required in the ordinary affairs of engineers, and that a sound knowledge of precedent, a sound knowledge of physical facts, is much better worth acquiring than an intimate acquaintance with the abstruse properties of conic sections.

Need we, in conclusion, remind the mathematically minded that the problems of practical engineering are as open to them as they are to the rest of the world. They know as much about the steam engine, the gas engine, the dynamo and motor, the machine tool, the screw propeller and flying machine, as the rest of the world knows. Can we then doubt that if revolutions are possible in the construction of such things by the application of advanced mathematics, that such advances would have been made long ago? Mathematics must prove their pre-eminence by works before engineers will be disposed to concede to them the position which has been gained and is still held by the step-by-step progress of the practical man who looks upon mathematics as a handmaid and not as a goddess, and who, recognising the necessity of making something, goes along step by step, blundering, if you will, but getting gradually to his goal. Without mathematics engineering could scarcely continue, and no advances would be made; but look where we will, we see the truth of the fact that in all save a very few cases the progress of invention is due to men who have attacked their problems by the experimental method, and this in spite of the fact that there was a fair field for both parties. That Sir J. J. Thomson is himself not blind to this fact is proved by the following passage in his address: "How great is the supply (of heat) the sun lavishes upon us," he says, "becomes clear when we consider that the heat received by the earth under a high sun and clear sky is equivalent, according to the measurements of Langley, to about 7000 horse-power per acre. Though our engineers have not yet discovered how to utilise this enormous supply of power, they will, I have not the slightest doubt, ultimately succeed in doing so." We are content to leave the subject at that; the mathematician shows us where the power lies, the engineer abstracts it.

### The Strength of Rolled Beams.

IT is a popular fiction that we have nothing to learn concerning that type of rolled beams and girders which is largely employed in buildings, small bridges, and structures of secondary importance. They are freely bought like bricks or lime or boards, without question, save as to price, and loaded without much care as to their fitness for the work they have to do. So long as their general dimensions appear to be suitable, nothing more is asked. They are simply marketable commodities, and the user depends on the reputation of the makers for their quality. Now and again, however, tests are made, and the results are not infrequently anything but reassuring. The rolling of a fairly heavy double-flanged beam is by no means a simple matter, because of the various "draughts" put on the metal in going through the rolls. The edges of the flanges do not run as fast as the central portions, and they must either be dragged through the grooves, or else the central portions must be compressed. The roots of the flanges—that is to say, the places where the central web joins the flanges—tend to be unsound, and initial stresses are no doubt set up which may ultimately do harm.

To overcome difficulties like these the Bethlehem Steel Company, of Pennsylvania, has been turning out I beams with the Grey universal beam mill, for which it is claimed that "in the Grey mill the flanges and web of the beam are formed by the simultaneous operation of independent horizontal and vertical rolls, thus admitting of the effective rolling of the metal in the flanges as well as the web. This renders it possible to produce wider flanges than by beam mills of the ordinary type, in which the linear speed of rolling at different points of the beam varies inversely with the distance from the centre of the roll, resulting in a dragging action upon the flange metal, which becomes emphasised with increasing flange width." It is further claimed that in beams of "standard" section the webs are too thick for economy, but that they cannot be made thinner in the ordinary mill. This does not include all the points in favour of the product of the Grey mill, but it is unnecessary to specify them particularly, because they do not appear to possess the advantages claimed for them. Mr. Marburg, professor of civil engineering in the University of Pennsylvania, has carried out a laboratory inquiry intended to settle the comparative values of the Grey beams and the standard beams. The results were unexpected. It is asserted for the Grey beams (1) that the material in the flanges receives more work in rolling, and is, therefore, of better quality; (2) that the material throughout the section is more nearly uniform in quality; (3) that the beams are comparatively free from internal stresses. The tests are far from establishing the validity of these claims. For the sake of comparison, standard section beams were tested at the same time, and it was found that these also did not come up to the nominal excellence attributed to them. The *Engineering News* is not unnaturally disconcerted, seeing how largely I beams are used in the construction of "skyscrapers." Our contemporary says:—"No doubt most of us have always had a silent conviction that an I beam would develop practically the full strength of its material, *i.e.*, would not fail until its extreme fibres were stressed approximately as high as the ultimate strength of the steel composing the beam. In this connection we have been inclined to think vaguely of something like 55,000 lb. to 62,000 lb. per square inch, and to credit our beams, when stressed to a 16,000 lb. fibre stress, with a safety factor of 3½ to 4. When we see from Professor Marburg's tests, however, that 15in. I beams averaged only 42,600 lb. per square inch in ultimate strength, while 24in. I beams showed only 34,000 lb. per square inch, our tacit assumptions seem gravely over-optimistic, and our safety factor drops to a figure between 2.0 and 2.7!" Why are these beams so defective? Let us see what Professor Marburg has to say on the subject.

It will be remembered that his experiments were mainly intended to settle whether the wide-flanged thin-webbed Grey beam was or was not better than the normal or standard beam made by the Bethlehem Company. A curious fact demonstrated by the inquiry is that while the elastic limit of the standard beam is very constant at about 20,000 lb. per inch for all sections, that of the Grey beams fall off very rapidly, being only 10,800 lb. for girders 30in. deep. The method of failure is instructive. The 15in. Grey girder gave way by the twisting of the web, while the standard failed by the lateral deflection of the top flange. This was the case with all depths and sizes. In the standard beam the initial cause of failure appeared to be the lateral weakness of the top flange in compression. While the flange gave way near the centre of the length of the girder, the vertical position of the web near the ends was well maintained. The failure of the Grey beam was, on the contrary, generally speaking, marked by a sudden and considerable twisting of the web, usually in opposite directions at opposite ends, the beam, as a whole, assuming the shape of a very flat letter S. Taking generally the breaking stress of the beams tested, we find that, according to Professor Marburg, the use of a working stress of 16,000 lb, or 7.14 tons, as usually recommended for buildings, is indefensible. In his judgment, further inquiry is imperatively demanded. His investigations showed that very considerable differences in quality exist in the same section of the beam, depending on the locality. Thus, to cite two or three examples, specimens cut from the web of Grey beams had an elastic limit of 36,800 lb. and a yield point of 42,500 lb. per square inch, while the root of the flange gave 16,300 lb. and 34,400 lb. only. In all the girders tested there were discrepancies of this kind. Nothing was done in the way of reheating to get rid of initial stresses. The low elastic limit of the metal near the roots of the flanges is very peculiar. Its cause has yet to be ascertained.

So far as can be seen, the Grey theory of rolling is unsound, rather better results being got with the standard mill. It must not be forgotten that the number of tests made was small, but the girders may be regarded as quite representative. There have been some serious accidents in the United States, tall buildings collapsing in whole or in part. Possibly an exaggerated estimate of the strength of beams may have been a contributing cause. We do not suppose the inquiry will cease at this point. No doubt the Pennsylvania Steel Company will fall in with Professor Marburg's suggestion that an extended inquiry should be carried out to throw more light on:—The low elastic limit of the metal near the root of the flange; its cause and prevention. The low elastic limits in bending for the deeper beams; their cause and prevention, unless it can be proved conclusively that the values obtained in the present series are abnormal. The effect, both

on the elastic limit in bending and modulus of rupture, of variations in the supports and lateral restraint at the ends and intermediate points. Extended tests should be carried out to settle the crippling strength of thin webs. An experimental inquiry is desirable relative to the existence and magnitude of internal stresses, and how these are affected by different methods of rolling, finishing-temperature, &c.

It is a long time since anything like a complete inquiry into the strength of rolled steel beams has been carried out in this country. A reference to text-books will show that investigation has been mainly confined to iron beams. Various individual and special tests have been and are being made, no doubt; but these are very far from covering the whole ground. They have been for the most part made with ship's beams, bulb, and angle steels. It goes without saying that British standard sections are the result of experiments, and yet it is possible that these experiments may not be in any way conclusive. It is not, we think, quite fair to take it for granted that the girders turned out by the Bethlehem mills are strictly exceptional.

### The Stream Line Theory and Collisions at Sea.

THERE would at first appear to be very little connection, if any, between stream lines and collisions, but a curious and exceptional paper is in front of us, which shows that under certain conditions the nature of the reactions on moving vessels in close proximity may make it much more difficult to avoid a collision than one would suppose. The paper is called "Some Model Experiments on Suction of Vessels," and its author is Naval Constructor D. W. Taylor of the United States Navy, who is well known for his work in connection with the resistance of ships and researches in the screw propeller problem.

The paper gives the result of some investigations made at the experimental tank on the mutual reactions on models of vessels moving side by side at different distances apart and when passing one another, and as it is a subject which has hitherto received little attention, the paper is of considerable interest. The models were all 20ft. in length, and from the other dimensions given would appear to be of battleship proportions. The speed at which they were timed was from 2 to 3 knots, and the corresponding speed for a vessel 490ft. in length would therefore be $9\frac{3}{4}$ to $14\frac{1}{2}$ knots. The models had a displacement "in fresh water"—but why drag in the fresh water?—of 3000 lb., so that the displacement of the full-sized ship of the above length would be about 19,000 tons. In the general result it was found that the mutual action between the models varied with the speed, as the resistance of the models and the forces measured are indicated on the diagrams in terms of the resistance. The forces were measured at points near the bow and stern, and it is stated that the results cannot be regarded as highly accurate, owing to the difficulty in towing the models exactly straight, but they show the general tendency very clearly. When towed abreast about one-fifth the length of the models apart, representing about 33 yards in our full-sized ship, there is an attraction between the two varying from 1·2 times the resistance at the bow to 2·2 times at the stern. As one would suppose, this attraction reduces rapidly as the distance between the vessels is increased. At one quarter the length apart, say 40 yards, for the full sized ship, the attraction diminishes to two-thirds the resistance at the bow to a force equal to the resistance at the stern, and so on, until when the distance has increased to half the length of the vessel or more, the suction has almost entirely disappeared. When one vessel is overtaking another there is a change in the direction and magnitude of the forces, beginning with a repulsion which is greater at the stern than at the bow of the overtaking vessel. When the bow of the overtaking vessel is abreast of the overtaken, the force at the bow changes to one of attraction, but the repulsion at the stern has increased in magnitude. From this point onward the attraction at the bow increases rapidly, while the repulsion at the stern diminishes rapidly, and eventually changes again, so that both forces at bow and stern become attractive. This continues until the vessels are abreast, after which the forces undergo changes in reverse order as the overtaking vessel passes the overtaken. It is pointed out that the existence of these forces makes the avoidance of collisions difficult after certain positions have been reached. There is a strong course acting on the overtaking ship tending to swing its bow in towards the overtaken ship which it would be probably impossible to counteract entirely by putting the helms over, and it is also pointed out that the magnitude of the forces would also be greater in shallow water, such as in the fairway of a river, where these conditions are of practical importance owing to the nearness with which it is often necessary for vessels to pass one another. The general results could have been predicted from the application of the stream line theory, although it would not be possible to evaluate the magnitude of the forces. We know that if the particles in a stream line are diverted, there is no resultant pressure so long as the particles return to their original direction with their original velocity, for in that case there is no permanent change of momentum. In the case of two vessels close together abreast, the momentum of the water flowing between them is reduced to a greater extent than that of the water flowing outside them, and the result is a pressure on each tending to force them together. Everybody has probably seen this phenomena exemplified in the tendency of boats to drift together in a tideway. The case of vessels approaching one another in parallel lines is more complex, but the direction of the resilient forces can be seen by drawing the stream lines round the two vessels. The magnitude of the forces appears greater than one would suppose to be the case, and as the figures given in the paper make no great claim to accuracy, the subject may well receive further experimental investigation.

The practical application of the results may not be great. No seaman wants to pass another vessel within a distance less than half the length of his ship if he can possibly avoid it, neither does he require to be told that in a narrow channel in close proximity to other vessels, reduced speed is essential to safety. On the other hand, if the magnitude of the forces are as great as found in these experiments, some light may be thrown on such cases as the Gladiator and St. Paul collision, for the conclusion to be drawn from the results given in Naval Constructor Taylor's paper is that once a certain relative position between two vessels has been reached, it is impossible to avoid a collision unless the way on both vessels is instantly checked.

### Iron Trade Revival.

THE iron trade is reviving. Of that there is no doubt. News of the change comes from all parts of the country. And, better than all, the account of quickened buying from one district is simultaneous with equally satisfactory reports from competing areas. Look where one may, the market information is the same. To say that the intelligence is gratifying is to express only a fraction of the fact. Under any circumstances, prosperity, if only at the start, must be a pleasing substitute for bad trade; but the present revival is doubly welcome because so long delayed. Commencing in the iron manufacturing States of the great Republic across the Atlantic, where the depression had been unrelieved since the panic, now nearly two years ago, it had been a surprise to iron producers in this country that the revival had not earlier affected the works and furnaces, and attention had been strained to catch the first reliable indications of the improvement having reached the Scotch and English iron districts in sufficient volume to warrant sensible recognition. It is in the raw iron trade that, so far, the revival is most pronounced, and, happily, each week is adding to the number of those exchanges where a better state of things is appearing. The Midland market has been the last to be touched, but the reports of the pig iron situation emanating from that part of the kingdom just now are all that could be desired. In common with the West of Scotland and the North of England, prices in the Midlands are steadily moving up, and the hesitancy of masters to book forward as far as buyers would like is speaking evidence of the belief which producers entertain that the improvement will continue. This week news comes of the first kindlings of the revival in the manufactured iron industry. The Scotch malleable iron makers have put on 7s. 6d. a ton on all sections of bars, and the influence of the advance is bound to be felt in the other iron-making districts. Cleveland should be the first to benefit, and probably will be, and next Lancashire and Staffordshire.

## PRUSSIAN RAILWAY ELECTRIFICATION.

AFTER much procrastination, the Prussian Railway Administration has at last decided to take the first decisive step towards the electrification of the main Prussian railway lines, and the 2,000,000 marks required for the equipment of the first trial section were sanctioned by the Prussian Chamber of Deputies last month. The section on which the first trials are to be made is 30 kiloms. long, and extends from Bitterfeld to Dessau. The service is to be so arranged that the steam locomotives which draw the trains over the main lines to Bitterfeld and Dessau are to be changed at these stations for electric locomotives, this form of traction alone being employed to work the trains over the trial section. If the experiment proves a success, the electrification of the main lines extending between Leipzig, Bitterfeld, Magdeburg, and of the branch line from Bitterfeld to Halle will probably soon after be proceeded with.

There are several reasons for saying that the section for these first trials has been most happily chosen. The first is, because other parallel lines exist over which the traffic intended for the electrical line could be diverted in the case of a temporary breakdown on the latter. Secondly, the line is in the interior of the country, which precludes any possibility of the military authorities raising any objections to it from strategical reasons. Thirdly, the line chosen is a section of a main line running to Berlin, so that the electrification could be easily extended right up to the capital. Fourthly, there are large brown coal deposits near Bitterfeld which will provide cheap fuel for the power station.

In the elaboration of the entire scheme, the experience gained by the working of the Hamburg electric railway has been turned to account. The overhead trolley system and the power-house have been so projected as to allow of the electrification scheme being readily extended, and hopes are entertained that the 26,000,000 marks which would be required for the whole extension will eventually be sanctioned by the Chamber of Deputies. At a meeting which was held in the Prussian Ministry of Public Works, and attended by Privy Councillor Wittfeld and a number of distinguished engineers, the principal points in connection with the proposed electric line were fixed. It was decided that although a frequency of 25 periods is being used on the Hamburg city railway, 15 period single-phase current should be adopted on the new line, because it has been found that electric motors for 15 periods last longer than motors built for 25 periods. It was also urged that in America 25 periods had first been tried, and subsequently superseded by 15, this lower frequency having been introduced there by the Westinghouse Company. An objection raised against the application of 15 periods was that this lower frequency entailed a considerably higher expenditure for the central power station. But it was shown, on the other hand, that the losses in transmission were lower with 15 periods than with 25. The tension at which the current is to be transmitted is to be 60,000 volts, and it is thought probable that this tension will be used on all the main lines converted in the future.

As has been mentioned above, the present section is about 30 kiloms. long, and the current will be transmitted to the locomotives through overhead trolley wires. The initial equipment of the power station will consist of a steam turbo-generator, capable of developing 3000 kilowatts, power factor 0.8, 3000 volts, 15 periods, single phase. The turbine will, in accordance with the general practice in vogue in Germany, be of the horizontal type. Two transformers will be installed which will step up from 3000 to 60,000 volts. The transformers will be cooled by oil, which will itself be kept cool by means of water passed through spirally wound pipes immersed in it. It has been found by experience in Hamburg that extremely severe short circuits occur on electric railways, and for this reason special care will be taken to construct all parts of the switchboards, that will have to withstand the effects of these short circuits, as substantially as possible. This refers particularly to the oil switches, and it will be interesting to observe how the various firms will solve the oil switch question.

Since it will be necessary to reconcile the speed of revolution resulting from the given periodicity with the speed at which a favourable steam consumption by the turbine is obtainable, it is to be expected that a two-pole turbo-generator will be decided upon, and that the revolutions per minute will be 900. To develop the necessary power at this speed the generating set will have to be made heavy, and will in consequence be expensive. The steam turbine will be designed for a pressure of admission of 13 atmospheres, in accordance with the general practice in Germany. The exhaust steam will be condensed in surface condensers.

In the specifications recently sent to the various firms which were asked to prepare tenders it is required that the condenser pumps shall be driven by a separate steam turbine. For several months now this method of driving condenser pumps has been gaining favour—more in Germany, perhaps, than anywhere else. Compared with the electrical driving of condenser pumps, it is claimed to have the advantage of being more reliable, for with electrically-driven condenser pumps it has happened that, through heavy short circuits, these pumps have been brought to a standstill, and this has resulted in the stoppage of the whole generating set. Such contingencies need, of course, not be feared with steam-driven pumps. The cooling water for the condensers and the additional boiler feed-water will be drawn by the condenser pumps direct from the river Mulde. The boilers will be erected in a separate building adjoining the engine-house, and will have to be specially arranged for the burning of brown coal fuel. The boilers generally used for brown coal fuel in Germany have pipes which slope more steeply than in ordinary boilers. For electric power stations water-tube boilers only are used, and these will presumably be employed in the present case. Endeavours have been made in Germany lately to introduce a new type of boiler known as the "Garbe" boiler. The results deduced from practical experience of these boilers are not yet sufficient to enable a sound opinion of their merits to be formed; but it is stated that the experience gained with them in small power stations has so far been satisfactory. The space taken up by these new boilers is small, although this advantage is somewhat offset by their requiring a higher boiler-house than ordinary land boilers. Superheaters are to be provided, and economisers will

also be installed. In view of the large quantities of brown coal required for a power station of such magnitude, hand firing will, of course, not be entertained, but mechanical stokers will be employed. The coal will be brought direct from the mine to the power station in railway trucks, and will be conveyed automatically to a bunker arranged above the boiler, whence it will fall through tubular chutes on to the grates.

It is hoped in engineering circles in Germany that the new trial plant described above will turn out a success, in order that the other railway lines, which would then be converted, may provide more work and better times for the electrical industry, which has been suffering severely from the effects of the present depression.



Fig. 1—VIEW SHOWING OPENING OVER CONVEYOR

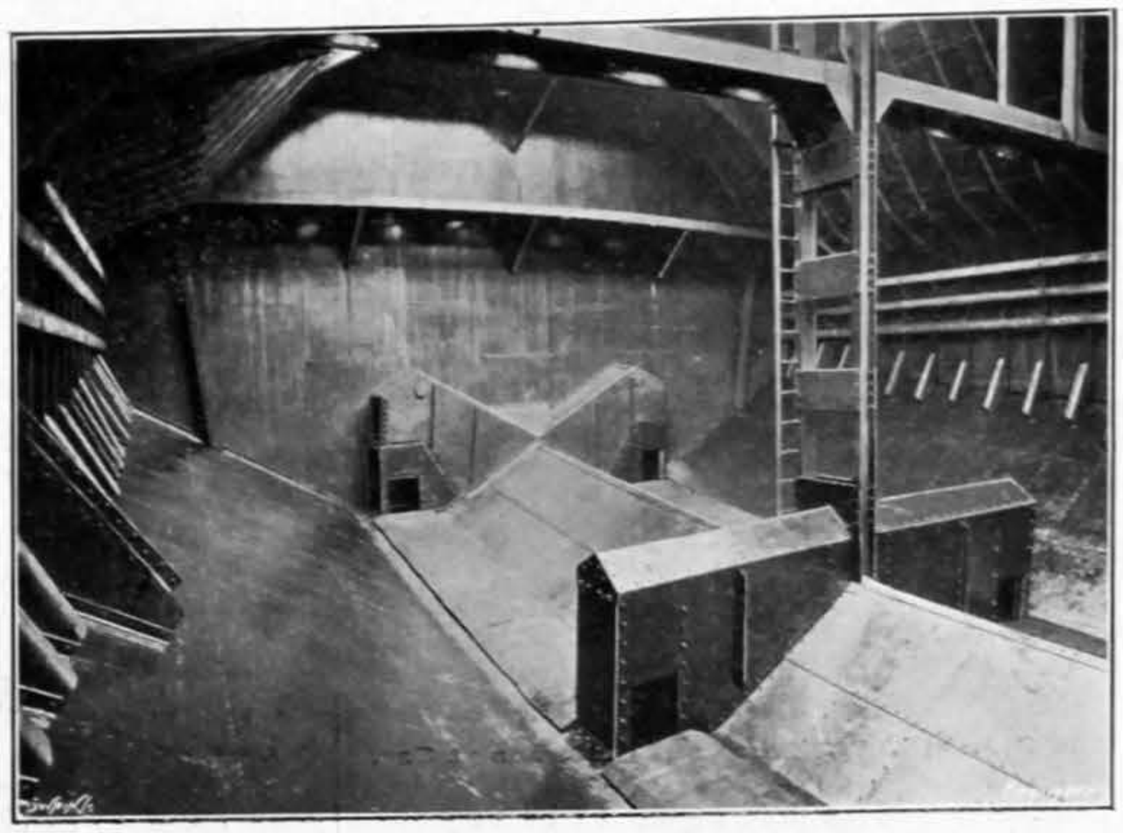


Fig. 2—VERTICAL SLIDE DOORS IN THE HOLDS

## A NEW TYPE OF SELF-DISCHARGING COALING VESSEL.

A NEW system of belt conveyor discharge has recently been patented by William Doxford and Sons, Limited, and adopted in a new vessel—the steamship Pallion—which they have recently built at the Pallion Shipyard, Sunderland, to the order of the Dunrobin Shipping Company, Limited, of Newcastle-upon-Tyne. This vessel has a length between perpendiculars of 270ft.; a breadth, moulded, of 44ft. 6in.; and a depth, moulded, of 23ft. 6in. She is a single deck self-trimming steamer, with large hatches and subdivisions in the hold, and she has a carrying capacity of 3100 tons on a 17ft. 10in. draught. The machinery, comprising triple-expansion engines, 21in., 35in., and 59in. diameter by 39in. stroke, and multitubular boilers of 180 lb. pressure, is placed aft. The cabin accommodation is fitted in the bridge, and the crew space in the forecastle, whilst the navigation accommodation is about amidships. The after hatchways are extended by trunks to the poop deck level, and have been so arranged as to give the vessel a proper trim when loaded with full bunkers, and the usual high coamings are fitted on the poop deck and on the main deck forward.

The bottom of the vessel is constructed on the cellular system for a portion of the breadth, and the inner bottom is raised and sloped upwards in the wings and built into the sides of the vessel, forming a suitable incline for gravitating the cargo to the conveyors, and also giving the vessel the advantage of being about half-loaded when in ballast and bunkers. In the centre line is constructed a slope top fore peak throughout the hold, and between this tunnel and the tunnel—Figs. 4 and 5—extending from the engine space to the raised portions of the double bottom are placed the conveyor belts, of the Robins pattern, one on either side of the vessel. The sides of the tunnel below the level of the hatchways over the belts are open for free access to the belts and carriers at all times. Over these conveyor belts are placed strong iron guide plates extending the full length of the hold and partially covering the belts, leaving a 24in. hatch over a 36in. belt. This space is covered in the holds by cross-laid hatch covers, 9in. in length and 3in. thickness, which support the cargo and leave the conveyors free to work without carrying the load. At the after end of the hold a portion of the hatch, over which the 9in. hatch cover is omitted, is covered by a horizontal iron slide door, operated by a ratchet in the tunnel. On the foreside of the bulkhead is constructed an access chamber in free communication with the tunnel, which is of such a form as partially to protect the slide door from the cargo when loading, and in the floor of this projection of the chamber is fitted a flap hatch to give access to the hold from the tunnel. At the after end of the cargo space the conveyors rise from the horizontal and pass upwards in iron chambers through the machinery space, and thence into the conveyor-driving engine-room, and discharge the load into guide shoots in the stern of the vessel. These carry the load on to return belts, which are extended forward on both sides on the deck. In a simple form these conveyors would terminate at the fore end of the machinery space, or poop front, and the load would be delivered into side shoots which telescope and are adjustable for loading barges on either side of the vessel, the shoots being suspended from derricks or other suitable means. In cases where the discharge is required at a higher level than is attained at the poop front and a large range of elevation is necessary, as, for instance, for delivery on high quays into trucks and into barges alongside, the conveyors are carried forward and hinged at the poop front, and the delivery end is suspended by suitable tackle from twin masts or framework, and is raised or lowered according to circumstances, delivering the load into telescopic shoots suspended therefrom. When the delivery is into trucks, the "offside" belt delivers amidships into a cross conveyor suspended on the masts, which carries the load to the shore side and delivers by shoots into the trucks. A development of this principle has, however, been applied to the steamship Pallion, as, in order to obviate the use of delivery shoots,

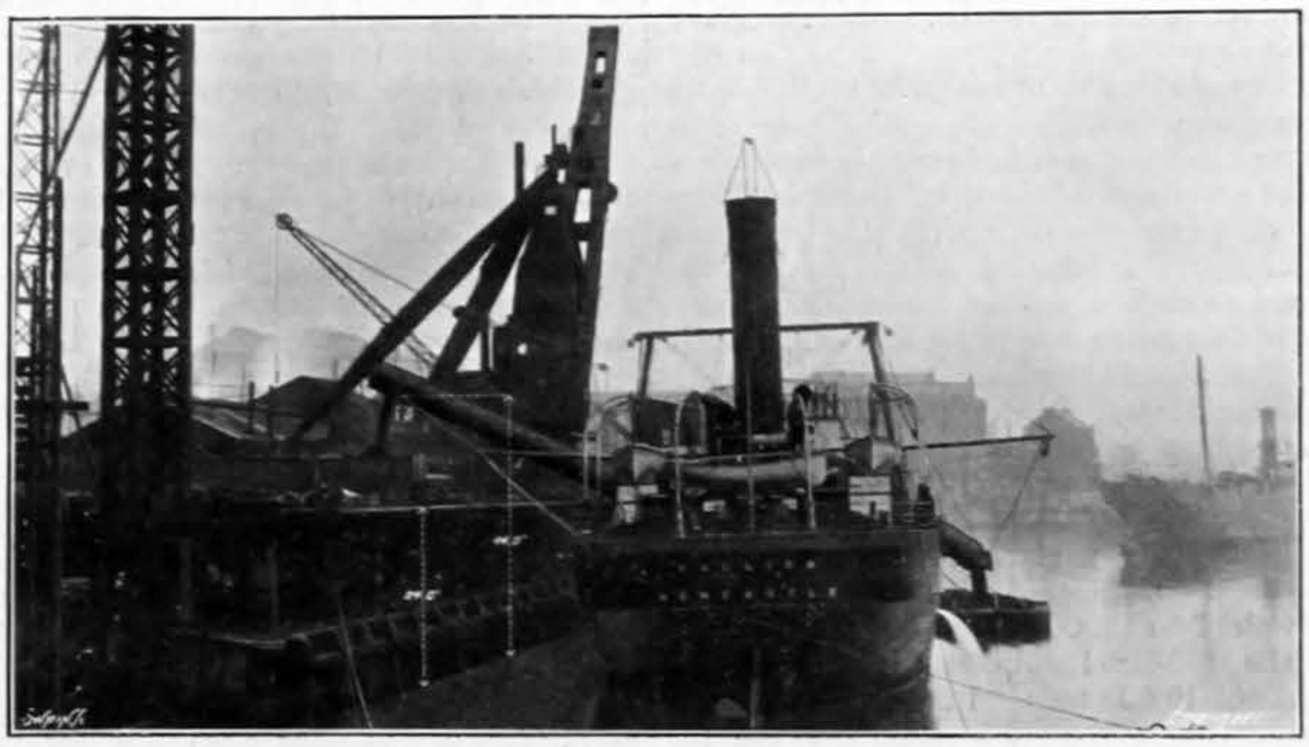


Fig. 3—SIMULTANEOUS DISCHARGE OF COAL INTO TRUCK AND LIGHTER

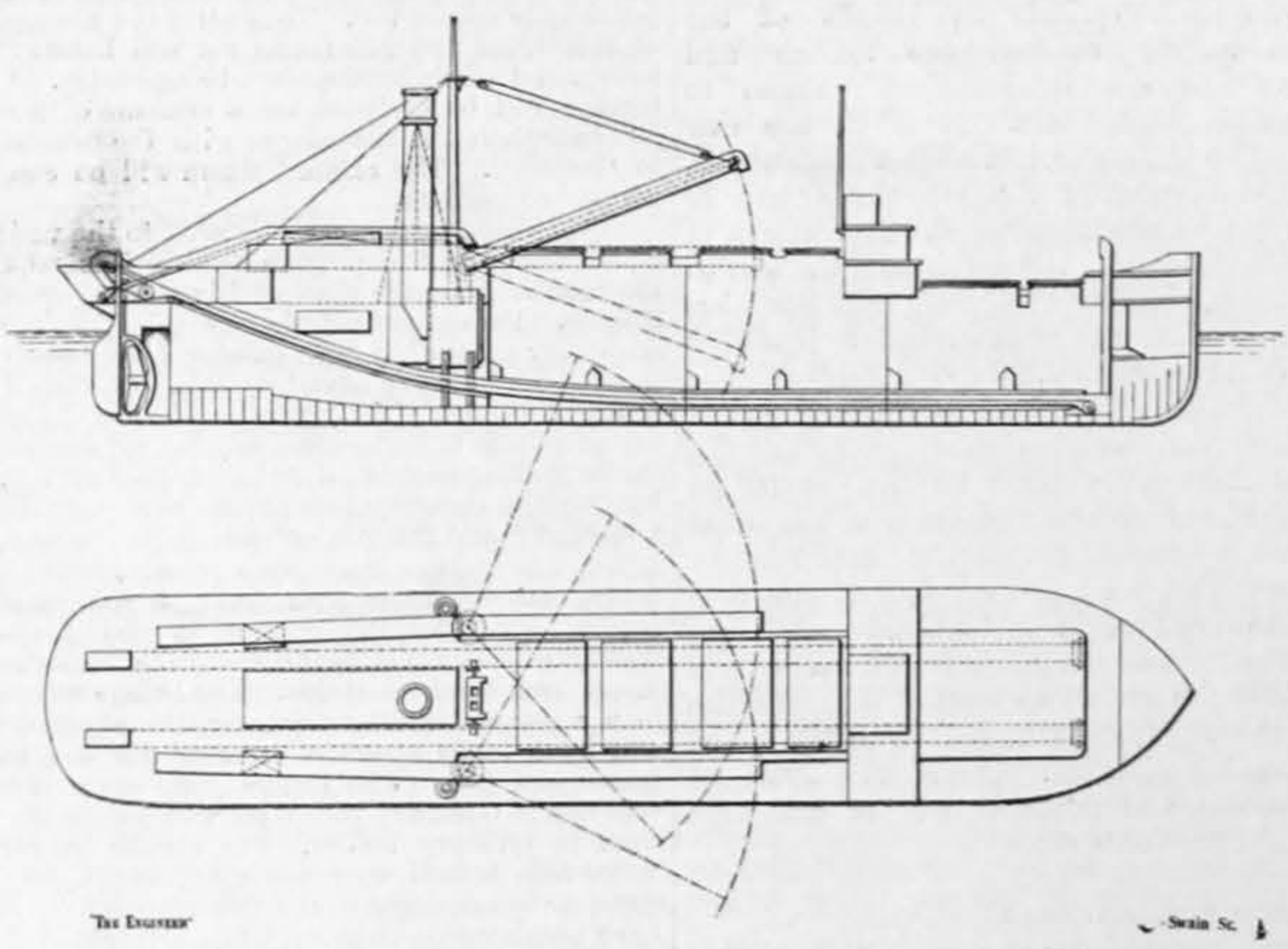


Fig. 4—LONGITUDINAL SECTION AND PLAN OF THE PALLION

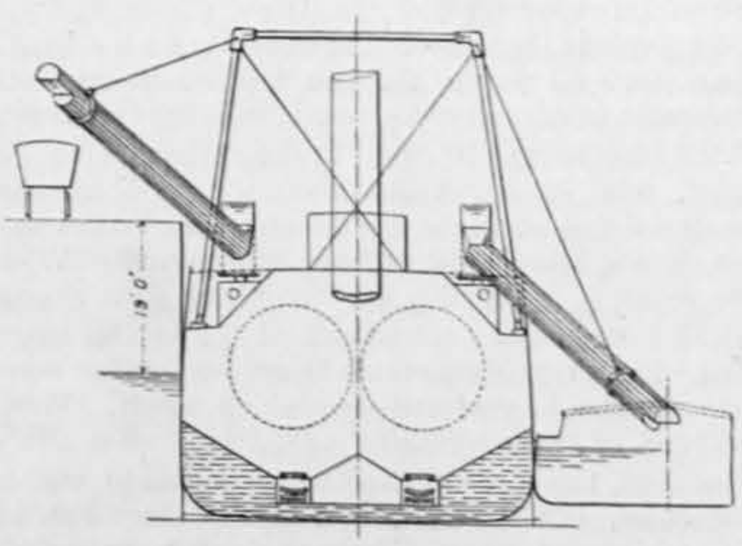
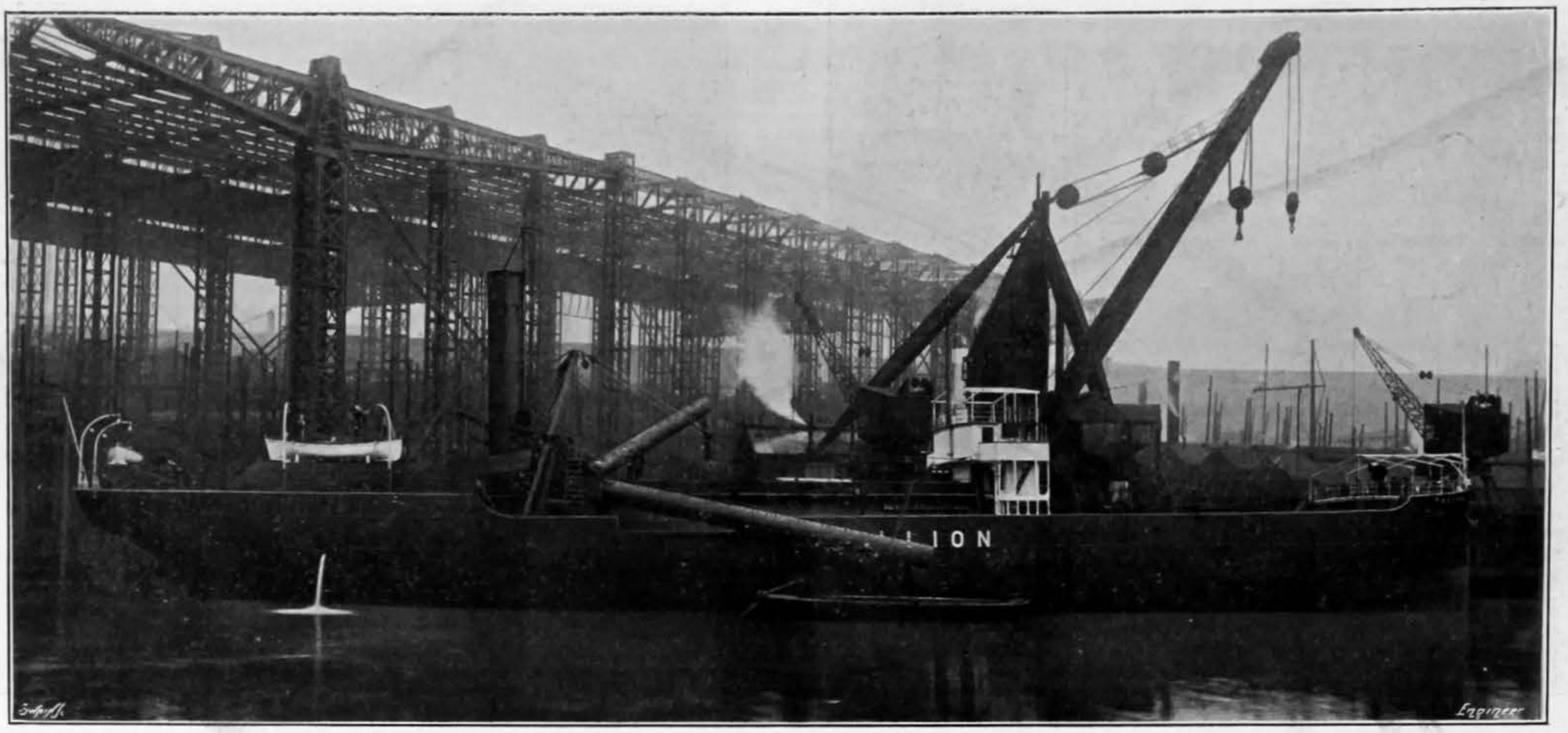


Fig. 5—CROSS SECTION OF THE PALLION

which result in considerable damage, the terminal conveyors are carried in swivel booms, which are raised or lowered and swung overboard to the points of delivery, thus permitting of the cargo being conveyed direct to the truck or barge without shoots. These booms may also be swung across to the reverse side of the vessel, so that both booms can deliver simultaneously into trucks or warehouse—Figs. 3 and 4. Another important feature of this discharging arrangement lies in the method of delivering the cargo on to the belts from the hold, and enabling the operator to have full control and free access at all times to the conveyors and to the face of the cargo. He may thus superintend and direct the continuous flow, and be in a position promptly to correct any tendency of the cargo to bridge or to choke the aperture leading to the belt, which

# THE SELF-DISCHARGING COALING VESSEL PALLION

WILLIAM DOXFORD AND SONS, LIMITED, SUNDERLAND, BUILDERS



being the smallest space the load has to pass through, ensures a continuous and uninterrupted delivery.

For unloading a coal cargo the following is the *modus operandi*:—Presumably the holds are full and the cargo lying solid, except under the overhang of the chamber on the bulkhead over the slide door, at which point the space is naturally only partially filled. The slide door in the covers over the conveyors, Fig. 1, is drawn back by the operator in the tunnel, and the loose coal over it immediately travels on to the conveyors, which may or may not have been started. If running, then the flow continues; if standing, no difficulty arises because the conveyor is only filled at that point, and the aperture becomes blocked and only clears and flows when the belt is started. Then, if no "bridging" occurs, the after part of the hold is rapidly emptied on to the conveyor which is carrying it on deck and into the receiving trucks or barges. If, however, any "bridging" is threatened, the operator in the tunnel ascends to the chamber, and has free access over the aperture to correct any block. If bridging occurs higher in the hold, then he breaks it by means of a pinch bar through prick-holes in the chamber sides. When the after end of the cargo has run to its natural angle of repose, the operator now in the hold merely removes the first cover and places it aft of the aperture, allowing another portion of cargo to run, he being in a free position to maintain the run and correct any tendency to bridging and to abnormal rushes. If such do occur and incline to block the aperture, he again corrects this, and, having run so much more, he removes the next segment of cover, and so on, gradually transferring the aperture from the after end to the fore end of the hold. The wing tanks and central tunnel—Figs. 2 and 5—being sloped, the cargo gravitates to the aperture, and the finals are manipulated by the operator, one man being on each side of the hold.

An important feature is the inclined shoot, over which all the cargo passes on to the belt. This shoot is carried on travellers on the guide plate sides, and is moved by the operator in the hold forward from stop to stop to correspond with the movement of the aperture, thus allowing two men to manipulate a whole cargo at the rate of 500 tons per hour. The conveyor-driving engines are of the compound surface-condensing type, worked from the main boilers, and are under the direct control of the engineer of the vessel, who has at all times free access to all the gear for oiling, overhauling, or adjustments. The driving engines are connected to the conveyors, so that either can be run independently or simultaneously, the power arranged being sufficient to deal with a full load on both belts delivering at the rate of 500 tons per hour. Accordingly, it is estimated that in regular working the steamship Pallion will be unloaded in six hours, or, allowing for stoppages in moving barges, &c., seven to eight hours, and this, too, with but one stoker, one engineer, two labourers in the hold, and two adjusting the shoots or booms into the craft. The gear, being placed quite independent of the cargo, is free to run empty, and all may be made ready and waiting for a start before the vessel is moored and the barges in position. This alone will save considerable time as compared with the work of rigging derricks, platforms, and the handling of baskets, &c.

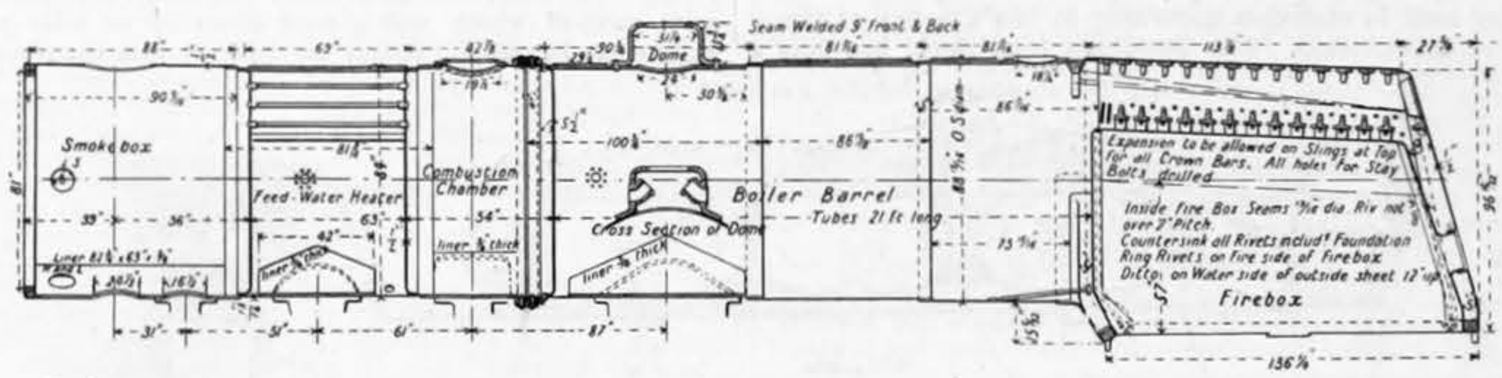
The total cost of discharging the cargo of the Pallion will not exceed £12, including the upkeep of the gear; and it is affirmed that the cost of discharging a similar cargo at, for instance, the port of Hamburg, is about £112, and that in the work no fewer than 110 men are employed for about eleven hours under favourable conditions. The Pallion has 1300 tons of water ballast carried in her double bottom and wing tanks, and the pumps are capable of discharging 300 tons per hour. There is a complete system of signal bells fitted throughout the tunnel at the various discharge doors, which enables the officer on deck to control the supply on either or both sides of the vessel. The vessel is fitted with an electric installation by the Sunderland Forge and Engineering Company, Limited. She is classed with the British Corporation Registry, Glasgow, and was built under the superintendence of Mr. G. Milne, of North Shields.

The advantages claimed by the inventors for this type of vessel would appear to be various. Harbour authorities will, it is urged, appreciate the accelerated despatch, as busy ports will be able to deal with a much larger import in a given area, and this will form an important factor as against the consideration of the probable increase of the harbour accommodation and facilities. Barge owners, again, will recognise the saving of time, and also the fact that the coal is delivered quietly from a reasonable height into the barge instead of being dropped in large grab loads as is frequently done. Coal merchants and consumers will reap an advantage, as there is no great fall, and, consequently, a minimum of breakage or loss of weight.

It should be here noted that the conveyors, whilst passing through the poop, are carried over two of Dennison's automatic weigh baulks, each of which give the actual weight of cargo delivered. The central tunnel in the hold, being under somewhat similar conditions to a mine, is electrically illuminated and fitted with a ventilating fan and upcast ventilator at the fore end, which is of such size as to form an access shaft to and from the deck. The tunnel also has free communication with the machinery space by means of a watertight door. A steamer such as the Pallion, is independent of shore labour, and so may avoid the frequent delays arising from labour troubles. The number of men required is so small, and the time occupied so short, that it would be a simple matter to agree with the crew of the vessel that they receive a fixed extra wage, and the discharge of the cargo become part of their ordinary duty. A liberal estimate of the cost of discharge, under such conditions, would not reach the sum of one penny per ton, and at this cost the cargo is also weighed.

## A COMBINED LOCOMOTIVE BOILER AND FEED-WATER HEATER.

THE immense locomotives of the Mallet duplex compound system for the Southern Pacific Railway were described in THE ENGINEER of May 21st last, and reference was made to the fact that the boiler comprises both a combustion chamber and a feed-water heater. We are now enabled to give above a longitudinal section of this boiler.




LOCOMOTIVE BOILER WITH FEED-WATER HEATER

The boiler has a total length, including fire-box and smoke-box, of 50ft. 3in., and it is 7ft. diameter in the barrel. The fire-box has a flat crown sheet carried by ⊥-shaped crown bars, which are suspended from brackets inside the arched shell of the outer fire-box by means of sling stays. The sides of both the inner and outer fire-box are flat and almost vertical. There are 27 cross-stays, $1\frac{5}{16}$in. in diameter; 987 screw stays, $\frac{7}{8}$in. and 1in. diameter; 298 Tate flexible 1in. stay bolts in the side sheets; 95 Tate stay bolts in the back head; and 44 in the throat. The fire-box is $10\frac{1}{2}$ft. long and $6\frac{1}{2}$ft. wide, with a sloping back head having a single fire door 13in. by 18in. The engine uses oil fuel.

The boiler barrel has first a 21ft. length filled with tubes in the usual way, at the end of which is a $4\frac{1}{2}$ft. length forming a combustion chamber. Beyond this, again, is a length of $5\frac{1}{4}$ft., which forms the feed-water heater. This has tubes duplicating those of the main part of the barrel in size and number. The water is forced continuously into the heater by the injectors, and passes out by a pipe leading to the boiler check or feed valve. Beyond the feed-water heater portion of the boiler is the smoke-box; this is 8ft. long, and contains a superheater consisting of pipe coils against each side of the smoke-box shell.

The steam dome, with connections for outside steam pipes, is at the forward end of the barrel proper, about 3ft. back from the combustion chamber tube plate. A special dome for the safety valves and whistle is placed just forward of the fire-box tube plate. The combustion chamber has a manhole in the top.

Owing to the great length of the boiler it is made with a separable joint for convenience in making repairs. This, as shown, is at the combustion chamber. On the end of each section of the shell at this joint is riveted a heavy forged ring, the face of one being concave in V-shape to receive the convex V-shaped face of the other ring. This makes an annular dovetail. When the sections are put together with the ring joint entered and faired up, horizontal bolts are put through the rings parallel with the axis of the boiler.

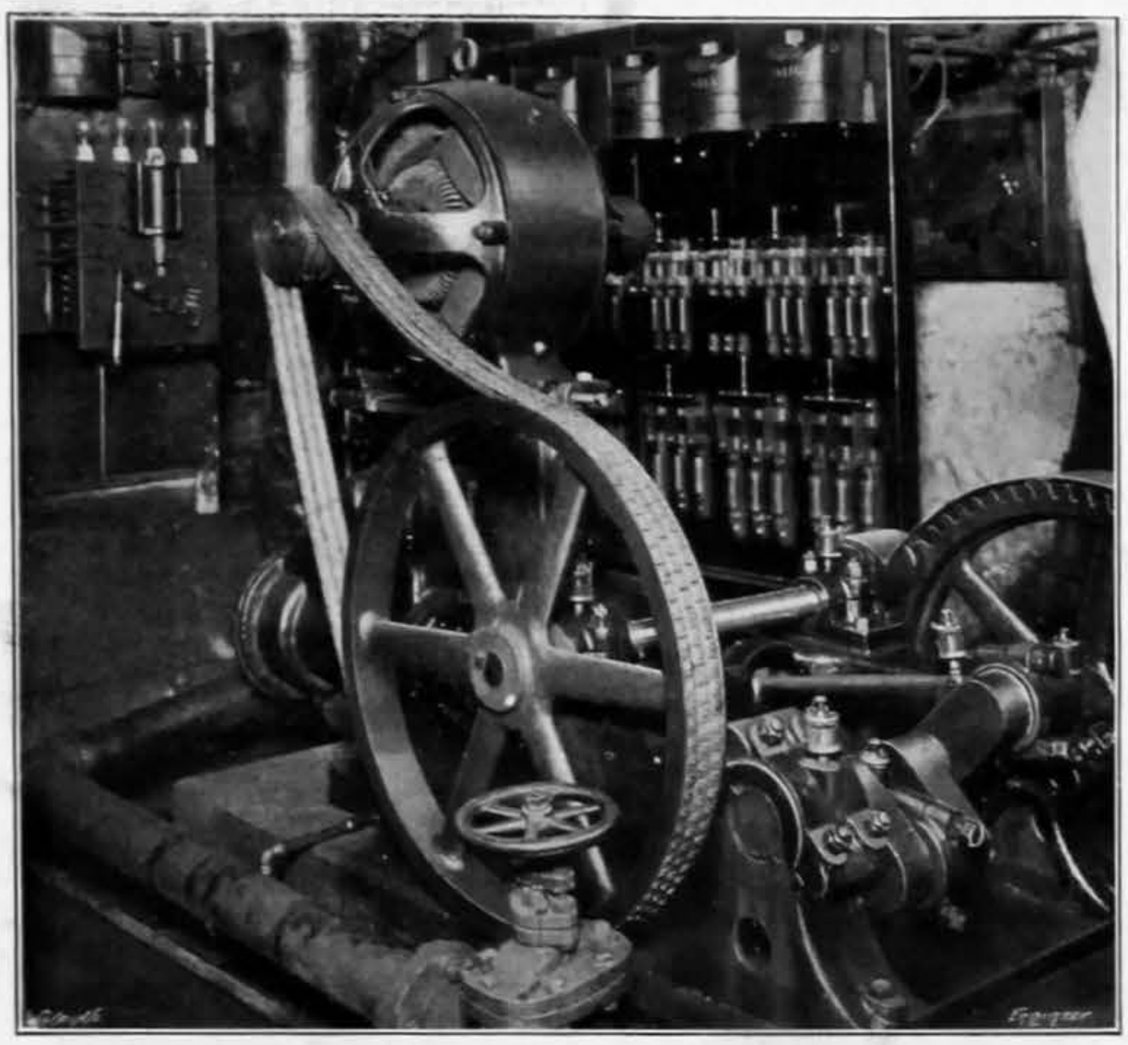
## AMERICAN ENGINEERING NEWS.

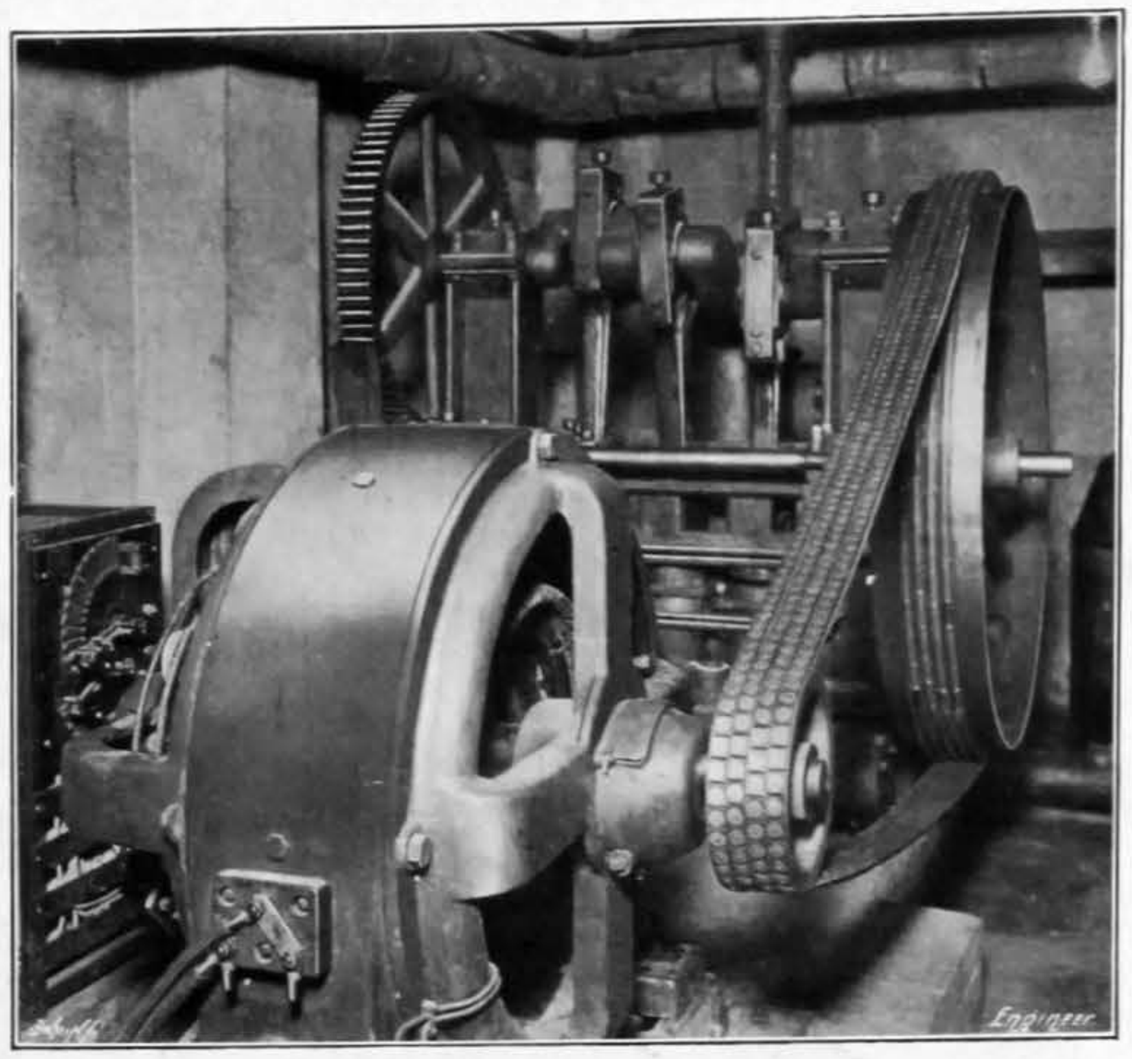
*A waterworks filter plant.*—A large number of American cities are treating their water supply by purification processes, and many others are building plants for this purpose. The city of Evansville, which built waterworks in 1872, is installing a filter plant with a capacity of 12 million gallons per day. The city's population is about 63,000. The water from the Ohio River is pumped to a channel across the ends of three coagulating basins, and fitted with hydraulically-operated gates for each of these basins. Two of the basins are 60ft. by 90ft., and the third is 30ft. by 90ft., the capacities being 1,000,000 gallons for each of the first and 500,000 gallons for the last. Their combined capacity equals five hours' total filtering capacity, but the basins may be operated singly or in combination to give periods of from one to five hours. The coagulants used are lime, iron sulphate, and hypochlorite of lime. From the basins the water is delivered to any of a set of twelve filters, which are concrete tanks, 14ft. by 22ft. At the bottom of each filter is a system of 2in. pipes with slotted-tube strainers tapped in at 6in. intervals. A bed of carefully selected gravel, graded in size, is laid so as to cover the strainers, and above this is a 30in. bed of filter sand. The water from the basins percolates downward through the sand and gravel to the strainers, and enters the pipe system, from which it is led to a clear-water basin having a capacity of 2,000,000 gallons. The rate of filtration of each filter is regulated by means of a controller fitted to the outlet. The filters are washed by an upward current of water or air pumped into the pipe system, the wash water overflowing into a conduit fitted with sand catchers. A building contains the pumping equipment, air compressors, machinery for mixing the chemical solutions, and a laboratory for making daily tests and analyses of the raw and treated water.

*Land reclamation for park purposes.*—The filling-in of low or submerged lands for park purposes is being

# CHAIN-BELTS DRIVING PUMPS

PEERLESS V-BELT COMPANY, CHICAGO, ENGINEERS





carried out in some American cities. At Chicago a large hydraulic dredger is used to pump sand and clay into an area of submerged land enclosed by a masonry wall. At Omaha the Park Commission has recently purchased a hydraulic dredger for pumping sand from the Missouri River in order to reclaim a large area of lowlands. This work will continue for about five years. The dredger is designed to make a cut 100ft. wide and 24ft. deep, and has a capacity of 250 cubic yards per hour. The hull is 70ft. by 25ft., and 7ft. deep, built of Oregon fir. A 12in. centrifugal dredging pump, 7½ft. diameter, directly connected to a marine engine having cylinders 14in. by 14in. and 22in. by 14in., is used. This engine is designed to run at 250 revolutions. Steam is supplied by a boiler of the semi-marine type, 21ft. long and 6ft. diameter, built for a working pressure of 125 lb. The ladder for the cutter and suction pipe is 30ft. long, built of steel, and hinged directly to the hull. Upon the ladder is mounted the engine which drives the 4in. cutter shaft by heavy cast steel gears. The cutters are of cast steel, 3ft. diameter and 3ft. long, built in sections and easily removable. The engines are run condensing, the vacuum being maintained by an independent jet condenser. The dredger is equipped with an electric lighting plant. The discharge pipe line is 12in. diameter and 2000ft. long, 800ft. being designed for floating. For the floating section the pontoons are 112ft. by 5ft., each supported by forty-eight oil barrels. The flexible pipe connections are 12in. diameter, 6ft. long, specially designed to withstand the abrasive effects of the materials dredged.

## A NEW AMERICAN DRIVING BELT.

A NEW American driving belt for power transmission is a belt-chain formed of a combination of steel chain and rawhide belt. The chain transmits the power and eliminates trouble due to stretching. The rawhide forms a sheath or covering for the chain, furnishing the friction surface and giving a noiseless drive. The belt-chain is of V-section, running in grooved pulleys, any sufficient number of belts being used in each case according to the amount of power to be transmitted. The belt-chain runs slack, but gets a good friction hold in the pulleys due to the wedging action in the grooves, for which an angle of 28 deg. is used.

The construction of the chain-belt is shown in the drawing, Fig. 3. Each alternate link of the chain is composed of a pair of bevel-faced plates having holes drilled in the ends, and between them passes a rivet which serves also as a separator to prevent binding. The other connecting links are single plates having gudgeons at each end to fit into the holes in the side plates. A strip of flexible rawhide is secured to the bottom of the chain by the rivets, but the rivets grip it only against projections on the under sides of the plates, so that there is sufficient play between the ends of the links and the rawhide sheath to give proper flexibility and prevent wear, as the chain is bent in running to and from the pulleys. The rawhide is used on account of its high coefficient of friction, and its durability when not subject to tensile stress. This stress, of course, is all taken up by the chain. The strip of rawhide is of sufficient width to bend up against the sides of the chain, thus fitting the grooves of the pulley. On top of each double link is a leather block, having its sides bevelled to fit within the pulley grooves.

The links are of machine steel, drop forged and case hardened. The holes are drilled and the gudgeons turned to a close and true fit. Lubrication is required only at intervals of two or three months. This belt-chain is manufactured by the Peerless V-Belt Company, 219, South Clinton-street, Chicago. It is made in two sizes, 1¼in. and ⅝in. wide.

The engravings—Figs. 1 and 2—show pumps driven from electric motors by these belt-chains. Fig. 1 shows a vertical triple-cylinder pump for boiler feed working against a pressure of 190 lb. It is driven by a 35 horse-power electric motor, with four belt-chains as the means of transmission. The pulleys are spaced 5ft. between centres, and the ratio of their diameters is about 1 to 5. The machine shown in in Fig. 2 is a horizontal duplex pump for the water supply service of an office building, and works against 100 lb. pressure. It is driven from a 15 horse-power motor, and the pulley centres are about 3ft. apart. This pump was originally driven from the motor by gearing, but the arrangement caused so much noise and vibration as to lead to complaints from the tenants. The belt-chain drive was then substituted, using three V-belts, and since then there has been no trouble.

Close spacing of centres is generally necessary in plants of this kind, where a large amount of machinery must be installed in the restricted space of a basement. This close spacing was the cause of trouble with pumps in another office building. A pump of the triplex type serves the passenger lifts and works against a pressure of 900 lb. It is driven from a 50 horse-power electric motor. The pulleys of the pump and motor are spaced 11ft. between centres, and the ratio of the pulley diameters is 1 to 10. Two sets of pulleys are used, and there were originally two 12in. flat belts, each of which was pressed down by an idler pulley equivalent to 230 lb. weight in order to give the necessary contact and friction. In spite of the use of these idlers there was so much slipping that a second pump was required, working intermittently to maintain the hydraulic pressure. Each 12in. belt has been replaced by four belt-chains, the pump fly-wheels being grooved, and grooved pulleys fitted to the motor shaft. These drive the pump without slipping, so that the pressure is maintained and the auxiliary pump has been disconnected. In addition to this, there is a saving of about 6 per cent. in electric power consumption.

The belt-chain has been used extensively for machinery driven from electric motors and gas or petrol engines. The applications include ventilating fans and blowers, pumps, coal conveyors, machine tools, refrigerating machines, air compressors, flour mill rollers, &c.

For the spacing of the driving and driven shafts with the belt-chain transmission it is recommended that the distance should be equal to the sum of the diameters of the pulleys for a ratio of 1 to 2 or 1 to 3 of the pulley diameters, and increasing with the ratio to the diameter of the larger pulley by four times that of the smaller pulley for a ratio of 1 to 10. Under these conditions the ⅝in. belt-chain will need about 200 linear feet of contact per minute to transmit one indicated horse-power on pulleys of 4½in. pitch diameter and over, while the 1¼in. belt-chain will require about 130 linear feet per minute for pulleys of 6in. and upwards. Where the spacing is shorter than that noted, of course the linear feet per horse-power must be increased. The maximum speed for the smaller belt-chain is about 3000 revolutions per minute, and the maximum travel about 6000ft. per minute. For the larger belt the maximum number of revolutions is about 2000 per minute and the maximum travel is about 4000ft. per minute.

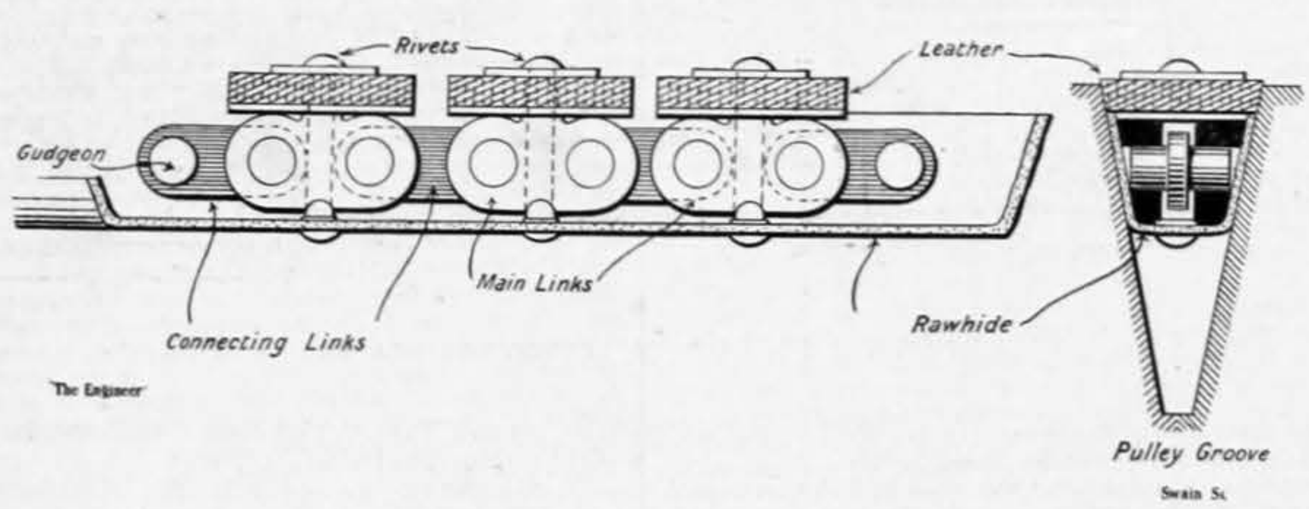



Fig. 3—SECTION OF VEE CHAIN BELT

## LETTERS TO THE EDITOR.

*(We do not hold ourselves responsible for the opinions of our correspondents.)*

### MARINE PROPULSION.

SIR,—In a previous letter I have shown that the conditions of marine propulsion are in one sense extremely simple—that, in a word, the energy expended or work done is measured in foot-pounds by the distance over which the force concerned acts. Thus, in the case of a paddle-wheel, the force exerted on the floats is precisely equal to the force exerted on the plummer blocks or their equivalent, but the force is exerted over a greater distance on the wheel than on the ship. The difference is slip, and is a dead but unavoidable loss. Not one of your correspondents has attempted to controvert the truth of this very obvious proposition.

Incidentally, a 12in. gun has been introduced. Sir George Greenhill, writing about this gun, gave the average gas pressure inside it as 6.25 tons per square inch. The muzzle energy of an 850 lb. projectile being 53,000 foot-tons, and the length of the bore 50ft., I showed in my letter that this must be wrong. Then Sir George writes to admit that I was right, and gives about 9 tons as the correct figure.

In last Friday's ENGINEER I find a letter from Mr. Ramsay, who first finds fault with me for saying that "Our faith in the very foundation of dynamics is shaken," and then proceeds to shake them, at all events for me, by a column of algebraical fireworks, which result in giving a gas pressure of 24 tons in the 12in. gun, and an average pressure of 12 tons. I may say here at once that nothing like 24 tons has ever been recorded in a modern gun, and I do not see how Sir G. Greenhill's figures are to be reconciled with Mr. Ramsay's. As a matter of plain fact all this algebra is entirely unnecessary. It is like using a steam hammer to break a butterfly. Mr. Ramsay has referred me to one book. May I be permitted to refer him to another, D. K. Clark's "Rules, Tables and Memoranda," pages 282-3-4, where he will find fourteen very simple equations dealing with every possible problem connected with force and motion.

But let us apply the simple principle which I have already recalled to the mind of your readers. We have in the case of the 12in. gun a muzzle velocity sufficient to give 53,000 foot-tons of energy to a projectile weighing 850 lb. With this weight we have, however, nothing to do. The velocity does not concern us. We only want to know what the average driving pressure behind the shot must be. That we get at once by dividing 53,000 by the distance over which the force moves I do not know what is the precise length of the chase of the gun; that is to say, of that part through which the projectile travels. I believe the total length of the gun is 51ft. 4in. The cartridge will take up about 8ft., leaving, say, 43ft. for the chase. We divide 53,000 by 43, and, get in round numbers, 1232 tons as the force which, moving over a distance of 43ft., represents 53,000 tons moving over 1ft. The area of a circle 12in. in diameter is 113 square inches, and $\frac{1232}{113} = 10.9$ tons as the average driving pressure, and 21.8 tons as the initial pressure.

Sir George Greenhill has taken the length of the chase as 50ft. The figures then stand $\frac{5300}{50} = 1060$, and $\frac{1060}{113} = 9.38$ tons average pressure. The initial pressure is double this, or 18.75 tons. The

uncertain point is the precise length of the chase. It will be seen that no formulæ or anything beyond the simplest arithmetic is needed to determine, as far as calculation can, the pressures in the gun.

I am met, however, by a difficulty. Lieut. Dawson delivered the Gustave Canet lecture on "The Engineering of Ordnance" at the twenty-fifth anniversary meeting of the Junior Institution of Engineers on the 30th of June last, and in it he gives the maximum pressure in the bore of the 12in. gun as 18 tons. This figure is quite incompatible with a length of chase of 43ft. and a muzzle energy of 53,000 foot-tons. The explanation is, of course, that Sir George Greenhill and Mr. Ramsay are both wrong in assuming the initial pressure to be twice the average pressure. To assume that the average is half the initial is to postulate that there is no pressure at all in the gun at the muzzle, whereas, in point of fact, there is a very high one. I have followed Sir George Greenhill in his methods, and have taken the average as half the initial, but I think the time has come to call attention to the obvious error involved, which has not been discovered by Mr. Ramsay.

The range of pressures is determined by the rate at which the cordite burns, and the maximum is maintained for a considerable distance along the chase. Lieut. Dawson says, "In the old powders almost complete combustion of the explosive took place before the projectile had time to move far down the bore of the gun. High pressures were therefore set up in the chamber, necessitating a massive breech. As the pressure fell off rapidly the gun thinned down considerably toward the muzzle, and was comparatively short. For smokeless powders the guns are more uniform in outline to suit the more uniform distribution of pressure, and they are longer to enable the full effects to be obtained from the comparatively slow-burning explosive." All this may be beside the mark, but it is just as well that the facts should be stated. Mr. Ramsay is again wrong in giving the recoil of the gun as 0.3768ft. I do not know accurately what the recoil of the 12in. gun is, but a gun firing a 660 lb. projectile, and weighing 47 tons, recoils through a distance of 36in. in a quarter of a second with a maximum speed of 22ft. per second; a hydraulic buffer resisting recoil with a force of about 200 tons. The explosion lasts 75 ten thousandths of a second, the muzzle velocity is 2950ft. per second, and the energy in the projectile 47,000 foot-tons.

It is perhaps advisable to say that Mr. Ramsay has not in any way disputed the soundness of my views concerning the action of marine propellers.

FUSE.

August 24th.

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SIR,—If Sir George Greenhill's ruling stands, that the work of action is not equal in all cases to the work of reaction, then it follows logically that work can be done without any action taking place. As:

| | | |
|---|---|---|
| | Action | = Reaction, |
| So | Reaction | = Action; |
| And | Action | = Work, |
| So that | Reaction | = Work − X, |

where X represents an amount of work of action which has no counterpart in reaction.

In other words, according to "T. S. C.," work varies inversely as the masses, and, according to Newton, velocities generated by one force vary inversely as the masses acted on; then Work = Velocity. "T. S. C." knows what Euclid would say to that. As Sir G. Greenhill recommended us to consult "Mach's Mechanics," will you allow me to cite the following from page 198, &c.

"Perhaps the most important achievement of Newton with respect to the principles is the distinct and general formulation of the law of the equality of action and reaction, of pressure and counter-pressure. . . . . A body that presses or pulls another body is, according to Newton, pressed or pulled in exactly the same degree by that other body. Pressure and counter-pressure, force and counter-force, are always equal to each other. As the measure of force is defined by Newton to be the quantity of motion or momentum (mass × velocity) generated in a unit of time, it consequently follows that bodies that act on each other communicate to each other in equal intervals of time equal and opposite quantities of motion (momenta), or receive contrary velocities reciprocally proportional to their masses. . . . We know that we do not experience any resistance from a body until we seek to set it in motion. The more swiftly we endeavour to hurl a heavy stone from us the more our body is forced back by it."

What I maintain about marine propulsion is:—The more swiftly we endeavour to hurl a heavy mass of water from the propeller, paddle, or ship generally, the more the ship is forced the other way (as back is only relative to the other being forward) by it. Is Mach's interpretation of Newton wrong, or is it not possible that the prolific Professor Rankine overlooked the logical connections between his mathematics? The essence of Rankine's theorems amounts to "the pushing aft of a large amount of water without moving it." But, further, Mach:—"Pressure and counter-pressure go hand in hand. . . . There exist in the domain of statics very many instinctive perceptions that involve the equality of pressure and counter-pressure. The trivial experience that one cannot lift one's self by pulling on one's chair is of this character."

The endeavour, according to "Fuse," of a paddle wheel or screw propeller to do 80 per cent. to 90 per cent. of its work on the vessel to which it is rigidly attached, save rotation, is surely of the same character. Again, Mach, page 275:—"Two things, however, are confounded—the question of the measure of force and the question of the constancy of the sums $\Sigma m v$ and $\Sigma m v^2$. The two have in reality nothing to do with each other. With regard to the second question, the later investigations of Newton really proved that for free material systems not acted on by external forces the Cartesian sum $\Sigma m v$ is a constant, and the investigations of Huygens showed that also the sum $\Sigma m v^2$ is a constant, provided work performed by forces does not alter it."

So far Mach. Now Professor H. Hertz:—

Paragraph 511: "When a force acting on a system does a certain amount of work, the counterforce exerted by the system always does an equal and opposite amount of work."

Paragraph 683: "Proposition: An impulse and its counter-impulse are always equal and opposite—*i.e.*, their components along every co-ordinate are equal and opposite, whether we consider these quantities as vector quantities with regard to the one system or with regard to the other system.

"Every impulse which is exerted by or on a material system can be resolved into a series of elementary impulses."

Does this require further elucidation? If, when we choose to describe the result of any action as "work done," reaction does a different amount of work, wherein consists equality of action or reaction?

The difference in work of action and work of reaction can only be brought about by calling velocity work. Whereas work is the overcoming of, or the offering of resistance. These are, according to "T. S. C." my "wrong fallacious" premises, upon which no tenable theory of marine propulsion can be built. Seeing that with my opinions I am now in company with the late Sir W. Anderson, Professor H. Hertz, Dr. Aveling, and, as I imagine, that of Mach, Clerk Maxwell, and even Newton, I can rest content with "T. S. C.'s" denunciation. Does anyone really seriously object to that propeller being called the most efficient which will relative to the ship, with given energy, drive the whole ocean back quickest? My statement of greatest amount at greatest velocity back is really the same thing.

W. PREIDEL.

August 23rd.

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### AMERICAN TRAIN FERRIES, RAILS, AND PERMANENT WAY.

SIR,—In reference to the description of the interesting train-ferry steamer Drottning Victoria in THE ENGINEER of July 30th, it may be of interest to note that while its journey is 65 miles, some of the American train ferries crossing Lake Michigan make journeys of 60 to 100 miles; they have to contend also with heavy storms and ice in the winter. These particular train-ferry steamers have a higher freeboard than the Drottning Victoria, the side plating being carried up to the deck which forms the roof over the train deck. The large boats, with four lines of rails, are 340ft. long, and carry thirty double-bogie goods wagons, averaging 35ft. to 40ft. over couplers. The train-ferry steamers crossing some of the straits connecting the Great Lakes have a low freeboard, the side plating extending only to the train deck, as they have not to encounter the heavy seas of an open stormy lake. One of these boats, with twin screws at each end, has three lines of rails, and can carry twenty-four long goods wagons, or twelve 70ft. passenger carriages. Some details of these American train ferries were given in THE ENGINEER of March 23rd and April 6th, 1906.

In your leader on the treatment of rail steel—also in THE ENGINEER of July 30th—you imply some doubt as to whether ingots are cropped in American rail-making practice. This cropping is universal, but for some years the engineers of the railways have contended that the amount is insufficient. The rail makers have to a great extent held aloof from discussion, and have contented themselves with their arbitrary power of doing as they pleased, the railways—as represented by the officers responsible for purchases—having in the main failed to support the demands of their own engineers for better rails and better rail specifications.

The question of cropping the ingots has been one of the actively fought points in all attempts by American technical societies to formulate standard specifications for rails. The so-called "manufacturers' specifications," adopted and followed by the rail makers, omit all reference to this, taking the position that the railway—or its engineer—needs to know nothing except the chemical and physical properties of the finished rail. The specifications of the American Railway Association require that "there shall be sheared from the end of the bloom formed from the top of the ingot 'sufficient' discard to ensure sound rails." The specifications of the American Railway Engineering and Maintenance of Way Association and those of the American Society of Civil Engineers say that "the shearing shall be not less than 25 per cent.," and shall be continued until the steel shows solid. The specifications of the American Society for Testing Materials leave the percentage blank, to be filled in according to agreement between the railway and the manufacturer. The reason for this is that the higher the percentage of cropping the greater will be the cost of the rails.

There has been vigorous discussion as to whether the specifications should require "sufficient" or a minimum definite percentage of cropping, and the weight of opinion appears to be in favour of the latter. Whatever specifications are adopted on the part of the railway, the great difficulty has been to ensure their observance by the manufacturers. The latter have entrenched themselves in the position that the railways have nothing to do with manufacture but are simply purchasers, and are, in fact, quite incompetent to say how rails should be made. There is no doubt that the manufacturers do know perfectly well how to make good rails, but the trouble is that they do not put their knowledge into practice. If rails break, it is due to some remarkable, mysterious, and quite undiscoverable cause, or else to the fault of the railway in operating heavy locomotives. Of course, some of the "big" railways enforce their own specifications to a greater or less extent, but most of them get their rails on the "take-'em-or-leave-'em" basis.

In your leader you refer to the spacing of sleepers as rail supports, and reduce this to the *reductio ad absurdum* of placing them too close to permit of proper packing of the ballast. But there is too wide a spacing as well too close a spacing, and it should not be so wide as to compel the rail to act as a girder supported on piers. It is very generally considered that the clear spacing should be not less than 10in., although where three closely-spaced sleepers are used under each rail joint, this is sometimes reduced to 5in. A few American railways, in districts where sleepers of varying width are furnished, specify a minimum number of inches of sleeper bearing for the rail, instead of an arbitrary number of sleepers.

For main lines with heavy traffic American railways use sixteen to eighteen sleepers per 30ft. rail, or eighteen to twenty sleepers for the 33ft. rail now in common use. The usual width is 8in., and the thickness 6in., but there is a strong tendency to increase the thickness to 7in. in order to give greater rigidity under modern loads. The 7in. thickness is used by many railways. Mr. Jacomb-Hood, in his paper for the International Railway Congress, suggests the advantages of flange rails over bull-head rails for heavy permanent way. Leaving this out of the question, and assuming the present chair road construction, the use of sleepers 8in. wide, 6in. or 7in. deep, and 8ft. long, spaced sixteen or eighteen to the rail, and well packed in good ballast, appears to offer a promising development in permanent way, and to relieve the rails from some excessive stresses to which they should not be subjected.

The rail is only one part of a permanent way structure, and should be relieved of its load by its supports. It is in the same position as the V's of a planing machine, serving to carry and guide the load, but well supported from beneath by a bed which rests upon the foundation. Apologies for the length of this letter.

Chicago. RAILWAYS.

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### PROPELLERS IN TUBES.

SIR,—My letter which appeared in your issue of June 11th, and to which Mr. Wadagaki takes exception, was not suggested by that gentleman's paper read at Liverpool, but by a letter from one of your correspondents, in which a proposal was made to put turbine propellers in tubes having an area of inlet very much smaller than the area of outlet. The letter referred to was illustrated by a sketch showing the form of tube proposed, and this sketch I reproduced in my letter.

Such a form could not possibly give good results for the reasons I gave.

With a Venturi tube of the form shown by Mr. Wadagaki in his letter in your issue of the 6th inst., in which the area of inlet is slightly larger than the area of outlet and the outside of the tube is made conical, we get a different condition of affairs.

There will be, as he says, an excess pressure on the outside of the tube, having a component in the direction of motion of the vessel, and such a tube would give a considerable thrust so long as it was not itself moving through the water; but I fear that the effect of the surface friction where it does so move would be the same as in the case of the stepped tube tried by Sir John Thornycroft, in which the friction outweighed the gain in propeller thrust.

Mr. Wadagaki is, however, quite justified in saying that this can best be judged by actual experiment. With his remarks on "cavitation," however, I cannot agree at all, and he would seem to have quite a different conception as to what "cavitation" means from that usually accepted. He says, "thus we have what is called 'cavitation,' and known as a serious cause of lost work with the common type of screw propeller, turned into a veritable boon in this system of propulsion."

Now I cannot conceive any circumstances under which "cavitation" can be anything but destructive to efficiency of propulsion.

Mr. Wadagaki objects to my statement that the limiting thrust per unit of area necessary to avoid "cavitation" would still be measured on the area of the propeller itself and not on the area of the discharge end of the tube, because, he says, the thrust on the propeller itself is not the total thrust in this particular system of propulsion, but only about two-thirds of it, and that therefore I am not justified in measuring its intensity by the area of the propeller alone. Now it must be remembered that with a tube shaped in the manner I was criticising, that is, with the largest area at the after end, the tube was actually pulling against the propeller and giving a negative thrust. With a tube of Mr. Wadagaki's form, I have already stated that the thrust shown by experiments made with the whole apparatus stationary is likely to disappear when the system is in motion; but if we admit that some effective thrust will be given by the tube, then undoubtedly the thrust to be measured on the propeller is less than the whole thrust, but the reduction in hydrostatic head at the neck of the tube where the propeller is situated causes "cavitation" to commence at a lower pressure per square inch of blade surface than if the tube were not there, and the result is the same. In fact, it is analogous to the case of a propeller working in a tunnel, the crown of which rises above the surface of the water. The limiting thrust to avoid "cavitation" is then reduced in proportion to the height to which the water is lifted in the tunnel, and, similarly, the limiting thrust which can be usefully applied per unit of blade surface of a propeller in the neck of a Venturi tube is reduced in proportion to the reduction of water pressure there.

Since writing my last letter I have read the article in your contemporary *Engineering* of April 30th, 1909, on Mr. Wadagaki's Newcastle paper, and I must say I am in complete agreement with the writer, who sums up by saying, "If the increased velocity at the neck of the tube could be obtained without reduction of hydrostatic head there would be something to be said for the idea but even then the energy would have to come from somewhere and to be paid for in some way or other. As we have already said, the idea is founded on a fallacy, though it is a very persistent one."

Southampton, August 17th. S. W. BARNABY.

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### LOCOMOTIVE CRANK AXLES.

SIR,—In the discussions at the recent meetings of the Institution of Mechanical Engineers at Liverpool, Mr. T. Hurry Riches suggested that results obtained from marine engines might be applied to locomotive work.

I am permitted to state that the Newburn Steel Works has supplied to several railway companies during the last five years a considerable number of built-up steel crank axles, some of which were designed to suit special requirements. Calculating these according to my communication in your issue of June 18th, page 637, on "The Diameter and Length of Bosses," to the formula (1),

$$\frac{D^4 - \delta^4}{D} = \frac{\delta^4}{l} \times \text{coefficient.}$$

Where D = outside diameter of boss;
$\delta$ = diameter of shaft in journal;
$l$ = length of boss;

the resulting coefficients for these built-up crank axles range from 4.5, 4.8, 5.5 to 6.3. Since the coefficient 4.2 represents the average proportions prevailing among the webs of built-up steel marine crank shafts, where the thickness of the web generally is = .66 $\delta$, the above resulting coefficients for built-up locomotive crank axles compare very satisfactorily, considering that the thickness of their webs is occasionally as low as .43 $\delta$ and .45 $\delta$, necessitating also an increased percentage of allowance for shrinkage.

I trust that these figures may be of interest to you, and to some who are taking advantage of the special benefit offered by built-up locomotive crank axles.

August 23rd. R. A. LEWIS, Newburn Steel Works.

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### BRITISH LOCOMOTIVE PRACTICE OF TO-DAY.

SIR,—The article published in your last week's issue on "Simple *v.* Compound: A Footplate Experience," is very interesting, but somewhat misleading. Your contributor says he has been careful to obtain accurate figures, and I do not for one moment doubt their accuracy. However, any educated engineer will agree with me when I say that the tests cited by your contributor are by no means conclusive. It must be borne in mind that the compound had an advantage over the simple engine of no less than 40 lb. per square inch in steam pressure, besides the advantage of a larger fire-box. The value of the trials would have been enhanced if one of the newest simple 4-4-0 engines- 999 class—had been selected. These engines, I believe, have boilers similar in all respects to those of the compounds. As a practical engineer, however, I contend that if locomotive trials are to be of any real value the engines to be tested must be on an absolute equality. Boilers should be of the same size and type, and worked at the same pressure. The engine wheels should be identical both as regards disposition and diameter. The cylinders also should be equal in number. Mr. Deeley would probably think it not worth while to alter one of his existing compounds into a three-cylinder simple engine; but it is interesting to note that Mr. J. G. Robinson has so altered one of his 4-4-2 express engines on the Great Central Railway, with, I understand, distinctly favourable results. Only under the above conditions can any test be considered satisfactory.

Birmingham, August 21st. CHAS W. DAUNCEY.

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### SAND IN CONCRETE.

SIR,—With reference to your article in this week's issue of THE ENGINEER on the above subject, seventeen or eighteen years ago I had occasion to make a number of experiments on the strength of concrete beams and arch ribs, the results of which were communicated to the Institution of Civil Engineers, and were published in the "Proceedings," vols. cxiii. and cxviii. The conclusions I then arrived at were:—(1) That a very small admixture of clay had a most detrimental effect, as it appeared to prevent the cement from adhering to the sand at all; (2) that pit sand was inferior to sand made by crushing sandstone; but (3) that the best results were obtained from an admixture of crushed sandstone and whinstone dust from the stone breakers, the last providing the greatest variety of size of grain, and therefore forming the denser mortar. I have in the course of my experience been occasionally unable to obtain sand free from dust, and no harm has apparently resulted from its use; but it has been dust of a gritty nature, not clay. Where dirt has a distinctly deleterious effect is where it envelops the particles of sand in a soapy film. In my opinion dirty sand should always be regarded with suspicion, and if circumstances render it impossible to wash it, it should certainly not be used without being first tested with cement.

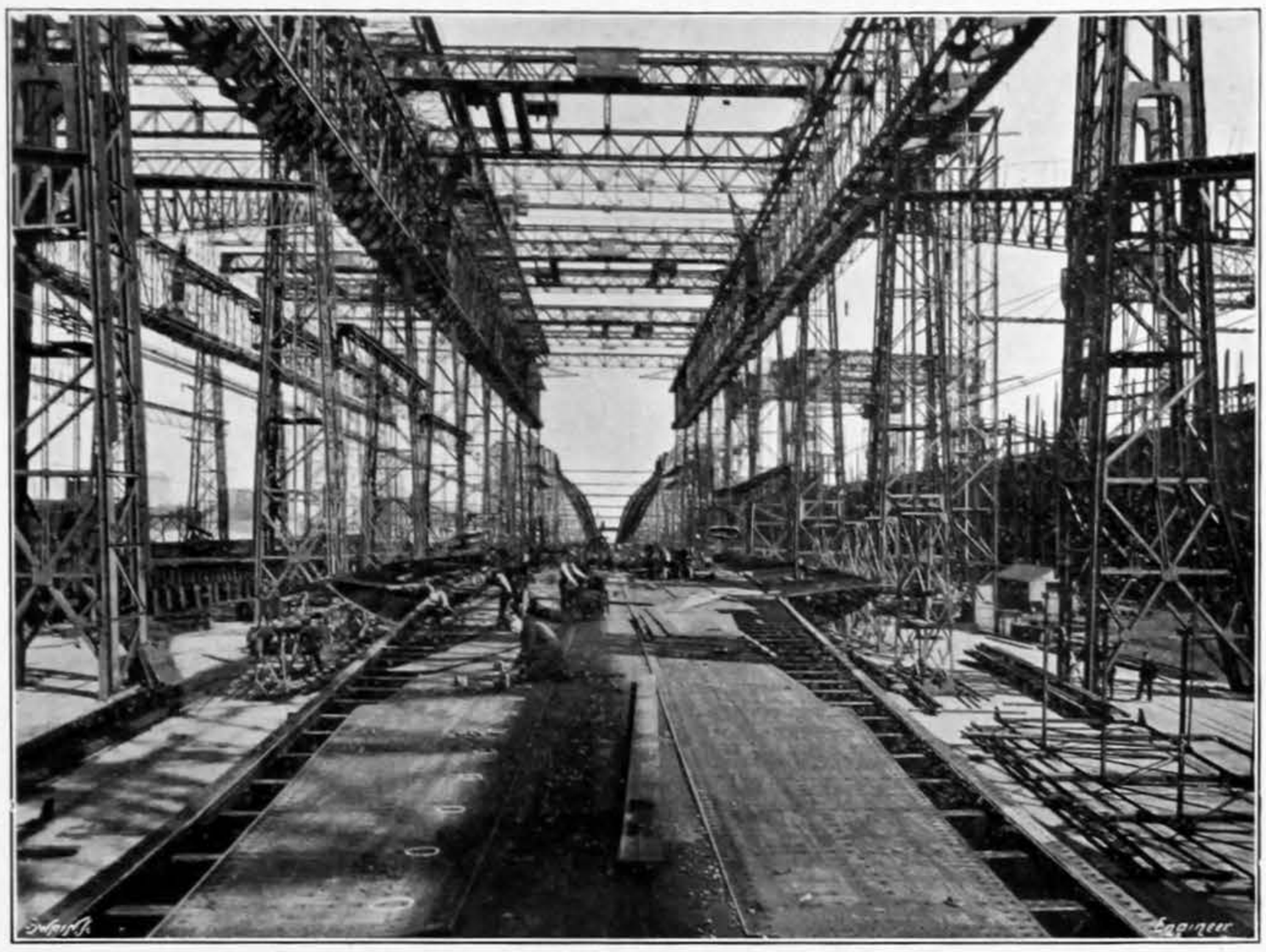
Ealing, August 21st. A. FAIRLIE BRUCE, M. Inst. C.E.

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SEWERS at Salt Lake City, states an American contemporary, are flushed by automatic flush tanks which discharge 280 gals. of water during each cycle of operations. The tanks are the Miller-Potter type, and are situated at various points along a sewerage system 106 miles in length, which is divided into a number of districts. An attendant starts at the beginning of one district, and proceeds along the line to its end, turning on the water at each of the tanks which he passes. When he has put the last tank of the district into action he returns to the starting point and shuts off the water successively in each tank, until he again reaches the end of the district. During the interval which elapses between the turning on of the water at any point and the closing of the valve after the attendant has completed the circuit of the district, each flush tank has had time to fill and discharge several times. This method is said to be economical, and effective in maintaining the entire system in a clean and satisfactory condition.

# WHITE STAR LINER OLYMPIC UNDER CONSTRUCTION

HARLAND AND WOLFF, LIMITED, BELFAST, BUILDERS



## THE WHITE STAR LINERS OLYMPIC AND TITANIC.

IN the building of a modern liner there are well-defined steps in the construction besides the five familiar stages of the laying of the keel, framing, plating, launching, and completion. These are the terms used to denote the main operations, but in the larger and more complicated structures of the present day there are many intermediate stages that have an interest of their own, and afford an indication of the progress of the work. This, of course, is especially the case in such gigantic vessels as the new White Star liners Olympic and Titanic, now under construction at Belfast, and the reports that have already appeared describing one of these intermediate stages—viz., the construction of the cellular double bottom—have dealt with a number of interesting points regarding the keel, centre-plate (or inner vertical keel), floors, and other parts forming this portion of the ship, special attention having been directed to the large amount of hydraulic riveting and the appliances for carrying out this work.

The double bottom—which in these vessels is more extensive than usual, being carried round the bilge—as is well known, serves several purposes. It provides space for water ballast, which, being so far down in the ship, has an important influence on the stability, in that the latter can by its means be regulated as desired under certain conditions. Then, while contributing greatly to the strength of the whole structure, it forms an important element of safety in the event of the vessel grounding at any time, the ship, in fact, having, as the term implies, a double bottom.

It will be seen from the accompanying reproductions of photographs taken on July 30th, little more than six months after the laying of the keel, that the tank top plating is now well advanced, and that the next important stage is being proceeded with—viz., the main framing of the vessel. These frames form the ribs of the ship, and it will be observed that numbers of the Olympic's ribs have already been set up near the after end. It is expected that the stern frame will be placed in position shortly, when the progress of construction will be even more apparent than it is now.

## TESTING CONDENSERS FOR LEAKAGES.

*(By a Correspondent.)*

IN view of the fact that the number of condensing plants—chiefly surface condensers—yearly installed is rapidly increasing, also seeing the keen competition that is constantly going on between engine builders with regard to water consumption or pounds of water per B.H.P on the various engines, these tests are often carried to the third decimal place when speaking of pounds of water per B.H.P. or E.H.P., as the case may be.

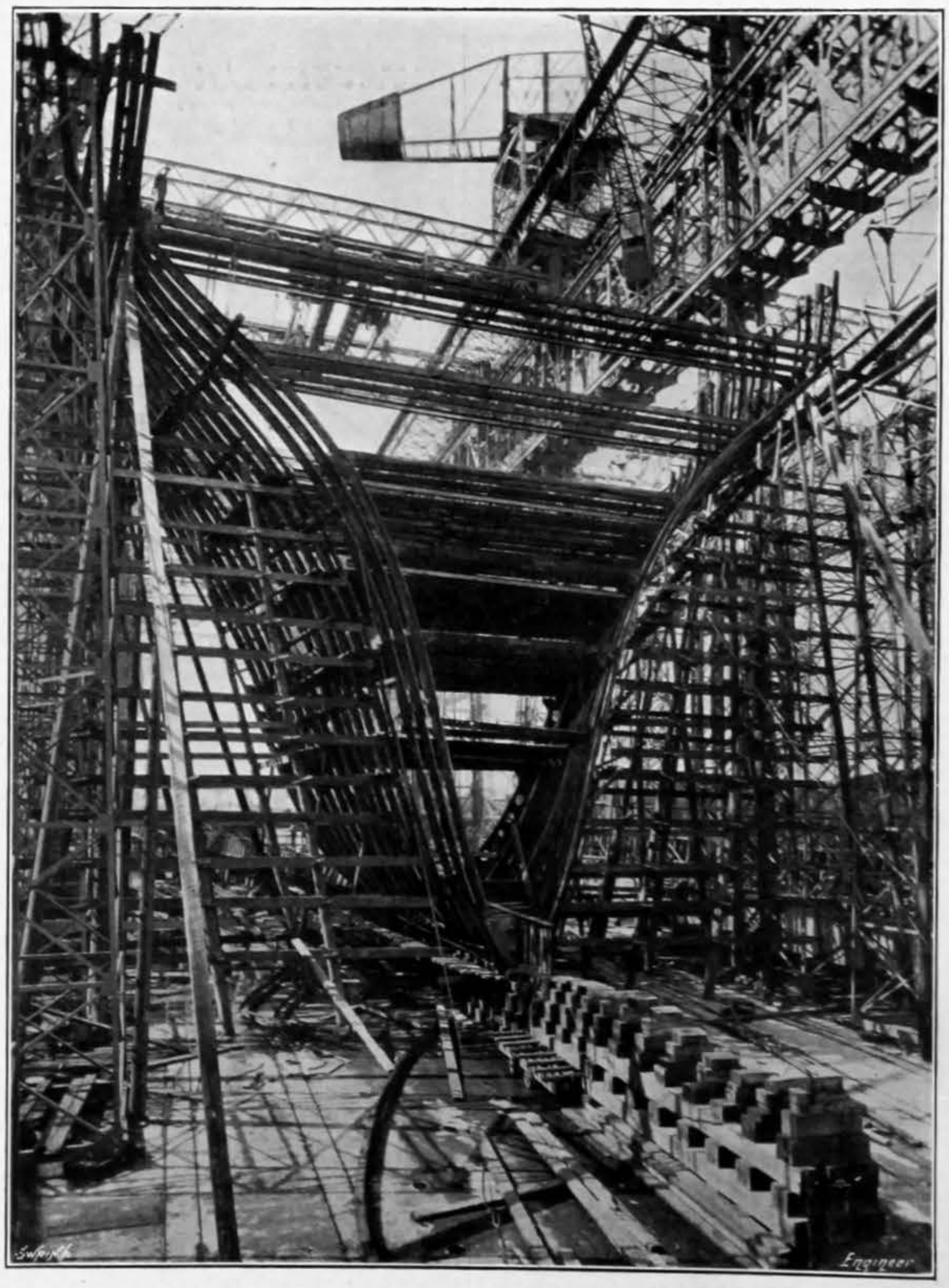
If this minute estimation is likely to continue, I think it high time we had it more widely known how simple yet very reliable tests can be made for leaky condensers. The maker's usual practice is to put a light water pressure first on the cooling-surface side and afterwards on the condensed-water side, at the same time carefully looking out for any water trickling through.

The station engineer, if doubtful, will run the condensing plant for several hours with only the circulating water going through the cooling surface, and carefully note if any condensed water is thrown up by the pump. Both of these methods for ordinary working conditions may suffice, but for a close competitive test they would not be, to my mind, sufficiently accurate, because I have known the behaviour of leakages to be very different when both waters are going through than when only one. My contention is that a condenser, like any other machine, should be tested under its full-load working conditions, and, so far as I know, there is no mechanical means of doing this; it is purely one for chemistry, and personally I consider the silver-nitrate test for chlorine or chloride to be the most suitable.

Even in the hands of an amateur it is possible to trace salt in water, although it may be only one part to one hundred thousand parts. Therefore the leakage, however slight, is quickly disclosed by the test mentioned.

The water frequently used for cooling purposes is that generally known as surface water, drawn from rivers, canals, &c., and such is always found to contain—among other things—sodium chloride or common salt in variable quantities. This, together with the fact that condensed water should never contain sodium salts, enables one to make a very reliable test for any leakages in a condenser. To carry out the test we shall require a standard solution of silver nitrate, which can be purchased from any qualified chemist, or for those who care to make it themselves, the particulars are as follows:—Dissolve 2.394 grammes of pure re-crystallised silver nitrate in distilled water and make solution up to one litre. We shall also require a solution of potassium chromate made by dissolving potassium chromate in distilled water—one part chromate, ten parts by weight of water. This potassium chromate solution is used as a colour indicator. The principle upon which the indicator depends is, that silver combines with chlorine in preference to chromic acid, and that accordingly no red chromate of silver is capable of being formed so long as chlorides are in the water, but that red chromate of silver instantly forms the moment nitrate of silver is in the slightest excess. Therefore, if we take a sample of water known to contain chlorine salts and into this drop, spot by spot, the silver nitrate solution, a white precipitate of chloride of silver will form, and continue to do so, until all the chlorine in the water has been precipitated. But as will be seen upon making the experiment, there is a difficulty in observing the exact point at which the formation of the precipitate ceases; this difficulty is overcome by the use of the colour indicator potassium chromate.

The details of analysis are as follows:—Measure out carefully 50 cubic centimetres of the condensed water, which should then be passed through a filter paper into a clean porcelain dish. To this add about half-a-dozen spots of the colour indicator, potassium chromate, at the same time stirring with a glass rod, the colour of water then will be distinctly yellow; this being so, the silver nitrate solution, which should be contained in a properly graduated burette, is carefully dropped spot, by spot, into the water, which should be constantly stirred the whole of the time. As will be observed, the first few spots will become red instantly they touch water, and die away to a pale yellow on stirring, that is if sodium chlorides are present. The dropping in of silver nitrate solution should be continued, also the stirring, until the water becomes permanently red. The very earliest point at which the chromate of silver begins to form, or the redness becomes persistent, the addition of silver solution should be stopped, and the amount used read off from the graduated burette; from this we can ascertain the quantity of salt present in the water. One cubic centimetre of silver nitrate solution practically corresponds to one grain of salt per gallon of water. If, on adding the first one or two spots of silver nitrate solution, the condensed water—which had previously been coloured by indicator—becomes permanently red, it is quite certain that there is little or no salt in water, consequently the condenser might be considered quite bottle-tight. If, on the other hand, it requires several cubic centimetres of silver nitrate solution to bring about a permanent red colour, then the condenser is certainly leaking, to what extent may be judged by the quantity of salt found to be present.



S.S. OLYMPIC—VIEW FROM COFFERDAM SHOWING FRAMES, ETC.

## THE BRITISH ASSOCIATION: SECTION G—ENGINEERING.

Address by SIR W. H. WHITE, K.C.B., Sc.D., LL.D., F.R.S., President of the Section.

ON the present occasion, when the meetings of the British Association for the Advancement of Science are held in the heart of this great dominion, it is natural that the proceedings of Section G (Engineering) should be largely concerned with the consideration of great engineering enterprises by means of which the resources of Canada have been and are being developed and the needs of its rapidly increasing population met. It will not be inappropriate, therefore, if the Presidential Address is mainly devoted to an illustration of the close connection which exists between the work of civil engineers and the foundation as well as the development of British Colonies and dominions beyond the seas.

British Colonies and Possessions have started from the sea front and have gradually pushed inland. Apart from maritime enterprise, therefore, and the possession of shipping, the British Empire could never have been created. An old English toast, once familiar, but which has of late years unfortunately fallen into comparative desuetude, wished success to "Ships, Colonies and Commerce." A great truth lies behind the phrase: these three interests are interdependent, and their prosperity means much for both the Mother Country and its offspring. As colonies have been multiplied, their resources developed, and their populations increased, over-sea commerce between them and the Mother Country has been enlarged; greater demands have been made upon shipping for the over-sea transport of passengers, produce and manufactures; there has been a growing necessity for free and uninterrupted communication between wildly scattered portions of the Empire, the maintenance of which has depended primarily and still depends on the possession of a supreme war fleet, under whose protection peaceful operations of the mercantile marine can proceed in safety, unchecked by foreign interference, but ever ready to meet foreign competition.

Now that our Colonies have become the homes of new nations it is as true as ever that the maintenance of British supremacy at sea in both the mercantile marine and the war fleet is essential to the continued existence and prosperity of the Empire. The trackless ocean supplies the cheapest and most convenient means of transport and intercommunication; continuous improvements in shipbuilding and marine engineering have abridged distances and given to sea passages a regularity and certainty formerly unknown. It is a literal fact that in the British Empire the "seas but join the nations they divide." Every triumph of engineering draws closer the links which bind together its several parts. Greater facilities for frequent and rapid interchange of information of what is happening in all sections of the Empire, and of knowing each other better, should lead, and has led, to increased sympathy, and a fuller realisation of common interest in all that affects the well-being of the Empire. Within the last few years the events of the Boer War have given remarkable proofs of the practical interest of the Colonies in Imperial concerns, and their readiness to share its burdens. The present year will always be remembered as that in which generous offers of assistance from the Colonies in the task of strengthening the Royal Navy at a critical period have led to a conference whose labours should produce important practical results, and make our future secure. Organised co-operation between the Mother Country and the Dominions beyond the seas in the maintenance of an Imperial Navy adequate for the protection of vital interests is essential to that security, and at last there is a prospect that this end will be attained.

While claiming for the shipbuilder and marine engineer an important place in the creation and maintenance of the Empire, it is recognised that the work of other branches of civil engineering has been equally important. The profession of the civil engineer was described in the Charter granted to the parent Institution in 1828 as "the art of directing the Great Sources of Power in Nature for the use and convenience of man; as the means of production and of traffic in states both for internal and external trade, as applied in the construction of roads, bridges, aqueducts, canals, river navigation, and docks, for internal intercourse and exchange; and in the construction of ports, harbours, moles, breakwaters, and lighthouses; and in the art of navigation by artificial power for the purposes of commerce; and in the construction and adaptation of machinery, and in the drainage of cities and towns." Since this description was penned there have been great and unforeseen developments in many directions, including those relating to improvements in the use of steam, the generation and practical applications of electrical power, the manufacture and extended employment of steel. The main ideas expressed eighty years ago, however, still remain applicable to the beneficent work of the civil engineer. His skill and enterprise, backed by adequate financial provision, are continuously being applied to improve and extend means of production, internal and external means of communication, inland and over-sea navigation, the use of mechanical power and appliances, the acceleration and cheapening of transport, the development and utilisation of natural resources, and the direction of the sources of power in Nature for the use and convenience of man. One of the chief fields of engineering operations at the present time is to be found in the Dominion of Canada, whose governing authorities have appreciated the fact that bold enterprise and generous financial provision for the execution of great engineering works are essential to the progress and prosperity of the country. Its vast extent, its magnificent lakes and rivers, its agricultural and mineral riches, its forests, its unrivalled water power, and many other potential sources of future wealth and progress, furnish exceptional incentives and opportunities to the engineer. From an early period in the history of Canada this fact has been realised, and attempts have been made to utilise natural advantages; while the same policy has been energetically adopted since the Dominion was established forty-two years ago. It is impossible in this Address even to enumerate the great engineering works which have been accomplished or are in process of execution; and it might be thought impertinent if the attempt were made by one who has only an outside knowledge of the facts. On the other hand, it may be of interest to illustrate by means of Canadian examples the truth of the general statement that civil engineering has exercised and must continue to exercise great influence upon the well-being and development of the British Empire.

By the kindness of the High Commissioner of Canada, Lord Strathcona—who has himself done so much for the development of the Dominion, including a great part in the construction of the Canadian Pacific Railway—the writer has been favoured with official reports and statistics bearing on the subject. These have been freely used in the statement which follows.

The subject is so extensive, and the time available for this address so short, that it will be necessary to omit detailed reference to important applications of engineering which are necessarily made, under modern conditions, in all great centres of population. Amongst these may be mentioned building construction, sanitation, water supply, heating, lighting, telegraphy, telephony, tramways, electric generating stations and their plant, and gas manufacture. No attempt will be made to deal with the important assistance given by engineers to the operations of agriculture, mining, and manufacture, or to the utilisation of the splendid forests of the Dominion, although the demands for machinery and mechanical power is, in these respects, exceptionally great, owing to the sparseness of the population and the magnitude of the work to be done. Notwithstanding the large immigration and rapid increase of population, these demands will certainly continue, and will probably become greater as the area under cultivation is increased, as manufactures are developed, and the natural resources of the country more largely utilised. The example of the United States places this anticipation beyond doubt, and demonstrates the great part which the engineer must continue to play in the development of Canada.

Even when the limitations described have been imposed upon the scope of this address, the field to be traversed is a wide one, and, without further preface, an endeavour will be made to describe a few of the most important services which the engineer has already rendered to the Dominion and will render in the immediate future.

### RAILWAYS.

It has well been said that the great problem of to-day in Canada is that of providing ample and cheap transport for her agricultural, mineral, and forest products from the interior to the sea, and so to the markets of the world. Important as inland navigation may be as an aid to this enterprise, it cannot possibly compare with railway development in actual and potential results. Apart from that development, the one united Dominion must have remained a dream. Thanks to the rapid and efficient intercommunication furnished by railways, widely scattered provinces are knit together in friendly and helpful union literally by "bonds of steel," which stretch from the Atlantic to the Pacific, and reach farther and farther north each year. Regions which would otherwise have remained inaccessible and unproductive have been turned into new provinces, whose fertility and future development it is not easy to forecast, and practically impossible to exaggerate.

In this department successive Administrations, both Federal and provincial, have realised the facts and possibilities of the position, and have given substantial assistance to private enterprise in the execution of great engineering works. Progress in railway development has been remarkable since Federation was accomplished forty-two years ago. During the preceding thirty years the total railway mileage in operation had been raised to 2278 miles; in 1887 it was 12,184 miles; in 1897, 16,550 miles; in 1907, 22,452 miles. The number of miles of railway actually under construction in 1907 was officially estimated at 3000, exclusive of lines projected but not yet under contract. In 1906, when the lines in operation were 21,353, it was estimated by competent authorities that the railways under construction, and projects for extensions likely to be carried into effect in the immediate future, reached a total of at least 10,000 miles, while probable further extensions of about 3500 miles were under consideration. Further, it was estimated that the capital expenditure required to complete these schemes would be about 60 millions sterling. These figures may need amendment, but there are others representing ascertained facts which equally well illustrate the magnitude of the railway interests of the Dominion.* The total capital invested in Canadian railways in 1907 was officially reported to be about £234,390,000; the aid given to railways up to that date by Dominion and Provincial Governments, and by municipalities, considerably exceeded £36,000,000 sterling in money; the land grants from the Dominion Government approached 32 million acres, while the Provincial Governments of Quebec, British Columbia, New Brunswick, and Nova Scotia had granted about 20½ million acres. The Governments have also guaranteed the bonds of railway companies to the extent of many millions of dollars. The capitalisation per mile of railway lines owned by the Governments—amounting to 1890 miles—is reported as being £11,400; this is practically the same amount as that for Indian railways, that for the United States being £13,600, and for New South Wales and Victoria about £12,600. For British railways the figure given is £54,700 per mile. The freight carried by Canadian railways in 1907 amounted to nearly 63,900,000 tons—of 2,000 lb.—which included about 14,000,000 tons of coal and coke, nearly 4,500,000 tons of ores and minerals, 10,250,000 tons of lumber and other forest products, nearly 7,900,000 tons of manufactures, and 2,309,000 tons of merchandise. In 1875, when 4800 miles of railway were in operation, the corresponding freight-tonnage was 5,670,000 tons; so that while the length of railway increased nearly 4.7 times, the tonnage increased nearly 11.3 times. During the same period passengers increased from 5,190,000 to 32,137,000. For twenty-eight railways making returns the average revenue per passenger per mile was 2.232 cents, and for the four principal railways it was 2.07 cents. For freight fifty-nine railways showed an average rate of 2.328 cents per ton-mile; and for the five principal railways it was .702 cent per ton-mile. The average distance travelled by a passenger was 64 miles, the corresponding figure for the United States being 30.3 miles. The average distance a ton of freight was hauled was 183 miles, as against 1o2 miles for the United States. In Canada, as the official reporter remarks, there is a small amount of suburban railway traffic and a low density of population. The following table is taken from the official Canadian Railway Statistics for 1907:—

| | For each mile of railway. Population. | Square miles of territory. |
|---|---|---|
| United States | 381 | 13.61 |
| United Kingdom | 1,821 | 5.29 |
| France | 1,590 | 8 46 |
| New South Wales | 686 | 146.09 |
| New Zealand | 358 | 43.42 |
| Victoria | 360 | 25.89 |
| India | 10,119 | 61.09 |
| Canada | 289 | 161.8 |

Canada has, therefore, the highest mileage measured against population and the lowest against territory.

The earliest great railway system of Canada, the Grand Trunk, had its beginnings in 1845; in 1907 it was working about 3600 miles within the Dominion. In association with the Government it is now engaged on the construction of the Grand Trunk Pacific Line, which will cross the continent wholly in Canadian territory, and have a length of 3600 miles, exclusive of branches.

The story of the Canadian Pacific Railway is well known, and need not be repeated; the influence which its existence and working have had upon the prosperity of the Dominion has been enormous and beneficial since its opening in 1885, and experience of its effect has led to the promotion of other trans-continental lines. In June, 1907, the total length in operation was nearly 9000 miles, and the company owned in addition great lines of steamships employed on Atlantic and Pacific services.

The Canadian Northern Railway system represents one of the most striking examples of recent railway development in the Dominion. In 1907 it was working nearly 2600 miles in the North-Western provinces, about 150 miles in Ontario, 500 miles in the Province of Quebec, and 430 miles in Nova Scotia and Cape Breton, making a total of nearly 3700 miles. In 1908 its mileage on the main system was reported to have increased to nearly 3400 miles, and the total length in operation had become 4800 miles. The North-Western Provinces have given substantial assistance to this great system, and its promoters are said to aim at a complete trans-continental route, as well as the development of railway communication to Hudson's Bay and the establishment of a line of steamships therefrom to Great Britain.

Besides these three great railway organisations, which in 1907 controlled about 75 per cent. of the mileage in operation, there are a large number of smaller companies, making up a total of about 80. Their total earnings in 1907 amounted to £29,350,000, the total working expenses being £20,750,000. Earnings from freight service were (in round figures) £19,000,000; from passenger service, £7,837,000; from express services, £655,000; from mails, £325,000, the balance coming from miscellaneous items. The total number of persons employed by the railways was 124,000; their salaries and wages amounted to £11,750,000. It was officially estimated that if to the railway employés were added persons employed in factories for rolling stock and railway materials, as well as those engaged in the casual service and shipping, with an allowance for their families, "quite 25 per cent. of the population win their daily bread from the carrying trade" of the Dominion.

*Most of these statistics are taken from the valuable Report for 1907, presented to the Minister of Railways and Canals by Mr. Butler, Deputy Minister, and Chief Engineer of the Department.

The equipment of the Canadian railways in 1907 included 3501 locomotives, 3642 passenger cars, and 113,514 freight cars. In the opinion of the official reporter on railway statistics, based chiefly on a comparison of the proportion of rolling stock to mileage in Canada and the United States, a considerable increase of rolling stock is required, and there is a possibility of greater efficiency being obtained in the utilisation of existing freight cars. The manufacturing resources of the Dominion are declared to be fully capable of meeting all requirements, as in 1907 they produced 227 locomotives, 397 passenger cars, and 13,350 freight cars. A reduction of grades and curvatures has been carried out on the principal railways in recent years, and this has permitted the hauling of heavier loads. It is estimated that in 1907 the average earnings per ton of freight hauled were 1.472 dols., and the average earnings per passenger carried were 1.219 dols. The earnings per train mile were 1.953 dols., and the working expenses 1.581 dols. The total earnings per mile of railway were 6535.64 dols., and the working expenses were 4620.9 dols. The working expenses were divided as follows in the official report:—

| | |
|---|---|
| Maintenance of way and structures | 20.13 per cent. |
| ,, equipment | 20.88 ,, |
| Conducting transportation | 55.25 ,, |
| General expenses | 3.74 ,, |

Allowing two cords of wood fuel to be equal to one ton, 5,609,000 tons of fuel—of which 5,578,000 tons were coal—were consumed by Canadian railway locomotives in 1907 in running 100,155,000 miles. The total cost was about £3,027,500, equal to 14.59 per cent. of the working expenses.

From this brief summary of facts some idea may be gained of the rapid development of Canadian railways, their immense capital value and traffic, and the remarkable influence they have had upon the progress and population of the Dominion. It is a matter for satisfaction that British capital and engineering skill have contributed in no small measure to produce this development, and it may be hoped that in the future they may render even greater service.

### INLAND NAVIGATION.

The most important system of inland navigation which Canada possesses is primarily due to the existence of the Great Lakes and the St. Lawrence River; but the utilisation of these natural advantages and the construction of a continuous navigable channel from the sea to the head of Lake Superior is due to the work of engineers. The importance of such a navigable waterway leading to the heart of the Dominion was recognised long ago by the Government. The first canal is said to have been opened in 1821, and from that time onwards the canal system has been developed, but the greatest progress has been made during the last forty years under successive Administrations. Up to March 31st, 1907, the capital expenditure on Canadian canals, exclusive of outlay by the Imperial Government, has approached £18,350,000 sterling, of which more than ten millions have been spent on enlargements. Besides minor canal systems, many of which are important, a great "trunk system" of water transit has been created from Montreal to Port Arthur, at the head of Lake Superior, this all-water route being nearly 1300 miles in length, having a minimum depth of water of 14ft. and effecting a total vertical rise of about 600ft. from tidal water in the St. Lawrence to Lake Superior. In order to effect this rise forty-nine locks are provided, most of which are 270ft. long and 45ft. wide, enabling vessels 255ft. long to be accommodated. Out of the total length of more than 1200 miles only 73½ miles consist of artificial channels. The Welland Canal, connecting Lakes Erie and Ontario—with a total rise from lake to lake of 327ft., effected in twenty-five locks—is 26¾ miles long. This canal dates from 1824; its enlargement to present dimensions was begun in 1872, and occupied fifteen years; the total expenditure on the canal has been nearly five and a-half millions sterling. Another important section of the waterway is the Sault Ste. Marie Canal—about 6000ft. in length and from 142ft. to 150ft. wide between the pier ends, with a lock 900ft. long, 60ft. wide, having 20¾ft. of water over the sills. The difference of level between Lakes Superior and Huron is 18ft. Commenced in 1888, the Sault Ste. Marie Canal was opened for traffic in 1895, the cost being about £930,000. Like its predecessor on the United States side of St. Mary's River—the so-called "Soo" Canal affords free passage for the ships of both countries. In 1898 about two and three-quarter millions represented the tonnage of vessels passing through the Canadian Canal, and of this total about 403,000 tons was in Canadian vessels. In 1907 the total tonnage had risen to 12,176,000 tons, of which 2,288,000 was in Canadian vessels. The Soulanges Canal is 14 miles long, with a rise of 84ft., effected in four locks. Commenced in 1892, it was opened for traffic in 1899, and cost nearly £1,400,000. The Lachine Canal was commenced in 1821, enlarged in 1843 and 1873, and, as completed in 1901, is 8½ miles long, has 45ft. rise, effected in five locks, and has cost from first to last about £2,300,000.

In the construction of this great waterway many difficult engineering problems have been solved, and every modern improvement has been introduced; electricity has been utilised in its equipment, both for power and lighting, so that navigation can proceed by night as well as by day. For the years 1903-7 the canals were declared free of tolls, but it is estimated officially that if tolls on the ordinary scale had been collected, the revenue for 1907 would have exceeded £91,000. In these five years the water-borne traffic of the Dominion increased from 9,204,000 tons in 1903 to 20,544,000 tons in 1907; in the same period the increase in Canadian railway traffic was from 47,373,000 tons to 63,866,000 tons. The official reporter justly remarks that "these results are exceedingly encouraging."

It was recognised long ago that the utilisation of the waterways of Canada from the Great Lakes to the sea would yield considerable advantages by facilitating cheap transport of agricultural products of the fertile regions from the great North-West, but the Canadian portions of that territory were then regarded as "a great lone land." Subsequent developments of the corn-growing regions of Canada have emphasised the value of the water route and its great potentialities. In his "History of Merchant Shipping" (published 1876), Lindsay dwelt upon this point, and foresaw that if the waterways of Canada were made continuously navigable, a struggle for supremacy in over-sea trade must arise between New York and the Canadian ports of Montreal and Quebec. The struggle is now in full force, so far as the grain trade is concerned, and it is likely to grow keener. The quantity of grain passed down the whole length of the St. Lawrence navigation to Montreal increased from about 450.000 tons in 1906 to 685,000 tons in 1907, while the quantity carried to Montreal by the Canadian Pacific Railway was about 387,000 tons for 1906 and 384,000 tons for 1907. On the other hand, the quantity carried by canals in the United States to New York fell from 294,500 tons in 1906 to 230,800 tons in 1907.

An important addition to the Canadian canal system has been proposed, and its execution will probably be undertaken when great works now in progress have been completed. This route extends from Georgian Bay on Lake Huron to the St. Lawrence, and would utilise Lake Nipissing as well as the French and Ottawa rivers. The distance to be traversed would be 450 miles, less than that of the present all-water route. On the basis of careful surveys it has been estimtaed that a canal having 20ft. depth of water could be constructed at a cost of twelve millions sterling, upon which capital a reasonable dividend could be paid, even if the charges made for transport were one-third less than the lowest rates of freight possible on the United States routes to New York. It would, of course, be most advantageous to have the available depth of water increased from 14ft. to 20ft., thus making possible the employment of larger and deeper draught vessels between the Lakes and Montreal. Considerable economies in the ratio of working expenses to freight earnings would be effected, break of bulk in transit to the sea would be avoided, and the cost of transport greatly reduced.

The magnitude of the grain trade and its growth may be

illustrated by the following figures for recent years:—In 1897 the grain cargoes passed down the Welland Canal to the ports of Kingston and Prescott numbered 377 and represented 515,000 tons; for 1907 the corresponding figures were 518 cargoes, weighing 841,000 tons. As to the elevators and mechanical appliances for handling economically these huge quantities of grain, nothing can be said here, although they involve the solution of many difficult engineering problems, and have been greatly simplified and improved as experience has been gained.

The bulk of the canal traffic, of course, moves eastwards and outwards from the interior provinces. For example, of the total quantity of freight (1,604,321 tons) passed through the whole length of the Welland Canal in 1907, about 75 per cent. moved eastwards, and more than 62 per cent. of the 2,100,000 tons which passed through the St. Lawrence canals moved in the same direction.

### Shipping on the Great Lakes.

Canadian shipping and shipbuilding on the Lakes have made considerable progress in recent years, although they do not rival those of the United States. According to authoritative statements, there were not twenty Canadian steamers engaged in the transport of grain fifteen years ago; only three of these were steel built, and the largest carried only 90,000 bushels. The total carrying capacity of Canadian grain-carriers at the present time has been estimated at ten million bushels, and the capital invested in the fleet is said to be about three millions sterling. Between the harvest and the close of navigation in winter it is estimated that no less than sixty million bushels of grain can be moved from port to port in Canadian steamers.

Many special engineering features have been introduced into the structures and equipment of these Lake grain-carriers. They are really huge steel barges of full form, of uniform cross-section for a considerable portion of their length, and they possess enormous cargo capacity, moderate engine power and speed, with structures of a simple nature which can be largely standardised and made to resemble bridge construction rather than ordinary shipbuilding. They can be built in a short time, the largest vessels occupying about four months in construction. In this way the cost of construction is cheapened, but the rates for labour and materials prevailing in the Lake shipyards are so high relatively to British costs that at present these grain carriers are said to cost about 40 per cent. more (per ton deadweight carried) than the cost of ordinary "tramp" steamers built in Great Britain. Their holds and hatchways are arranged so as to facilitate the rapid shipment and discharge of cargoes. At their ports of call special mechanical appliances are provided for dealing with cargoes, most of which consist of grain, ore or coal.

In the design and construction of these cargo-handling appliances the mechanical engineer has displayed great ingenuity, and the results obtained in rate of shipment and discharge of cargoes of grain, ore and coal are remarkable. Cases are on record where vessels carrying 7000 tons deadweight have been loaded in four hours and discharged in ten hours; more than 5000 tons of ore have been discharged in about four hours. The draught of water of the steamers must be kept within moderate limits and the breadths of the locks are moderate, so that increase in carrying power must be chiefly obtained by increase in length; consequently, as individual cargoes are increased, a greater number of lifting appliances can be brought to bear simultaneously, and the rate of loading or discharge can be maintained or accelerated.

The season of navigation extends over only seven or eight months in the year; consequently, "quick despatch" is essential to success. A large vessel of this class has the following approximate dimensions:—Length about 600ft.; breadth, 58ft. to 60ft.; depth, 32ft.; draught of water, 19ft. to 19½ft. when carrying 10,000 to 11,000 tons of cargo; corresponding displacement, 16,000 tons. The engines of such a ship develop about 2000 horse-power, and drive her at eleven to twelve statute miles per hour in fair weather. The large size and moderate speed result in very economical conditions of working, and the freight rates are exceedingly low. From official returns it appears that for these deadweight cargoes the freight per ton-mile across the Lakes is from .04 to .05 of a penny per ton-mile, the corresponding railway rate being about ten times that amount. The multiplication of this type of vessel on the Great Lakes is a proof that it satisfactorily fulfils the conditions of service. Similar vessels would not be well adapted for ocean work, which demands greater structural strength, different proportions, and a more liberal equipment; but shipbuilders generally may benefit from a study of the Lake steamers.

The greater portion of the traffic on the Lakes passes through the "Soo" canals. The voyages are comparatively short, the average length of the trip being about 840 miles. Consequently, individual vessels make several passages during the season when navigation is open, and the total number of passages, as well as the total aggregate tonnage of the ships, reaches very high figures. In the season of 1907, for example, when the canals were open less than 240 days 20,440 vessels—counting as a vessel each passage—with an aggregate registered tonnage exceeding 44 million tons, passed through the United States and Canadian canals at the Soo. The aggregate freight tonnage carried exceeded 58 million tons, the weight of coal approached 11½ million tons, the iron ore carried weighed 39,600,000 tons, and the grain transported amounted to 136 million bushels. The conditions of the Suez Canal are, of course, entirely different, as vessels passing through are engaged on long voyages, and individual ships make few passages in the year. On the other hand, Suez Canal traffic proceeds uninterruptedly throughout the year, while the Soo canals are closed during the winter months. Subject to these differences in working conditions, it may be of interest to state that in 1907 4267 vessels of 14,728,000 tons passed through the Suez Canal, and paid transit dues which amounted to £4,460,000, whereas the passage of the Soo canals was free.

### The St. Lawrence Ship Channel.

Closely allied with the waterway from Montreal to Lake Superior is the improvement of the channel of the St. Lawrence from Montreal to Quebec and beyond towards the sea. From the Straits of Belleisle to Montreal the distance is 986 miles; from Quebec to Montreal it is 160 miles. Formerly the minimum depth of water between Quebec and Montreal prevented the passage of vessels drawing more than 10ft. to 12ft. during the greater part of the season of navigation. In 1826 the question of deepening the river channel was raised; in 1844 the work was begun, but was abandoned three years later; in 1851 it was resumed, and has since been continued. In 1869 the minimum depth of the channel at low-water was increased to 20ft.; in 1882 it was 25ft.; in 1888 27½ft. for 108 miles from Montreal to a point within tidal influence. A channel having a minimum width of 450ft., and 550ft. to 750ft. wide at the bends, with a minimum depth of 30ft., was completed in 1906 from Montreal to tide water at Batiscan. Certain work remains to be done between this point and Quebec in order to complete the project adopted in 1889 and amended in 1906, but it is anticipated this will be finished in about four years. Below Quebec the channel is 1000ft. wide. When once dredged it is stated that the channel remains permanent. Accidents in the channel are few. The superintending engineer, in his Report of July, 1908, indicates the magnitude of the work done by comparisons with the Suez and Panama Canals, the figures standing as in table.

| — | Length. | Minimum depth. | Minimum breadth. | Estimated excavation. |
|---|---|---|---|---|
| | miles. | ft. | ft. | cubic yards. |
| Suez Canal .. .. .. | 100 | 29½ | 100 (bottom) | — |
| Panama Canal .. .. | 49 | 41 | 200 (minimum) / 500 (maximum) | 80,000,000 |
| St. Lawrence Channel | 220* | 30 | 450 (minimum) / 1000 (maximum) | 70,000,000 |

* Length of channel requiring improvement demands dredging and excavation over a length of about 70 miles.

In 1844 the largest vessels navigating the St. Lawrence to Montreal were of 500 tons; now the Virginian and Victorian, of the Allan Line (12,000 tons), and the Laurentic and Megantic, of the White Star Line (15,000 tons), proceed to that port, and have made the passage from Quebec in less than ten hours. Ordinarily this passage occupies eleven to twelve hours, the return passage being made in nine to ten hours.

In the execution of these great works a specially designed dredging plant, including several types, has been employed, and works about seven months in the year, and the rock dredging and blasting in the section below Quebec has involved great difficulty. The total amount of rock to be removed amounted to 1,700,000 cubic yards, extending over nearly three miles, and the whole bottom was covered with huge boulders, some of which were 30 to 40 tons in weight. These great masses had to be lifted before blasting and dredging was done. During the fiscal year 1907 8 the expenditure on dredging plant and dredging was nearly £132,000, and 4,832,000 cubic yards of material were removed. At the close of that year 56 millions of cubic yards out of the estimated total of 70 millions had been dredged; the length completed to 30ft. minimum depth was 59 miles out of 70 miles. These facts indicate the advanced condition of the undertaking, and the prospect of its completion at an early date.

In order to secure the safe and continuous navigation of this channel by night as well as by day, under all conditions of weather, during the season when the river is open, every precaution and aid which engineering skill and invention can provide has been laid under contribution. A marine signal service with telephonic equipment has been provided; submarine bells have been established for use in foggy weather; a complete system of buoys and lighting has been installed; the channel is periodically examined and swept to ensure that there are no obstructions; the question of prolongation of the season for navigation by the use of ice-breakers is being studied. The harbour of Montreal has been greatly improved in accommodation and equipment, and the aggregate tonnage, as well as average size of sea-going vessels, using the port have been much increased. In 1898, 868 such vessels aggregating 1,584,000 tons arrived at Montreal; in 1907, 742 vessels aggregating 1,926,000 tons arrived. Of the latter, 522 vessels aggregating 1,525,000 tons were British. At the St. Charles Docks and Wharves, Quebec, in the season of 1907, 235 vessels of 1,009,000 tons were entered inwards, and 67 vessels of 249,000 tons outwards, the first outward steamer leaving on April 7th, and the first ocean steamer arriving on April 26th. The last arrival from the sea was on December 9th, and the ice formed in the tidal basin on December 12th.

Still further improvements of the St. Lawrence navigation are now proposed, and the work was commenced in 1907. It is intended to increase the depth of the channel to a minimum of 35ft. from the sea to Montreal, and the superintending engineer reported in 1908 that with certain moderate additions to the dredging and steam plant this work could be completed in six seasons. The widths and curves of the existing channel will not require any important changes, as they were designed from the first for the largest classes of steamships. When this increased depth has been obtained Montreal as a port will have an approach channel comparing favourably with that of other ports available for transatlantic traffic. At Southampton the existing depth at low water in the approach channel is about 32ft., and it is proposed to obtain 34ft. At Liverpool the minimum depth at low water over the bar and in the approach channel in the Mersey is about 28ft. The Ambrose Channel leading to New York is to have 40ft. depth at low water when the works are completed. Ample depth of water is of the first importance in the economical working of the largest and swiftest ships, and the Canadian Government has been well-advised in deciding to carry out the great scheme above described.

### Water-power.

Canada has unrivalled resources in water-power, and its extent and possible utilisation have been made the subject of investigation by engineers for many years past. One of the most important memoirs on the subject was presented to the Royal Society of Canada in his presidential address of 1899 by Mr. Keefer, C.M.G. In recent times many other engineers have studied the subject and carried out important works. Exact knowledge of the total power represented by the waterfalls and rapids of the Dominion is not available, nor can any close estimate be made of the power which may be employed hereafter in factories, mills, or industrial processes, because profitable employment obviously depends upon commercial considerations, which must be governed largely by the localities in which water-power may be found, and the cost of works and of transmission of energy to places where it can be utilised. It has been estimated that on the line from Lake Superior through the chain of lakes and rivers leading to Niagara and thence through the St. Lawrence to the sea eleven millions horse-power may be developed.* Mr. Langelier has estimated that in the Province of Quebec the water-power aggregates more than eighteen millions horse-power; other provinces all possess large resources of the same kind as yet untouched. The most striking example of the utilisation of water-power is that on the Niagara River, which the writer had the good fortune to visit in 1904 during his Presidency of the Institution of Civil Engineers; the works on the Canadian side were then in full progress, and at a stage which enabled one to realise completely their great difficulty and immense scale. The three companies whose works are near the Falls on the Canadian side have provided for a total ultimate development of over 400,000 horse-power, and a fourth establishment lower down the river, intended chiefly for the use of Hamilton, is to develop 40,000 horse-power. In the construction of the works, in the electric generating plant, the arrangements for transmitting power over long distances, and other features of importance, remarkable engineering skill and daring have been displayed. American capital and enterprise have had much to do with these undertakings, as they have with many other important Canadian enterprises; but it may be hoped that British capital will keep its lead and be freely employed in the development and utilisation of all the resources of the Dominion, including that magnificent asset its water-power. The applications of water-power are already very numerous, including not merely the creation of electrical energy and its use for lighting and power in towns and factories situated at considerable distances from the Falls, but for manufactures and industrial processes carried on near the Falls. Amongst these manufactures, that of aluminium and carbide of calcium may be mentioned, while paper and pulp mills and saw mills constitute important industries. Great advances have been made in the transmission of electrical power over long distances, and very high pressures are being used. Electric traction on railways and tramways also derives its power from the same sources, and is being rapidly developed. In 1901 there were 553 miles of electric railways, and in 1907 815 miles.

*(To be continued.)*

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It is stated in the *Industrial World* that the Pittsburgh Department of Public Works has prepared plans for a reinforced concrete bridge in that city. The structure will be 630ft. long, with a roadway of 50ft., and 10ft. sidewalks. The main span will be 300ft., and will stand 115ft. above the boulevard.

* The *Times Financial Supplement*, April 2nd, 1906, contains a valuable article on this subject, from which many of the above figures are taken.

## THE IRON, COAL, AND GENERAL TRADES OF BIRMINGHAM, WOLVERHAMPTON, AND OTHER DISTRICTS.

*(From our own Correspondent.)*

### Pig Iron Revival.

The revival in the pig iron trade of this district continues, and most producers of raw material are now in a strong position, and refuse to enter into forward commitments except on terms considerably better than those current for prompt deliveries. Prices of all brands are firm, and on 'Change to-day (Thursday) in Birmingham the expectations noted last week that the improvement will develop into a good autumn trade were repeated. Consumers of raw material have been covering, in view of the possibility of a further advance in prices, and to-day some further good orders were placed at enhanced rates. Prices were fully 6d. per ton dearer on the week, and in some cases an increase of 1s. 6d. was named, but in these latter instances the figures quoted may be taken rather as an indication of the strength of makers' position than as an actual business figure. Derbyshire forge iron was quoted 50s. per ton; Northampton forge iron, 47s.; Lincolnshire, 51s.; South Staffordshire part-mine iron, 49s. 6d. to 50s.; and common forge iron, 46s. 6d. North Staffordshire iron was worth about 50s. There was some stiffening of quotations for Staffordshire all-mine and cold-blast qualities, but no actual change is at present announced on the former figures of 80s. to 81s. for best all-mine and 110s. cold-blast. As the market closed to-day some brands of both Staffordshire and Midland pigs were withdrawn. It is not at all unlikely that prior to the October quarterly meetings all-mine iron will be put up—at least, if the revival holds.

### Manufactured Iron Outlook.

Finished ironmasters attempted to-day in Birmingham to get some advance on rolled iron to compensate for the dearer situation in raw material, but they were successful in only few instances. Should the returning confidence in the pig market be continued, however, manufactured iron consumers here must soon have to concede better values, particularly now that Scotch and Cleveland prices have advanced 5s. to 7s. 6d. per ton. Unmarked bars were £5 17s. 6d. to £6, second grade marked bars £7, and best ditto £8 per ton. A fair number of inquiries have come to hand recently in connection with the renewal of bar contracts, but sales for early delivery have not expanded to any large extent. Hoop iron is still £6 15s., and rivet iron £6 15s. to £7.

### Galvanised and Black Sheet Trade.

Black sheets for galvanising and merchant purposes show little improvement, and makers are pressing for orders at £7 2s. 6d. for 24 w.g. sheets, though £7 5s. is still maintained as a nominal quotation. Sheets of 20 w.g. are £7 and £7 2s. 6d, and 27 and 28 w.g. £7 15s. to £7 17s. 6d. Galvanised sheets continue the subject of severe internal competition amongst the makers, associated and non-associated. The Welsh and other coast firms are carrying off the bulk of the orders; £10 10s. to £11 and £11 5s. are regarded as the general quotations of the market for doubles f.o.b. Liverpool or equal-distance outports. Large London exporters in particular, however, declare that they will not give £11, and they call it an "absurd" price in the present severe price-cutting situation. The present position of the industry is a most unenviable one, and no one can tell how the war of competition will end.

### Tube Strip Prices.

The long depression has been very trying to makers of gas strip, and the slackness of trade lends colour to some of the statements which are frequently made in connection with the Gas Tube Strip Association. It has been suggested that though an official minimum has been in existence, members have devised means of evading it, while in other quarters it has been asserted that no hard-and-fast minimum was arranged. It is now once again reported that a reduction of 5s. has been declared, making the price £6 per ton, less 2½ per cent., and it is also said that for a considerable time past members of the Association have been accepting business at £6, less 2½ per cent. These statements have been officially denied. Unassociated makers, however, have been selling at less than £6 per ton for a long time, and the general belief of the market now is that the combination firms have also been authorised to do so. The great trouble in this trade is, of course, Belgian competition and the fear that is entertained of its renewed outbreak. So long as this trouble threatens native prices are certain to be easy and open to manipulation by buyers. Wisely enough, the Staffordshire makers are determined to keep out the Belgians at any cost.

### Steel Trade.

Crude steel is firm at the prices lately stated. There is rather more activity as regards sections, but values remain unchanged. Bessemer sheet bars are £4 12s. 6d. for Bessemer to £4 15s. for Siemens. The advance of 5s. per ton this week in steel plates in the West of Scotland and on the North-East Coast is received with much satisfaction by local steel makers, who conclude that by lessening the severity of Scotch and Cleveland competition the advance will strengthen Midland prices. Staffordshire mild steel bars are quoted £6 7s. 6d. to £6 17s. 6d., angles £5 10s. to £5 15s., girder plates £5 15s. to £5 17s. 6d., and boiler plates £7.

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## NOTES FROM LANCASHIRE.

*(From our own Correspondent.)*

Manchester, Thursday.

### Sharp Advance in Pig Iron.

The predictions of the past few weeks with regard to pig iron have been more than verified by the advances of the past few days. Up to Friday they seemed to be confined mainly to warrants, but under the influence of strong American advices, something like a "boom" has set in, not only in this centre, but throughout the country generally. This is not confined to one brand of iron, but all classes have participated, and a good trade during the autumn seems now to be assured. There was a good attendance on the Iron Exchange on Tuesday, and the under current was admittedly strong. Prices advanced rapidly, Middlesbrough and hematite taking the lead. Lincolnshire on Friday was officially advanced 6d. per ton, but merchants held out for 1s., and even 1s. 6d. was freely talked of. Derbyshire and Staffordshire followed suit, although, perhaps, not to the same extent. On the month the following advances may be noted:—Lincolnshire, 2s. 6d.; Staffordshire, 2s. to 2s. 6d.; Derbyshire, 1s.; Middlesbrough, 2s. to 2s. 6d. Scotch: Gartsherrie, 1s. 9d.; Glengarnock, 1s. 6d.; Eglinton, 1s. to 1s. 6d.; Dalmellington, 1s. to 1s. 6d.; West Coast hematite, 2s. 6d.; East Coast ditto, 1s. 6d. to 2s. 6d. per ton. Forge iron appears to have been in better inquiry, and closes about 2s. to 2s. 6d. per ton higher on the month.

### Finished Iron and Steel.

There is no change to note in the first named, although in steel and steel products the feeling is strong. The Scottish advance, however, has not been followed here, although it is stated there is an upward movement in marine boiler plates.

### Copper, Sheet Lead, and Tin.

Tough ingots higher, but manufactured unchanged.

Sheet lead: Easier. Tin: English ingots again dearer by about £2 per ton.

**Quotations.**

Lincolnshire, No. 3 foundry, quoted 54s. 6d. to 55s.; Staffordshire, 53s. 6d. to 54s.; Derbyshire, 53s. 6d. to 54s.; Middlesbrough, open brands, 60s. to 90s. 4d. Scotch: Gartsherrie, 60s. 6d. to 60s. 9d.; Glengarnock, 60s. 6d.; Eglinton, 59s. to 59s. 6d.; Dalmellington, 58s. 6d. to 59s., delivered Manchester. West Coast hematite, 61s.; East Coast ditto, 57s. 6d., to 58s. 6d. both f.o.t. Delivered Heysham: Gartsherrie, 58s. 6d. to 58s. 9d.; Glengarnock, 58s. 6d.; Eglinton, 57s. to 57s. 6d.; Dalmellington, 56s. 6d. to 57s. Delivered Preston: Gartsherrie, 59s. 6d. to 59s. 9d.; Glengarnock, 59s. 6d.; Eglinton, 58s. to 58s. 6d.; Dalmellington, 57s. 6d. to 58s. Finished iron: Bars, £6 10s.; hoops, £7 12s. 6d.; sheets, £7 15s. to £8. Steel: Bars, £6 2s. 6d. to £6 5s.; Lancashire hoops, £7 5s.; Staffordshire ditto, £6 17s. 6d. to £7; sheets, £7 17s. 6d. to £8; boiler plates, £7 2s. 6d.; plates for tank, girder, and bridge work, £6 5s.; English billets, £4 12s. 6d. to £4 15s.; foreign ditto, £4 10s. to £4 12s. 6d.; cold-drawn steel, £9 5s. to £9 10s. Copper: Sheets, £72; tough ingot, £63; best selected, £63 per ton. Copper tubes, 8½d.; brass tubes, 6⅞d.; condenser, 7⅞d.; rolled brass, 6½d.; brass wire, 6½d.; brass turning rods, 6½d.; yellow metal, 6d. per lb. Sheet lead, £16 15s. per ton. English tin ingots, £135 10s. per ton.

**The Lancashire Coal Trade.**

There was a better attendance on the Coal Exchange than usual, but owing to the open weather, and the Lancashire holidays, actual business continued dull. There is no change to report in either demand or official quotations.

BARROW-IN-FURNESS, Thursday.

**Hematites.**

The improvement in the hematite pig iron trade referred to last week has been further demonstrated, as not only has the demand from several sources increased, but buyers have been making inquiries for fuller deliveries at forward dates, a good indication of their idea that before many weeks are over there will be a bigger trade done at fuller prices. Indeed, prices which began to move last week have shown a further upward tendency this week, and now makers are quoting 61s. to 62s. for mixed Bessemer numbers net f.o.b., and warrant sellers are asking 59s. 9d. net cash, buyers 59s. 6d. There is much more business in the hands of makers, and they are preparing to put additional furnaces in blast. Two furnaces at the Solway Works, belonging to the new Cumberland combination, are to be lighted at once, and it is probable that other furnaces in the Furness district will shortly be put into operation. A better business is being done in special hematite iron, and makers are now quoting up to 63s. for this high graded metal. Several of the makers of iron have taken up the work of making special hematites according to specifications supplied. Only the best of raw material is used for this purpose, and it is believed that, in future, those using this class of iron for purposes in which the most reliable article is essential will prefer to specify what they want now that they know they can get it. Ferro-manganese is selling better, and there is a good trade in spiegeleisen. Iron ore is in better inquiry, and the best classes are most sought after. Prices range from 11s. to 17s. 6d. for ordinary and best net at mines.

**Steel.**

There are much better prospects in the steel trade, and the rail mills are better employed than they have been of late, and orders are coming in more freely. There is also the prospect of a revival in the demand for steel shipbuilding material. Prices are somewhat higher, in harmony with the advance in the price of iron.

**Shipbuilding and Engineering.**

Shipbuilders are quoting for some new work which is now in the market, as they are anxious to get orders to keep their works going during the winter months. Prospects for next spring are satisfactory. Engineers are short of orders in the marine department.

**Shipping and Coal.**

More activity is shown in the shipping trade. The exports of iron and steel last week from West Coast ports were 15,297 tons—7728 tons of iron and 7569 tons of steel—as compared with 8930 tons in the corresponding week of last year, an increase of 6367 tons. The aggregate of exports to date this year has reached 390,129 tons, compared with 320,620 tons in the corresponding period of last year, an increase of 69,509 tons. Coal and coke are firmer and in rather better sale.

## THE SHEFFIELD DISTRICT.

*(From our own Correspondent.)*

**The Coal Trade.**

As to demand, the coal trade at the present time is very active, but, unfortunately, the difficulties arising from "Feasts," the Eight Hours Act, and pit boys are affecting adversely the working at the collieries. There is considerable unrest as to the results of the working of the Act in particular, the men not earning what they think is sufficient money and the new arrangements necessarily causing some friction. Barnsley is the "head-centre" of the "Feast" institution, and the holidays extended from last Saturday to Tuesday night, in some instances a little longer. Advantage is now taken of this holiday time more largely than used to be the case for going to the seaside, the different railway companies encouraging the colliers' exodus by liberal inducements in the way of travelling facilities.

**House and Steam Coal Firm.**

Though the absence of householders at the seaside and other resorts naturally tells upon the call for coal, business continues steady, and stocking orders are freely forthcoming, mainly for the higher grade qualities. Rather less is being done with London merchants, deliveries on contract account showing some shrinkage, due, no doubt, to the holiday influence. Qoutations are maintained for best Barnsley at 11s. 6d. to 13s. per ton at pit; secondary descriptions from 10s. to 11s. per ton at pit. Steam coal is as actively inquired for as ever, the briskness in shipments being expected to continue to the end of the season. For the last week or two the weight forwarded from Hull has not been equal to that for the corresponding week of last year; but this has been largely due to the lessened quantity sent to Sweden during the industrial trouble there. Now that this is settling down, the return will, no doubt, soon begin to show different results. The last issued, however—for the week ending 17th August—shows the coal exports from Hull to have been 68 196 tons, compared with 85,698 tons for the similar week of 1908. Cronstadt again resumes first place in the list with 11,022 tons, Rotterdam coming second with 7999 tons, and Hamburg third with 6586 tons.

**Small Coal and Coke.**

The better qualities of small coal keep in good demand, and values are fully maintained. In coke the hardening tendencies noted last week are still evident, and values are firmly maintained at the advanced quotations then given, best washed coke making from 11s. to 11s. 6d. per ton, unwashed 10s. 6d. to 11s. per ton.

**Iron—Derbyshire again Advanced.**

Producers of pig iron are asking higher prices than have been ruling for some weeks back. This is rather in consequence of a more hopeful feeling in trade than owing to actual demand, though there has been increased buying for local purposes, more especially in hematite, of late. Supplies wanted for forward delivery can only be obtained at an advance of 1s. to 2s. a ton. For Lincolnshire the official quotations remain, but prices are stiffening, and makers are not disposed to sell freely even at present quotations, believing that before long, as trade improves, better values will be obtainable. Lincolnshire, No. 3 foundry, 50s. 6d. per ton; No. 4 foundry, 49s. 6d. per ton; No. 4 forge, 49s. 6d. per ton; No. 5 forge, mottled and white, 49s. 6d. per ton; basic, 50s. 6d. per ton net, delivered in Sheffield and Rotherham. Derbyshire irons are advanced another shilling a ton, No. 3 foundry being now 51s. per ton, and No. 4 forge 50s. per ton net, delivered in Sheffield and Rotherham.

**Bars, Hoops, and Sheets.**

Quotations unaltered. Bars, £6 10s. per ton; hoops, £7 10s. per ton; sheets, £8 10s. per ton.

**The Heavy Industries.**

There is nothing fresh to report in the steel trade, which continues languid for all markets, at home and abroad. Engineering establishments are still inadequately employed, and will remain in that condition until there is greater activity on the part of railway companies and shipowners. A hopeful sign in the latter direction is the report that more vessels are being employed. The strike in Sweden is practically over, and its effects have not been felt much, except by several firms who are large users of Swedish iron, and even these, having considerable stocks, were only temporarily inconvenienced. During the past few days paragraphs have appeared in the papers with respect to large orders from the British and other Governments given, or to be given, to the Coventry Ordnance Works, Limited. These would be very welcome, both at Coventry and at Sheffield, where the firms of John Brown and Co. and Cammell, Laird and Co. are much interested as the principal proprietors. The work would, no doubt, be of a heavy character, and provide a considerable amount of employment to the Sheffield works in the early stages. The order recently placed in Darlington for 500 40-ton all-steel bogie freight wagons for Argentina is of considerable importance to this district in these times of small orders and simple replacements, and, it is anticipated, will add materially to the requirements of several makers of axles, tires, and springs.

**Colliery Development in South Yorkshire.**

Sinking operations are to be begun, within about a month's time, at a new colliery at Thorne Moore, three miles from Thorne. It is expected that the famous Barnsley bed of coal will be found to be 9ft. thick, and of rich quality; but it will not be reached until at a depth of 920 yards. Messrs. Pease and Co. are the owners, and Messrs. J. Eaton and Son are the sinkers. Messrs. Eaton sank the new pit at Bentley, nearer to Doncaster, where the Barnsley bed was reached at a depth of 623 yards. The two shafts for the new Thorne colliery will each be 22ft. in diameter inside the walling. It is estimated that when coal is reached, and operations are in full swing, there will be work for between 3000 and 4000 employés, and that an output of 4000 tons a day will be obtained.

**Derwent Valley Waterworks.**

Mr. O. B. Steward, clerk to the Derwent Valley Water Board, has issued a report showing the progress of the works. The period covered is the three months from March to June. At the Bole Hill quarries 271 men are employed, and up to the 10th of June 1,071,712 tons of stone had been obtained. At Howden reservoir 443 men are engaged, and on the Derwent dam 332. The work at both these places is proceeding satisfactorily. The Howden dam will be 1080ft. long, and the reservoir 1¼ miles in length, its capacity being 1886 million gallons. The Derwent dam will be 1110ft. long, and the reservoir 1¾ miles long; its capacity 2000 million gallons. All the other works are making satisfactory progress. The population of Birchinlee is 949. With regard to the afforestation of the catchment area, the 32 acres authorised by the Board have been completed, and the engineer has been authorised to proceed with the planting of a further area not exceeding 50 acres. The total number of workmen engaged on June 10th was 2025, and of these 1088 were in the direct employ of the Board. The cost of the works to June has been £2,434,619 9s. 11d.

## NORTH OF ENGLAND.

*(From our own Correspondent.)*

**Cleveland Pig Iron.**

QUITE a little "boom" has sprung up this week in the iron and steel industries of this district; buying in several branches has been brisk, and advances in prices the order of the day. The tone was altogether optimistic, and buyers have been much keener to operate than the sellers. The former wanted to purchase for delivery a long time ahead, but sellers did not want to commit themselves too heavily in the face of a rising market, the rise being due as much to an increase in legitimate trade as to an influx of speculation. Evidence is accumulating of the improvement in trade, and there appears to be a general upward movement, it being as noticeable in the finished as in the pig iron branches. A large business has been done during the last few days, and the price of Cleveland warrants touched a higher figure than has been known since last October—51s. 4½d. cash buyers, that being 1s. 3d. advance in a week, 2s. advance since the present month commenced, and 5s. 4½d. rise from the minimum of the current year, that being reported about the middle of March. It is said that the outside public have come in to speculate in warrants, and on Wednesday some of the operators were endeavouring to take their profits, which action rather weakened the price; in fact, at the close of the day buyers would give only 50s. 11d. cash. Makers of Cleveland pig iron have improved their position considerably this week, and have sold No. 3 somewhat freely up to 51s. 3d. per ton for early delivery, but Wednesday's quotation was at 51s. for prompt and 51s. 9d. for delivery up to the end of the year. No. 1 has risen to 53s. 6d., No. 4 foundry to 49s. 9d., and No. 4 forge to 49s. 6d. per ton, all for prompt delivery.

**Hematite Pig Iron.**

Producers of East Coast hematite pig iron have waited long for a revival of their trade, and have had a very bad time during the last two years, but now a genuine and general improvement has come with a rush, demand having become very active all at once, and a substantial rise in prices has at last to be recorded. In the main the welcome change has been brought about by the improving condition of the shipbuilding industry. Consumers and merchants have arrived at the conclusion that the time to buy has come, and that if they wait they will have to pay higher prices. Very good orders have therefore been distributed, and more could have been secured if the makers had seen their way to sell freely ahead, but they do not want to commit themselves too heavily in face of a rising market. At the close of last week mixed numbers of East Coast hematite iron could readily be got at 55s. 6d. per ton for early delivery, that being 6d. per ton above the price that had ruled for weeks, but now fully 57s. 6d. must be paid; indeed, it is regularly given, and 57s. 9d. and 58s. has been forthcoming for prompt delivery, while 60s. is asked for the first quarter of next year. This is a sharp rise, and yet quotations are still relatively cheaper than those of Cleveland pig iron. Makers of hematite pig iron are this week in high spirits, and certainly their position is considerably better than it was; indeed, some ironmasters are able to choose their customers. No. 1 for early delivery is at 58s., and No. 4 forge at 57s. The sellers of foreign ore have lost no time in advancing quotations, and do not give the iron producer much opportunity of securing profits. Ore has long been too dear compared with the prices realisable for pig iron. This week the price of Rubio ore has been advanced from 16s. 3d. to 17s. per ton by most merchants, and some are asking 17s. 6d. per ton c.i.f. Tees. Likewise the sellers of coke have run up their prices, and quotations indeed are somewhat erratic. Some are asking 17s. per ton delivered Middlesbrough furnaces, but the general price is 16s. per ton, an advance this month of fully 6d. per ton, and this with the rise in ore absorbs almost all the extra that is being obtained for hematite pig iron.

**Stocks of Pig Iron.**

If statistics had their usual influence on the market the prices would be dropping instead of rising, for it must be acknowledged that the figures of the stocks are very bad indeed. But apparently holders just now ignore the rapid increase in stocks, as the quantity now held will not be excessive if trade improves to the extent now promised. Connal's stock of Cleveland pig iron on the 25th was 280,265 tons—an increase this month of 21,094 tons. The stock consisted of 268,625 tons of No. 3, 8770 tons of No. 4 foundry, and 2870 tons of other iron not deliverable as standard.

**Exports of Pig Iron.**

Fair shipments of pig iron from the Cleveland district can be reported, and prospects of their increasing are good, for the autumn export demand will shortly have to be satisfied. The worst is that there is so little wanted by Germany this year, though this is not surprising when one takes into account the wretched condition of trade in that country. The exports up to the 25th were 89,912 tons, compared with 70,811 tons last month, 77,805 tons in August last year, and 109,268 tons in August, 1907, all to the 25th.

**Manufactured Iron and Steel.**

A decided improvement in business is manifesting itself in the finished branches of the iron and steel industries, and this is one of the most encouraging features of the trade, emphasising, as it does, the fact that there is a real revival in trade, and not a spurt only brought about chiefly by speculative operations. Prices have long been stationary, but this week there are substantial advances to be reported, chiefly as a result of the improvement in shipbuilding. Iron and steel plates, iron angles, and iron bars have all been advanced 5s. per ton—the first advances for at least two years, and there is every reason to believe that the upward movement will continue. Steel ship plates are now up to £6, steel boiler plates to £7, iron ship plates to £6 5s., iron ship angles to £7, common iron bars to £7, best iron bars to £7 7s. 6d., and best best iron bars to £7 15s. per ton, all less 2½ per cent. f.o.t. The daily papers have made a good deal of capital recently about the importation of German steel ship plates into the Wear, but evidently the North of England manufacturers attach little importance to this or prices would not have been raised within the last few days. The fact is the quantity imported is small. The prices paid could hardly pay the exporters. It is not at all likely that a competition will spring up in this district between German and British plates, and the producers of the latter are not disquieted. Steel ship angles have not yet been advanced, but can still be bought at £5 7s. 6d. per ton, and packing iron and steel at £5 5s., while steel stanchions are kept at £6 15s., all less 2½ per cent. Early advances, however, are expected in these as well as in ship rivets, and, indeed, all other shipbuilding materials that have not been raised in value this week. Steel bars are quoted at £6, steel hoops at £6 5s., and steel strip at £6 2s. 6d., all less 2½ per cent., while steel joists are at £5 7s. 6d., less 2½ per cent. Heavy steel rails are certainly in brisker request, and prospects are encouraging; they can generally be bought at £5 5s. net f.o.b. Galvanised and corrugated iron or steel sheets are selling well at the recently reduced price—£10 10s., less 4 per cent. for 24 gauge in bundles f.o.b.

**Shipbuilding.**

There can be no question that there is a brighter outlook for those engaged in shipbuilding, and the conditions are certainly more satisfactory than they have been for the past two years. The Government orders, present and prospective, have no doubt had a good effect upon the shipbuilding industry, and general shipowners are being tempted to distribute orders more freely, so that the number of empty berths at the yards is steadily being lessened. Orders for tramp steamers, as well as liners, are beginning to come in, as it will be necessary to increase quotations for new steamers. As a rule, there is greater confidence all round, and those who would get their needs supplied at anything near the bottom in prices have to lose no more time in giving out their orders. The inquiry for a new Cunarder has tended to strengthen the shipbuilding industry in this district. There are many indications of improvement in shipbuilding, and it is expected that in the coming winter depression will be much less felt than it was a year ago. Not only is there more new work, but the repairing yards are once more busy, and the marine engine works are more fully employed.

**Engineering, &c.**

Trade is showing improvement at the engineering shops, and at works where departments had to be closed for lack of orders they have been re-opened. The Blake Boiler, Wagon and Engineering Company, Limited, Darlington, which during the past twelve months has supplied 325 wagons for the Buenos Aires and Western Railway Company, in Argentina, has secured an order from the same company for a still larger number. The wagons are to carry 40 tons, and will be built for the 5ft. 6in. gauge. There is more being done in locomotive work, also in points and crossings, and more regular work than for a long time is afforded at establishments producing these. Sir W. G. Armstrong, Whitworth and Co. have applied to the Newcastle Corporation for a much larger site at Walker for shipbuilding purposes than they originally asked for. The company desires to make such alterations that there will be sufficient space for the building of a Dreadnought, and for the accommodation of the largest vessels afloat. The new shipbuilding yard at Southbank, near Middlesbrough, which is being laid out by Smith's Dock Company, Limited, will be brought into use towards the end of the present year, and the site of the present yard at North Shields will be utilised for a graving dock. At Southbank there will be accommodation for the simultaneous construction of the hulls of twelve steam trawlers.

**Coal and Coke.**

It is curious to note that while best steam coals continue to decline in price, best gas coals are firm, and whereas the former were not long ago realising 13s. per ton f.o.b., they can now be bought at 10s. 9d., but best gas coals have been maintained at 11s. to 11s. 6d. for a long time. It is very unusual to see best steam coal below best gas coal in price. The trade in the latter is, however, steady and legitimate, while that in steam coal has lately been inflated by reason of the Welsh and Scotch labour difficulties, and these having been settled amicably prices have come down with a run. Coke is very stiff in price, and supply is hardly equal to demand. Some sellers have advanced their quotations for furnace coke to 17s. per ton, delivered at Middlesbrough, or equal thereto, but generally 16s. will be accepted. The Executive Committee of the Durham Miners' Association

have issued a circular to their members protesting against the practice of ceasing work without giving notice to the masters. Pits were stopped, and the men's agents knew nothing until they saw the fact announced in the papers. No opportunity was given to remedy any grievance, though no trade organisation possessed such complete machinery for settling disputes as theirs. Messrs. Doxford and Sons have patented what they term a "Belt Conveyor Discharge," and have this week at their yard at Sunderland given a demonstration of its working. It has been fitted to the steamer Pallion. The new machinery elevates the coal from the holds by means of running belts, and discharges on to either side of the ship into barges or on to the quay. We refer in detail to this vessel in another column. The Warrenby Relief Fund, which was opened in 1895, after the boiler explosion at the Redcar Ironworks, when a dozen men were killed, has now been closed. In addition to assisting the widows directly, the fund, which reached £2300, was used to help the children until they attained fourteen years of age.

## NOTES FROM SCOTLAND.

*(From our own Correspondent.)*

### The Revival in Trade.

ADDITIONAL evidence has been furnished since last report of the revival in trade. It would seem that the upward movement in the values of raw iron, which at the first was admittedly of a speculative nature, is now being accelerated by reports as to the placing of contracts for which large supplies of iron will be required. How far the upward trend of prices may go it is impossible to forecast. Many industries in which iron is employed are experiencing an improvement in business, and the demand for the raw material is accordingly becoming more general and widespread. The bullish feeling in the markets has been gathering force, but makers of iron and steel are apparently anxious that its influence should be restrained, so that prices may not be rushed in such a manner as to check the outcome of orders. Fortunately stocks of iron are not so heavy as they have sometimes been in times of boom, and warrants in circulation are also limited; so that if the speculative market is pushed too rapidly the "bears" are likely to come in for their share of the business.

### Pig Iron Market.

The Glasgow warrant market has been active since last report, and an increasing amount of iron has changed hands, the prices reaching a higher point, despite occasional fluctuations. Business has been done in Cleveland warrants from 50s. 7d. to 51s. 4d. cash, 50s. 11½d. to 51s. 7d. one month, and 51s. 3½d. to 52s. three months. Transactions are also recorded at 50s. 11½d. to 51s. for delivery in twenty-two days, 51s. twenty-seven days, 51s. 4d. eleven days, 51s. 5d. eighteen days, and 51s. 9d. for 15th October. The amount of iron turned over in the last few days has been greater than for a long time past. The upward movement in Cleveland iron has been attended by an advance in other classes of warrants. Scotch warrants have risen from 56s. 9d. to 58s. 3d., receding subsequently to 57s. 3d., but the stock is so low, and warrants so few, that transactions involving delivery of iron are all but impossible. Standard foundry pig iron has advanced from 49s. 3d. to 50s. 3d. per ton.

### Hematite Ore and Pigs.

The imports of hematite ore into the Clyde are increasing as might have been expected owing to the anticipation that larger quantities of it will be required. The quantity received for the year to date is about 100,000 tons greater than in the same period of last year, and the past week's imports consist of eighteen large steamboat cargoes, three of which came from England and the rest from abroad. There has been more life in hematite warrants in the last few days than for a long period, and as the quantity in circulation is comparatively limited, prices have sharply increased. Business has been done in our market in Cumberland warrants 58s. 9d. cash, 59s. for delivery in November, and 60s. 2d. and 60s. 3d. for delivery in twenty-seven days. There has also been a material rise in Scotch hematite, which is now quoted by merchants at 60s. for delivery at the West of Scotland steelworks. This latter figure marks an advance of 3s. 6d. per ton from the lowest point touched this year.

### Scotch Makers' Pig Iron.

The position of the Scotch makers is becoming stronger. The inquiry for both G.M.B. and special brands has been active and general, both for local and English consumption as well as for shipment. Two additional furnaces have been lighted since last report to produce ordinary iron, one at Gartsherrie and the other at Ardeer, and the number now in blast in Scotland is 82, compared with 80 last week, and 75 at this time last year. There are now 39 furnaces producing ordinary, 38 hematite, and 5 basic pig iron. Some of the makers have this week intimated a further advance of 1s. per ton in prices. The f.a.s. prices at Glasgow at the time of writing are, for Govan and Monkland Nos. 1, 58s.; Nos. 3, 56s.; Carnbroe, No. 1, 59s. 6d.; No. 3, 56s. 6d.; Clyde, No. 1, 62s.; No. 3, 57s.; Gartsherrie, Langloan, and Calder, Nos. 1, 62s. 6d.; Nos. 3, 57s. 6d.; Summerlee, No. 1, 63s. 6d.; No. 3, 58s. 6d.; Coltness, No. 1, 88s.; No. 3, 58s. 6d.; Eglinton, at Ardrossan or Troon, No. 1, 58s.; No. 3, 56s.; Glengarnock, at Ardrossan, No. 1, 63s. 6d.; No. 3, 58s. 6d.; Dalmellington, at Ayr, No. 1, 60s. 6d.; No. 3, 55s. 6d.; Shotts, at Leith, No. 1, 62s. 6d.; No. 3, 53s. 6d.; Carron, at Grangemouth, No. 1, 64s. 6d.; No. 3, 57s. 6d. per ton.

### Pig Iron Shipments.

The shipments of pig iron from Scottish ports in the past week amounted to 4774 tons, comparing with 5462 in the corresponding week of last year. There were despatched to Canada 525 tons, South America 180, India 185, Australia 795, France 250, Germany 140, Holland 260, Russia 10, Belgium 45, China and Japan 27, other countries 255, the coastwise shipments being 2102 tons, against 2887 in the same week of 1908. The arrivals at Grangemouth of pig iron from Cleveland and district were 9415 tons, being 579 tons less than in the corresponding week of last year.

### Finished Iron and Steel.

Orders have been coming to hand more freely, especially in the steel trade, and the inquiries seem to point to a considerable expansion in demand. The rise in the prices of pig iron led the makers of malleable iron to advance their prices 7s. 6d. per ton. The steel makers have had several meetings discussing prices, but the general feeling has been that the matter at this stage requires to be dealt with cautiously. There can be no doubt that the tendency of prices is upwards, and it is reported that, as a rule, the steel makers are quoting present rates only against prompt specifications. This policy will enable them to put their machinery into fuller operation. The impression increases that there are orders in reserve for a very respectable quantity of steel material both for shipbuilding and other purposes. The export trade also promises well, and there is a large amount of this kind of business in hand, merchants and shippers pressing for early delivery. Some steelmakers have in prospect good lines of shipbuilding material. There is a good demand for tubes for a variety of purposes. Plain and galvanised sheets are also in demand. Ironfounders in some instances find business better than for a considerable time past, general and miscellaneous castings being more plentiful, while there is more life in the domestic branch of the foundry trade.

### Engineering and Shipbuilding.

The outlook in the engineering trade is more encouraging, and business is coming forward more freely. The marine branch has fair prospects, with a good business in progress. The Caledonian Railway has placed with a Glasgow firm orders for nineteen renewal bridges, which will provide employment during a lengthened period and absorb a large amount of material. A large order for railway plant has also been secured by a Glasgow company for the Argentine Republic. Some fair shipbuilding orders have been received, and it is understood that there are others of importance in prospect.

### The Coal Trade.

The coal markets are generally quiet, but shipments have been heavier than usual, and the current business for export is good, especially on the East Coast. Home consumers are purchasing only for present requirements, and prices for all kinds of coal are practically unchanged.

## WALES AND ADJOINING COUNTIES.

*(From our own Correspondent.)*

### State of the Coal Trade.

COLLIERIES are now getting into fuller work as the holiday season wanes, and it is satisfactory to note that there is a fair maintenance of prices. Many believed that prices would advance quietly into the 18s. net, but the older attendants on 'Change, who have been somewhat disappointed that house coals have not declined more during the hot season, are satisfied if prices can be retained about present rates until the autumnal season is more advanced. It will be seen that prices have only moved slightly. There has been a better attendance this week, and a little more animation, but on 'Change chief interest is being directed to the contest in the Committee Courts, where the issue will have a most important effect on business. Best steam and seconds are in strong demand, and while Monday brought about substantial dealings—considering that it was the first day of the week—Tuesday was still more animated, and dry coals were again in strong demand. The latest quotations were as follows:—Best large steam, 17s. 9d. to 18s.; best seconds, 16s. 3d. to 17s. 3d.; ordinary seconds, 15s. 6d. to 15s. 9d.; best drys, 16s. 6d. to 17s.; ordinary drys, 14s. to 14s. 6d.; best washed nuts, 14s. to 15s.; seconds, 13s. to 13s. 6d.; best washed peas, 12s. 6d. to 13s.; seconds, 11s. to 12s.; very best small steam, 9s. to 9s. 6d.; best ordinaries, 7s. 3d. to 8s. 3d.; inferior sorts, 6s. 6d. to 6s. 9d.; best Monmouthshire black vein, 15s. 9d. to 16s.; ordinary Western Valleys, 15s. 3d. to 15s. 6d.; best Eastern Valleys, 13s. 9d. to 14s. 3d.; seconds, 13s. to 13s. 3d. Bituminous coal: Very best households, 16s. 6d. to 17s.; best ordinaries, 14s. 6d. to 15s. 6d.; No. 3 Rhondda, 17s. 3d. to 17s. 6d.; brush, 13s. 6d. to 13s. 9d.; small, 10s. 6d. to 11s.; No. 2 Rhondda, 12s. to 12s. 6d.; through, 9s. 6d. to 10s.; small, 8s. to 8s. 3d. Patent fuel, 15s. 6d. to 17s. 6d. Coke: Special foundry, 24s. 6d. to 27s. 6d.; ordinary foundry, 19s. to 22s.; furnace, 17s. to 18s. Pitwood, 20s. 6d to 21s. Public interest has been diverted to the results of using the best Welsh steam coal on leading steamers, where some striking figures are shown. This has been the case with the Cunard liner Lusitania, which arrived at New York at 9.55 p.m. on August 12th in 4 days 16 h. 40 min., thus lowering her time record by 2 h. and 55 min. The average speed was for 2890 miles 25.65 knots. The last 247 miles figured at the rate of 25.77 knots.

### Last Week's Coal Trade.

Those who watch keenly the changes of the trade say that it is not the higher-priced coals which show the earliest indications of change. These for some time will exhibit firmness when the inferior coals are beginning to waver. For some weeks the inferior coals, fairly good in quality but inferior as regards the best steam or bituminous, have been in better demand. Last week a better supply enabled coalowners to sell more freely, and to accept also a slight reduction in price. In several instances there were deductions of 3d. from the past quotations. Dry coals remained stiff and rather scarce. The coal prospects are against the likelihood this time of an ascent in price from 18s. This figure was obtainable last week, and in some quarters 18s. 3d. was asked, but the tendency is downwards, and one prominent reason is to be seen in the fact that bookings for September are not at all largely placed. Buyers are waiting to see reduced quotations.

### Newport Coal.

Newport has again given evidence of its healthy condition and steady increase in coal development by having shipped 92,449 tons of coal in the course of last week. The large new collieries now in progress, the great dock equipment, and the future of the Rhymney Valley are all significant. What the Rhondda has been, the Rhymney Valley promises to emulate, if not surpass. This is the site of the new Rhondda, and the only point of contest between authorities is whether its best coals will rival those of which the 4ft. Merthyr is one of the finest examples. The late Richard Fothergill, who was one of the successful advocates in the House for the selection of steam coals for the Admiralty, used to describe it as the finest in the earth, opening like a cauliflower. Newport steam coal is now in strong demand. The only falling off has been in placing forward, which has not been so urgently done during the last week or two. Latest prices:—Lower figures are being accepted for second quality Eastern Valleys. Best Newport black vein, 15s. 6d. to 15s. 9d.; Western Valleys, 15s. to 15s. 6d.; Eastern Valleys, 13s. 6d. to 14s.; other kinds, 12s. 9d. to 13s.; best smalls, 8s. to 8s. 3d.; seconds, 7s. 3d. to 7s. 6d.; inferiors, 6s. 9d. to 7s.; best house coal, 15s. to 15s. 3d.; seconds, 14s. to 14s. 3d.; patent fuel, 15s. 3d. to 15s. 6d. Coke: Foundry, 18s. 6d. to 19s. 6d.; furnace, 17s. to 17s. 6d. Pitwood, ex ship, 20s. to 20s. 6d. Steam coals are beginning to droop. A noticeable circumstance last week connected with the smaller port was that Port Talbot cleared in two cargoes 7400 tons coal to Bordeaux.

### Swansea Coal.

The port, which is recovering from holiday influence, showed last week a gratifying increase. Close upon 90,000 tons of coal were despatched. The collieries are now working with greater regularity, and there is a strong impression prevailing that the season of winter coals now at hand will be a brisk one. From the margin of the Neath valleys to Pembrokeshire the famous seams of anthracite now in steady development are well placed for the increasing demand which is obtained every season. Strength and firmness were shown when the market opened this week, and best large Swansea was in good demand. Red vein not in good form, and a reduction appears to be setting in; machine coals scarce; rubbly culm firm. Lowest prices:—Anthracite coal, large hand picked, 24s. to 25s. net; seconds, net, 21s. 6d. to 22s. 6d.; big vein, large, 19s. 6d. to 21s., less 2½; red vein, 12s. to 12s. 6d., less 2½; machine-made cobbles, 23s. 6d. to 24s. net; Paris nuts, 25s. to 25s. 6d. net; French nuts, 25s. to 26s. net; German nuts same; beans, 17s. 6d. to 18s. net; machine-made large peas, 11s. 6d. to 12s. 6d. net; fine peas, 10s. to 11s. net; rubbly culm, 5s. 6d. to 6s., less 2½; duff, 3s. to 3s. 3d. net. Steam coal:—Best large, 17s. to 17s. 6d., less 2½; seconds, 14s. to 15s., less 2½; bunkers, 10s. to 10s. 9d., less 2½; small, 8s. to 10s., less 2½. Bituminous coal: No. 3 Rhondda, 18s. to 18s. 6d., less 2½; through, 15s. to 15s. 6d., less 2½; small, 10s. 3d. to 10s. 9d., less 2½. Patent fuel, 13s. 9d. to 14s., less 2½.

### Shipping "Combine."

The progress of the ship era, as regards the coal ports of Wales, is on the eve, to all appearances, of receiving a striking addition. When the era opened the coal fleet was limited to sailing vessels trading to Bristol and London, and all of small dimensions. From the thirties these have increased in size, and with the advent of steam power have received an intruder, as old sailors consider, which has gradually displaced sailing vessels by steamers, some of large dimensions. Leading coalowners, such as Radford, now have large fleets, chiefly steamers. One, Messrs. Tatem and Co., have now fifteen large steamers, and it is proposed to amalgamate these and form one large undertaking. The capital is to be £330,000 in £1 shares. The lowest value of any vessel of the fleet is set at 42 per cent. of the original, while the Lady Lewis, which is only two years old, is credited with 2 per cent.

### Iron and Steel.

There are significant rumours of changes in the iron and steel trades of the district, but it will be wise to discountenance them for a time. At the first glance they appear to be improbable, but the trade is evidently entering upon a course so distinct from that pursued by the founders that it is not safe to deny the possibility of alterations which may be forced by the turn of affairs, or for economical reasons. At one time the existence of ironstone in a district determined the site of the furnace. Now Welsh ironstone only comes in as a very small accessory; the position on the coast has followed that of Rubio ore. The substitution of hot for cold is the chief consideration. The importation of pig iron from Spain blast was not a more vital change than that of increased production. Dowlais, for example, is being laid out for a very great increase, so large as to make it imperative to have a corresponding increase in demand. Trade continues in a very unsatisfactory state. Up to a late period, while the principal works remained in a weak state, Dowlais displayed a great deal of vitality. A smart business was being done in rails for the Colonies, and the development employed a number of men. Of late there is less being done in reconstruction, and the operatives are being reduced. A large number of mechanics and others are under notice, and at the steel works the regular time is now getting to be four days per week; foundry and locomotive shops are being similarly treated. The stoppage of important work and the issue of notices suggests some radical changes, and now that Cyfarthfa works are practically stopped, the outlook becomes serious. Dumping continues, and appears to be steadily increasing. Imports this week small. In the Swansea Valley the make of pig continues satisfactory. Metal Exchange quotations:—Hematite mixed numbers, 59s. 10½d. cash and month; Middlesbrough, 51s. 4d. cash, 51s. 7d. month; Scotch, 57s. 3d. cash and month; Welsh hematite, 62s. 6d. to 63s. 6d., delivered; East Coast hematite 62s. to 62s. 6d., c.i.f.; steel bars, Siemens, £4 10s.; Bessemer, £4 8s. 9d. to £4 10s. Other quotations: Block tin, £137 17s. 6d. cash, and £139 2s. 6d. three months; copper, £59 17s 6d. cash, and £60 16s. 3d. three months; lead, £13; spelter, £22 2s.; silver, 23½d. per ounce. According to a telegraphic dispatch received as we go to press the prices of rails, bars, and ore were slightly advanced, while the prospects generally in Wales and the Midlands assumed a brighter aspect.

### Tin-plate.

The harbour returns, Swansea, last week were as follows:—Received from works 84,186 boxes; shipped during the week, 90,964 boxes; stock remaining, 130,257 boxes. The important event of the week was the annual meeting of the Swansea Metal Exchange, Col. Wright in the chair. The review by the chairman was received with great interest, and as a reliable commentary on trade, and replete with subject matter for discussion, will be widely read. In moving the adoption of the report, the chairman congratulated the attendance that the make of tin-plate, black plate, and galvanised sheets had not suffered so much in Wales as elsewhere. Last year when he addressed them the tide of trade showed a decline. The tin-plates exported in 1907 amounted to 406,328 tons, and in 1908 to 402,869 tons, a decrease of 3459 tons. Black plates in 1907 totalled 71,531 tons, in 1908 to 61,068 tons, a decrease of 10,463 tons. Galvanised sheets exported in 1907 were 467,889, in 1908 to 390,124, a decrease of 77,765 tons, or 6 per cent. The chairman, after showing the loss sustained by these items to the iron and steel industry, went on to comment upon the increased dumping. Up to 1907 the imports to which he specially alluded were shown as a total under the heading of foreign steel, and included blooms, billets, slabs, steel and tin-plate bars. In 1907 we imported 527,201 tons of these classes. In 1908 the classes were divided under three headings, viz:—Ingots, 21,147 tons; blooms, billets, and slabs, 409,206 tons; steel and tin-plate bars, 130,187 tons, making a total of 560,540 tons, which gave an increase of 233,339. This, the chairman showed, if the manufactures could have been confined to Wales, would, roughly stated, have kept five blast furnaces, two steel works, and two collieries fully employed. Concluding a long and able survey of conditions and prospects, the chairman deduced a valuable moral, showing that foreign rivalry emphasised the necessity for the retention and improvement of trade relations and freedom from labour troubles, and maintaining the excellence of make and manufacture. Latest prices: Ordinary tin-plates, Bessemer primes, 12s. 1½d. to 12s. 3d.; Siemens primes, 12s. 1½d. to 12s. 3d.; ternes, 21s. 3d. to 21s. 6d.; c.a. roofing sheets, £8 7s. 6d. to £8 10s.; big sheets for galvanising, £8 10s. per ton; finished black plate, £9 10s. per ton; galvanised sheets, 24 g., £10 5s. to £11 nominal.

## PERSONAL AND BUSINESS ANNOUNCEMENTS.

MR. VINCENT S. ALLPRESS asks us to state that in future all letters and correspondence, &c., should be addressed to him either at 39, Victoria-street, Westminster, or to Southwick, Sussex.

THE British Griffin Chilled Iron and Steel Company, Limited, asks us to state that the recent fire at 139, Cannon-street, will in no way affect its business, but that on and after Wednesday, the 1st September, its London address will be 81, Cannon-street, E.C.

MR. T. R. WILTON, B.A., informs us that he has commenced practice at 18, Westminster Chambers, 1, Crosshall-street, Liverpool, as a civil engineer. Mr. Wilton was for many years an assistant to Mr. A. G. Lyster, M. Inst. C.E., Engineer in Chief to the Mersey Docks and Harbour Board.

THE Hon. Alexander Murray, M. Inst. C.E., Colonial Engineer and Surveyor-General to the Government of the Straits Settlements, is retiring on pension, after a period of no less than thirty-eight years' service in the Eastern Colonies. He has held his present appointment since January, 1898, when he left the Ceylon Public Works Department, where he had risen to be Assistant Director of Public Works. During the decade in which he has been head of the Straits Settlements Public Works many important works have been put through in the three Settlements of Singapore, Penang, and Malacca, while in the last year or two Labuan has been added to the original Settlements. During this time the expenditure of the Colony on public works has been trebled and the staff doubled.

INSTITUTION OF MINING ELECTRICAL ENGINEERS.—A Council Meeting of the Institution of Mining Electrical Engineers was held at the Royal Victoria Hotel, Sheffield, on Saturday, the 21st inst. A report was presented by the Hon. Secretary, Mr. J. G. Williams, 3, Moresby Parks, Whitehaven, showing that the membership had reached 300, with a prospective immediate increase to 400 by the addition of candidates who had not yet been formally elected. The Draft Memorandum and Articles of Association were submitted and provisionally approved. It was resolved to create a Diploma Class of Membership, to which candidates could only obtain admission by examination, after having had an approved term of practical experience in charge of electrical plant in mines. It was further arranged that entrance fees should be payable by members of all classes who join after the incorporation of the Institution,

## NOTES FROM GERMANY, FRANCE, BELGIUM, &c.

*(From our own Correspondent.)*

### Rheinland-Westphalia.

IN spite of a slightly better employment that can be noticed in some departments, quotations leave much to be desired, and the competing mills have even succeeded in further reducing the prices for bars. At a recent meeting of the Steel Convention it was stated that the amount of orders booked at present is 300,000 t. higher than at this time last year. Inland demand in semi-finished steel was stated to have slightly improved, exports remaining limited. Present quotations are to be maintained during the next quarter. In the beginning of the present month the orders booked for sectional iron were 75,000 t. higher than in August, 1908, while deliveries during the first seven months of this year were 174,000 t. higher than in the corresponding period last year.

### The Silesian Iron Market.

A greater activity in the building line has caused inland demand for girders and sectional iron to rise, and five to six weeks are the terms of delivery now generally asked, against two to three weeks in last month. Rates have not shown any forward movement; offers of West German firms are plentiful, prices rarely exceeding M. 91 p.t., free Rhenish-Westphalian works, while merchant iron from the Saar is being sold at M. 88 p.t. at works, and this has forced the Silesian ironworks to maintain their low rates; export to any but the nearest countries is quite out of the question. Of the plate market much the same is reported, employment showing an improvement, while quotations remain unremunerative. Official quotations of the Düsseldorf 'Change from August 6th are as under:—Raw spathose ore, M. 10.90; roasted ditto, M. 15.50; Nassau red iron ore, M. 11.50 per ton net at mines. Spiegeleisen, 10 to 12 per cent. grade, M. 60 to M. 63; white forge pig, M. 55 to M. 58; iron for steel making, M. 54 to M. 56; German Bessemer, M. 56 to M. 58; basic, free place of consumption, M. 48 to M. 50; Luxemburg forge pig, free Luxemburg, M. 43 to M. 45; Luxemburg foundry pig, No. 3 M. 45 to M. 46; German foundry pig, No. 1, M. 54 to M. 56; No. 3, M. 53 to M. 55; German hematite, M. 55 to M. 57; common bars in basic, M. 95 to M. 100; iron bars, M. 122.50 to M. 125; hoops, M. 120 to M. 122 50; steel plates, M. 104 to M. 110; boiler plates, M. 114 to M. 120; sheets, M. 117.50 to M. 125, all per ton, free at works.

### Austria-Hungary.

There was a little more life felt in the bar and girder department, German imports being less, but there was not much business done generally, a languid tendency prevailing in most branches. In pit coal, as well as in brown coal, a satisfactory business has been transacted, and there will be more life presently, the sugar mills now coming forward with more orders.

### Iron and Steel in France.

Makers of semi-finished steel have been doing a fairly remunerative business of late; buyers have come forward more freely with their contracts, and the export trade shows an improvement of 40 to 50 per cent. against previous months. The rolling mills and constructional shops purchase freely, French railway companies having placed numerous orders for locomotives and wagons, and the rail works are well occupied. A contract of 20,000 t. rails was recently placed with some of the leading firms. The mills of Pont à Mousson are doing a good export trade, having secured 16,000 t. pipes for Mexico, and also for Cairo. For merchant iron 155f. to 160f. p.t. is generally paid in the North, which means an advance of 5f. p.t. against previous months; in the Haute-Marne and Centre 165f. to 170f. p.t. are given, and in the Loire 180f. p.t. Girders are in improving request at 190f. p.t. Heavy plates, being in rising demand, have realised 5f. p.t. more than in last quarter. In the Haute-Marne 3 mm. plates are quoted 190f. to 195f. p.t.; in the East and North 165f. to 170f. p.t. are usually given. On the French coal market good trade is reported, especially in engine fuel.

### Fair Activity in Belgium.

There is no change in the character of the trade in iron and steel; purchases have rather increased in volume, as more work is coming forward in the manufactured iron department. Some mills have been able to raise bars to £4 10s. f.o.b. Antwerp, while those in less active occupation quote £4 9s. per ton. Plates and sheets generally meet with better request. A somewhat fluctuating tendency was felt on the pig iron market, foundry pig varying between 65f. and 66f. p.t., while forge pig iron only realises 65f. p.t. Compared with last year, output in pig iron shows an improvement; of 44 existing blast furnaces 36 only are in blow, with a daily output of 4800 t. Production in July was 148,110 t., against 102,890 t. in the year before, and during the first seven months of this year 887,390 t. were produced, against 681,270 t. during the same period last year. On the Belgian coal market a steady and remunerative trade is being done.

## AMERICAN NOTES.

*(From our own Correspondent.)*

NEW YORK, August 15th.

CHANGES of conditions come suddenly in the United States. The collapse of railway building two years ago and the cutting down of expenses in every conceivable manner left the great iron and steel industry with 40 per cent. of its trade practically cut off. Many influences have united to keep the railroad companies out of the market until recently. The last department in the steel industry to improve is the steel rail industry. Within a very short time orders have begun to flow in. Western mills are deriving the first benefits. The Illinois steel mills and the great Gary plant have now more orders for rails than they can complete by the close of the year by upwards of 100,000 tons. Overflow orders are being sent east. The cause of this sudden burst was the action of three large railway systems in ordering equipment amounting in value to 23,000,000 dols. Thousands of buyers of securities are again buying, and quotations for railway and industrial stocks show a steady upward tendency. Large orders for steel are arriving at eastern plants, and the possibility of not obtaining deliveries in time to suit is leading to a rush of orders by some large buyers. During the month of June the orders for cars amounted to 7600, for July 25,000, and thus far in August 30,000. The strike at the works of the Pressed Steel Car Company, near Pittsburgh, continues.

In structural steel the demand is again large, and orders for early delivery cannot be taken care of. The plate mills by this time are all full of work, and a large amount of business is in sight for the autumn months. The furnace interests are rejoicing over the complete transformation of their business. Prices are quietly moving upwards, especially in steel-making iron. An additional source of activity is found in the shipyards along the Atlantic Coast. The rapid development in the Southern States, especially in the cotton and mineral belts, has stimulated commercial relations. The result is a demand for shipping facilities. All the yards are now running to full capacity. Among recent rail orders are 20,000 tons by the Baltimore and Ohio Road, 10,000 tons by the Chicago and Great Western, and 5000 tons by Burlington. The Pennsylvania Company has added to its recent order cars which will cost three million dollars. Greater activity prevails in copper. During July the Copper Producers' Association report an increase in deliveries of 32,000,000 pounds. Arrivals of tin this month 10,000 tons in round figures.

## BRITISH PATENT SPECIFICATIONS.

*When an invention is communicated from abroad the name and address of the Communicator is printed in italics.*

*When the abridgment is not illustrated the Specification is without drawings.*

*Copies of Specifications may be obtained at the Patent-office Sale Branch, 25, Southampton-buildings, Chancery-lane, London, W.C., at 8d. each.*

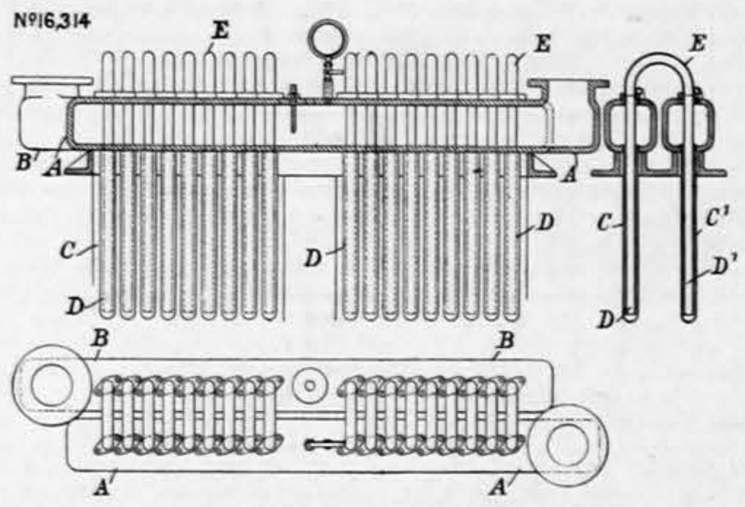
*The first date given is the date of application; the second date at the end of the abridgment is the date of the advertisement of the acceptance of the complete specification.*

*Any person may on any of the grounds mentioned in the Acts, within two months of the date given at the end of the abridgment, give notice at the Patent-office of opposition to the grant of a Patent.*

### STEAM GENERATORS.

16,314. August 1st, 1908.—IMPROVEMENTS IN APPARATUS FOR SUPERHEATING STEAM, Andrew Bolton, of 49, Deansgate, Manchester, and Thomas Carter Beeley, of Hyde Junction Ironworks, Hyde, both in the County of Lancaster.

Two separate boxes as A and B are provided placed parallel to each other, one box being for the inlet and the other box for the outlet of the steam, each box having one or more rows of tubes C $C^1$ depending therefrom; the upper ends of these tubes are open, and are expanded in the bottom of the separate boxes, and the bottom ends of the tubes are closed. Tubes D $D^1$ of lesser diameter are placed within and extending respectively nearly to

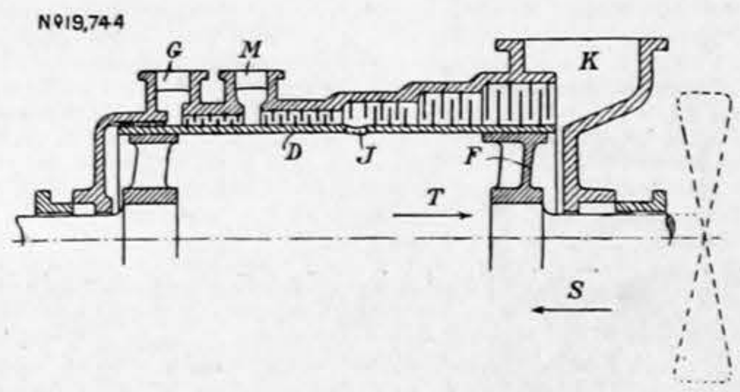



the bottom of the closed ended tubes; the bottom ends of these inserted tubes are open, and the upper end of each of the inserted tubes D on the inlet side or box is connected to the upper end of a corresponding tube $D^1$ on the outlet side or box B by a semi-circular tube E. By these means the steam entering the inlet box A will pass down the set of tubes C whose bottom ends are closed, ascend the tubes D inserted therein, pass through the semi-circular connecting tubes E, pass down the inserted tubes $D^1$ connected therewith, ascend the closed ended tubes $C^1$ in which they are inserted, and enter the other or outlet box, passing from thence to the outlet pipes. There are seven illustrations.—*August 4th*, 1909.

### TURBINES.

19,744. September 19th, 1908.—IMPROVEMENTS IN AND RELATING TO BALANCING MEANS FOR STEAM TURBINES, *Carl Roth, of 9, Anna Scrarse Zehendorf, near Berlin.*

Steam enters by the pipe G and passes through the blades below it. At a point J any suitable connection is made to the interior of the drum. For instance, an opening is provided in the drum D to admit steam to the inside of the drum, and from the opening J the blading on the drum and casing is continued to the exhaust K. At a convenient distance between the steam inlet G and the opening J, the inlet M from the overload valve is arranged. The drum is of constant diameter throughout its

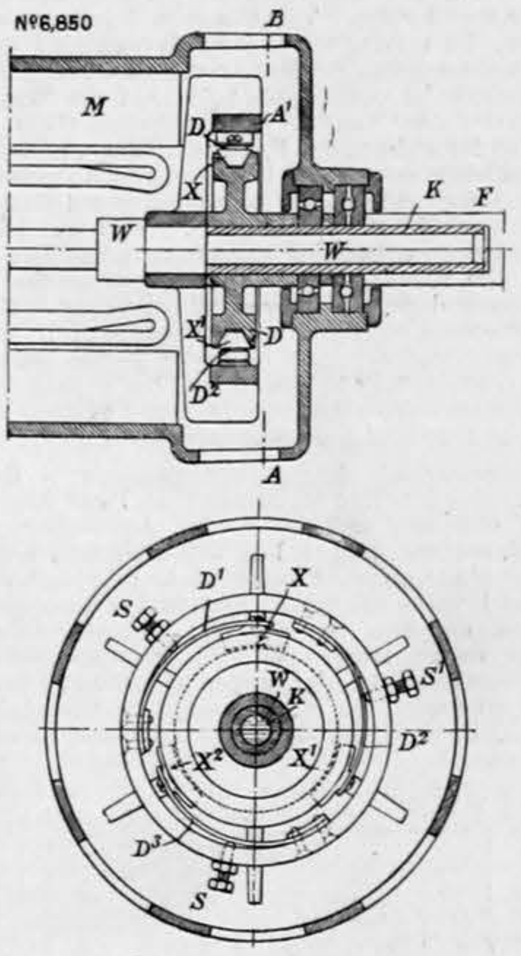



length, and no end balancing faces are provided on which there is a resultant pressure. The shaft is continued outside the casing towards the right, and carries the propeller. The direction of the thrust on the propeller is that shown by the arrow S, while the direction of the pressure on the turbine blades and also on the closed disc F is that of the arrow T. When the end pressure on the propeller shaft varies, the load on the turbine also varies, and in consequence the pressure of steam passing through the opening J alters. Thus if the end pressure of the propeller shaft increases and the overload valve is opened so that steam passes through the opening M, the pressure of steam passing through the opening J in the turbine drum is increased, and in consequence the resultant end pressure on the closed disc F is also increased. In this way automatic control of the end pressure is secured. There are two other modifications.—*August 4th*, 1909.

### TRANSMISSION OF POWER.

6850. March 22nd, 1909.—IMPROVEMENTS IN FRICTION COUPLINGS ADAPTED FOR USE WITH ELECTRO-MOTORS FOR DRIVING MACHINE TOOLS AND THE LIKE, *La Société Anonyme Electricité Electro-mécanique, of 34, Rue du Bosquet, Brussels, Belgium.*

This invention has for its object to avoid the overload and the consequent premature disabling of electric motors, and to this end an improved adjustable friction coupling, of the kind provided with friction driving blocks carried by spring arms adjusted by screws, is employed. On the shaft W of the electro-motor M one member $A^1$ of the coupling is secured. A sleeve K turning freely on the shaft W carries at one end the second member D of the coupling, the other end of the said sleeve having secured thereon the tool carrier F or the like, which may, for example, carry a drill or boring tool. The outer surface of the member D is provided with a V-shaped groove into which friction blocks X $X^1$ $X^2$, carried by springs $D^1$ $D^2$ $D^3$ attached to the member $A^1$ are pressed by means of the screws *s s s*. The power transmitted from the motor to the tool thus depends upon the frictional resistance of the blocks $D^1$ $D^2$ $D^3$, which latter may be regulated proportionally to the power. When the load becomes too heavy and tends to overload the motor, the friction blocks $D^1$ $D^2$ $D^3$, being adjusted by the screws to the overload point of the motor, will slip, thus preventing any overloading of the motor and breaking of the drill or other tool.—*August 4th*, 1909.

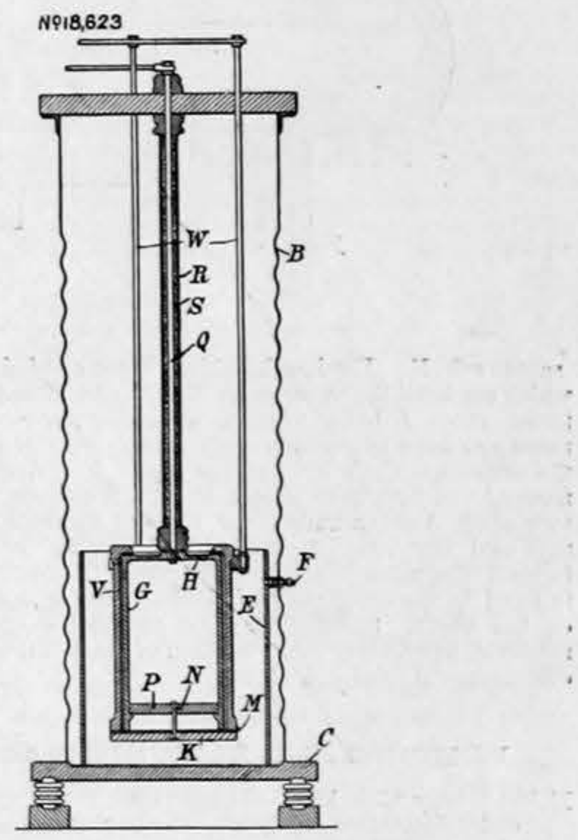



*Section on line A.B.*

### SWITCH GEAR.

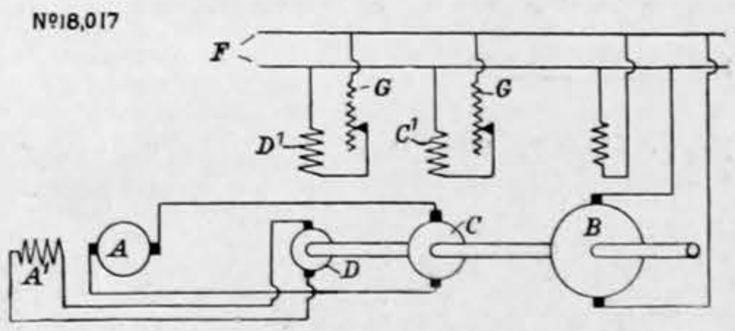
18,623. September 4th, 1908.—IMPROVEMENTS IN ELECTRIC STARTING SWITCHES USING LIQUID RESISTANCE, the Sandycroft Foundry Company, Limited, engineers, and Thomas Murthwaite Dutton, both of Sandycroft, Chester.

The liquid is contained in a tall metal cylinder B, which is corrugated to assist in the dissipation of heat. The container is mounted upon a base C, which has supports of porcelain. Within this cylinder there is provided a cylindrical electrode E, which may be of wrought iron, and which is joined to a connecting nut F. The inner electrode G is also cylindrical, and is preferably of cast iron. The casting is closed at the upper end, which, however, is protected by a layer H of enamel or other suitable insulating material. At the lower end the mouth of the cylinder is closed by a plate of wood or the like K, between which and the edge of the cylinder G a tight joint is made by an india-rubber or other packing M. The plate K is pressed against the mouth of the cylinder by a bolt N passing through it and through a cross-piece P resting against projections in the interior of the cylinder. This inner electrode, with its bottom cover, is supported in the vessel by means of the conductor Q, through which the current passes. This conductor is surrounded with an iron tube R filled with bitumen or the like S. Porcelain insulators are preferably interposed at the top and bottom of this tube. With cylindrical electrodes the insulating screen V also takes the form of a cylinder, which, however, is open at both ends. This cylinder is supported by a number of rods W, by means of which it may be raised or lowered in the liquid. The screen may be made of porcelain or other insulating material, or of enamelled iron or the like.—*August 4th*, 1909.




### DYNAMOS AND MOTORS.

18,017. August 27th, 1908.—IMPROVEMENTS IN OR RELATING TO THE REGULATION OF ELECTRIC MOTORS, Siemens Brothers' Dynamo Works, Limited, of York Mansion, York-street, Westminster.

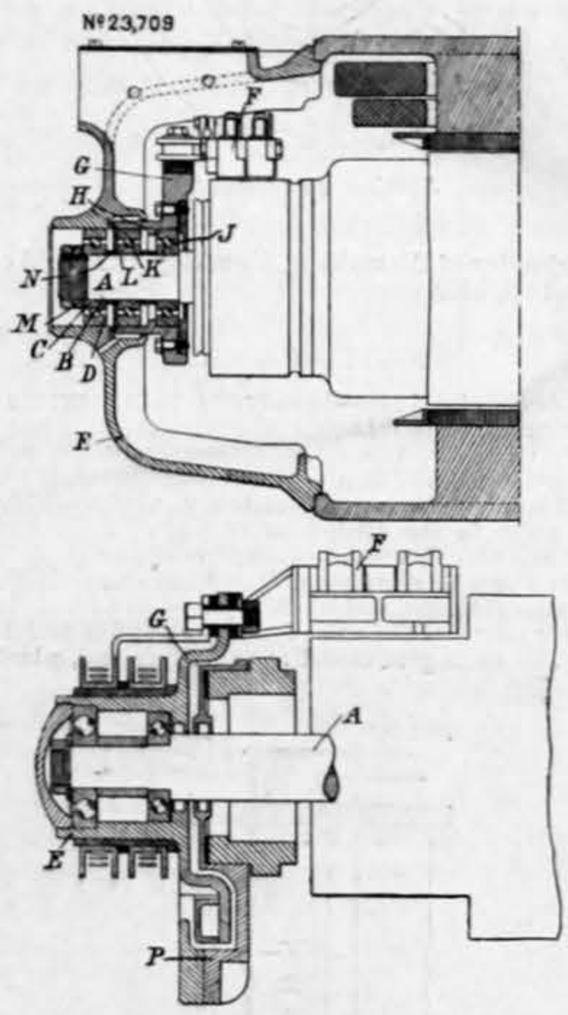



This invention has reference to improved arrangements either for regulating the speed of direct and single or polyphase commu-

tator motors with separate or shunt excitation, or for improving the power factor in the case of alternating current motors. The object of the invention is to maintain a high electrical efficiency under all conditions of load and speed. A indicates the motor whose field and armature voltage are to be altered as described in the complete specification. This motor is driven by a combined set consisting of a driving motor B which is coupled mechanically to a dynamo C for driving the first mentioned motor, and to a second dynamo D for exciting the field $A^1$ of the first mentioned motor A. The fields $C^1$ and $D^1$ of the dynamos C and D are separately excited from the mains F, and each has a voltage regulator G. The regulators are coupled together in such a manner that the fields of the two dynamos must be altered simultaneously in the manner set forth in the specification. This can be done, for example, by merely connecting mechanically together the sliding contacts of the regulators G in such a manner that they each move to an equal degree, and by suitably grading the resistances to give the required variation in the currents of $D^1$ and $C^1$. If, however, the resistances cannot be graded in the manner desired the sliding contacts may be geared together so that the required relative movements are obtained. A vector diagram is given for explaining the theory of the arrangement.—*August 4th*, 1909.

23,709. November 5th, 1909.—Improvements in Brush Gear for Dynamo-electric Machinery, by Peter Logan Raeburn Fraser, engineer, and the Tudor Accumulator Company, Limited, engineers, all of 119, Victoria-street, London, S.W.

The object of the present invention is to provide a construction in which the brushes are moved over with certainty immediately the rotation changes its direction, while during running there is no undue friction on the armature shaft. In the arrangement shown in the upper engraving, the armature shaft A is supported on ball bearings B, placed between an inner race C fixed to the shaft and an outer race D on the

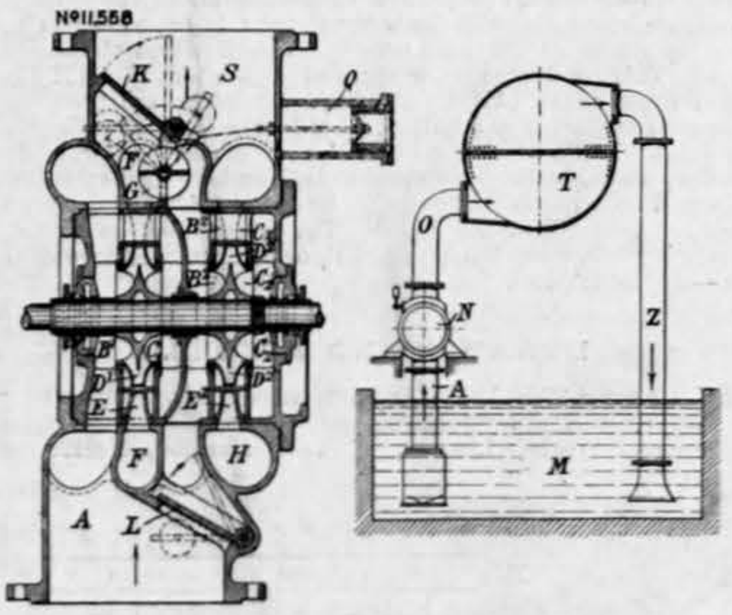



ramework E. The brush holders F are carried by a frame G to which are fixed the outer races H of the ball bearings J and K, the inner races L being fixed to the armature shaft A. The inner races are kept in position between the nuts M and a shoulder on the armature shaft by distance pieces N. According to another form of the invention shown in the lower engraving the armature shaft A is extended for a short distance through its bearings and the inner race of a ball bearing is fixed on the shaft beyond the main bearing. The frame G carrying the brushes F is fixed to the outer race of the ball bearing, and can turn freely on the shaft. Suitable stops are provided on the frame P of the machine, preventing the rotation of the brushes too far in either direction.—*August 4th*, 1909.

## PUMPING AND BLOWING MACHINERY.

11,558. May 15th, 1909.—Improvements in Centrifugal Pumps, *Gebrüder Sulzer, of Winterthur and Ludwigshafen a-R, in the Empire of Germany.*

This invention relates to a multiple coupled centrifugal pump in which the coupled pumps may operate in series for producing a suitably high pressure, or in parallel for pumping a suitably large quantity. The water flows from the suction pipe A through the chambers $B^1$ $C_1$, the first disc $D^1$, and the duct E into the first

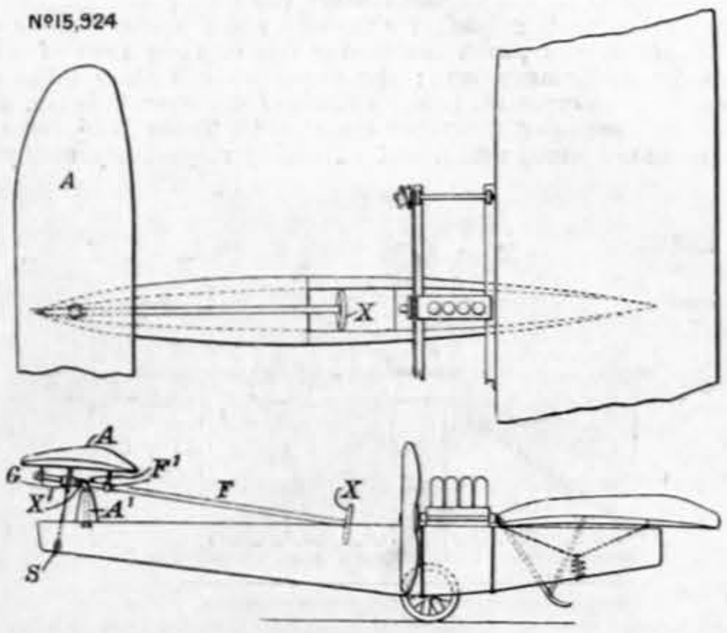



delivery chamber F. When the valve G is open the water flows from chamber F through chambers $B^2$ and $C_2$ into the second disc $D^2$, and thence through the duct $E^2$ and chamber H into the delivery pipe S. Since the pressure in the pipe S is in excess of that in chamber F, the valve K remains closed; so also does the valve L, for the pressure in chamber $B^2$ exceeds that in pipe A. When the pump discs $D^1$ and $D^2$ are to operate in parallel, the valve G is closed, so that the first disc delivers water directly into pipe S, and the second sucks water directly from pipe A. In the right-hand engraving the water circulates from the reservoir M through pipe A, pump N, pipe O, condenser T, and pipe Z. For moving the valve G a device Q is used, which consists of a piston, subject on the one hand to the pressure in pipe O, and on the other hand to a spring, such that when the pressure in O falls below a predetermined value the valve G is shut. The spring is so adjusted that the valve G is automatically shut as soon as the pipe Z becomes full of water, and therefore acts to assist the lift of the pump, diminishing the pressure in pipe O.—*August 4th*, 1909.

## AERONAUTICS.

15,924. July 27th, 1908.—Improvements in Aeronautical Machines, Thomas Wigston Kingslake Clarke, of St. Catherine's, Mapa-road, Surbiton.

For steering the machine, either or both of the supporting surfaces, but preferably the leading one, is mounted on a central pivot $A^1$, and is provided with a lever F, furnished with a steering wheel X, and mounted in a bearing which is pivoted at $F^1$. By raising or lowering the lever the plane of the supporting surface may be canted to an angle oblique to the main axis of the machine. The lever is, moreover, mounted in bearings $X^1$, to work as a spindle, and is furnished with a drum or drums G, to which cords

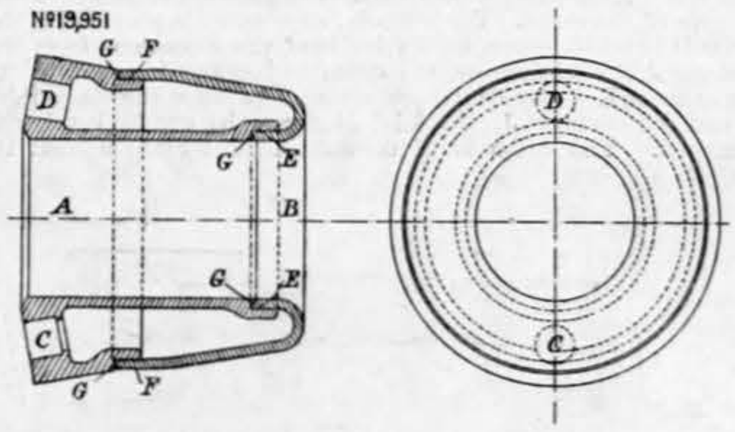



are attached, or about which they are wound, these cords, after passing around guide sheaves S, being respectively attached to the outer extremities of the supporting surfaces, or alternatively to the frame, so that upon turning the spindle F and its drum or drums, either one extremity or the other of the supporting surface A is depressed, according to the direction in which the spindle is rotated. By these means the angular position of the supporting surface A, even when rigid in character, may, by the manipulation of a single steering wheel, be set obliquely to the plane of flight, or may be tilted laterally about its transverse axis. It may also, if deemed desirable, be pivoted about its vertical axis $A^1$ at right angles thereto.—*August 4th*, 1909.

## MISCELLANEOUS.

19,951. September 23rd, 1908.—Improvements in the Manufacture of Tuyeres for Blast Furnaces, William Haigh Benson, Woodlands, Ashgate-road, Chesterfield.

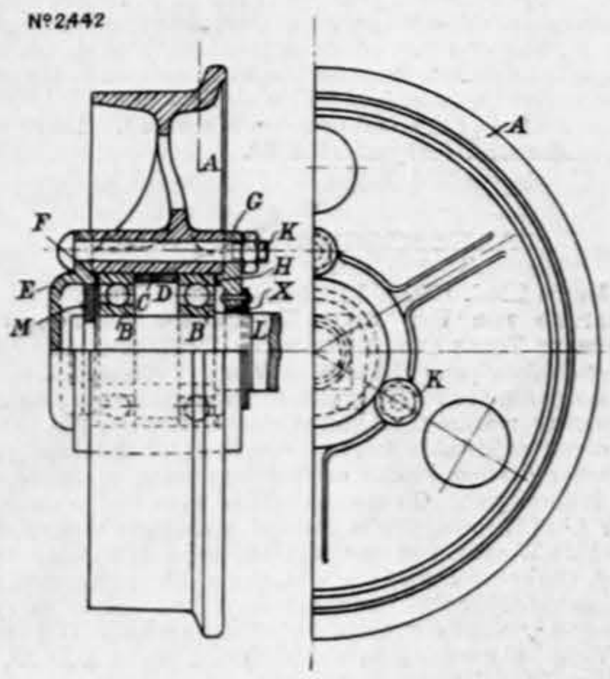
The present invention has for its object to reduce to a minimum the cost of maintenance of blast furnace tuyeres. The tuyere is made as usual in two parts, respectively A and B. The body part A, which is made of cast copper, is provided with an inlet C and an outlet D, allowing the cooling water to flow freely through




the tuyere. This body part A is made sufficiently strong to last for an indefinite period. The renewable nose B is made of wrought drawn copper and screwed in the body part A. The inside joint E which is in the blast passage has a sliding joint bevelled at the end, and the outside joint F is bevelled and screwed, suitable recesses being provided for the purpose in the body part A. This method of connecting the two parts has been found the most convenient for changing the noses rapidly.—*August 4th*, 1909.

2442. February 2nd, 1909.—Improvements in Ball Bearings, *The Gelsenkirchener Gusstahl and Eisenwerke, vorm. Munscheid and Co., and Hermann Sennlaub, both of Gelsenkirchen in Westphalia, Prussia.*

In the hub of the wheel A there are contained two sets of bear-



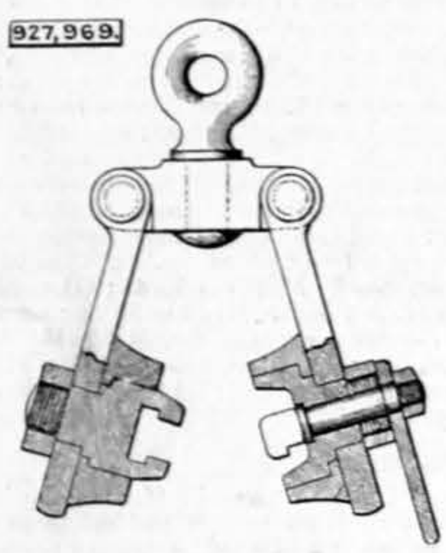

ing rings B, each consisting of an outer and an inner ring provided with ball-races for the balls, which by mechanical means are pressed between the rings so as to form with them a complete structure, the displacement of these bearing rings being prevented by means of the distance ring C, the interior D of which serves as a receptacle for lubricating material. The axle L with its bearing and distance rings are secured in position in the hub by means of a ring or flange G and a cover E, which are clamped together by screw bolts K passing through the hub, whilst longitudinal displacement of the whole of the axle L is prevented by a transversely divided ring M that is lodged within the cap E, and engages with a peripheral groove in the axle L. The cover E is provided with a washer F, and the flange G with a felt ring H; whilst to the flange G there is riveted a leather packing X which prevents the escape of the lubricating material and the entry of dust. Upon drawing together the flanges G and C by means of the screw-bolts K the entire device is firmly clamped together and is kept in position on the shaft L by the divided ring M.—*August 4th*, 1909.

## SELECTED AMERICAN PATENTS.

*From the United States Patent-office Official Gazette.*

927,969. Rope Pulley made in Two Parts, *J. F. Henry, Boulogne-sur-Mer, France.—Filed December 7th*, 1908.

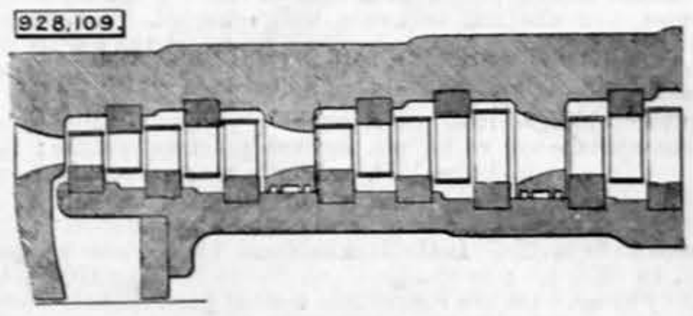
This is a patent for a pulley which can be opened as shown to




release a rope, and so save time in overhauling it. There is only one claim.

928,109. Elastic Fluid Turbine, *C. G. Curtis, New York, N.Y., assignor, by mesne assignments, to General Electric Company, a Corporation of New York.—Filed November 1st*, 1907.

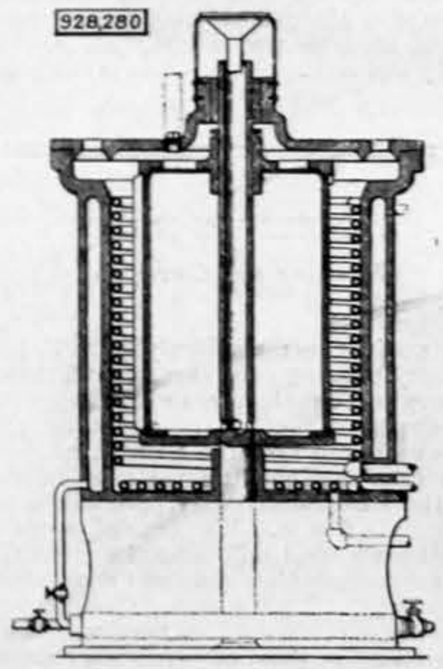
This is a species of covering patent, with ten claims. The second gives a good idea of the nature of the patent. A turbine having a shell and a drum, there being a passage for working fluid between




the shell and drum, rows of fixed and moving buckets within the passage, with large clearances between the relatively moving surfaces and a diaphragm dividing the passage into stages of different pressures, there being one row at least of fixed and a plurality of rows of moving buckets in each stage, the said diaphragm having a central opening in which the drum rotates.

928,280. Process of Separating Water from Oil, *J. W. Pittock, Philadelphia, Pa., assignor to the Oil and Waste Saving Machine Company, Philadelphia, Pa., a Corporation of Pennsylvania.—Filed August 27th*, 1908.

This is a patent for a method of separating lubricating oil from water, consisting in forcibly projecting the intimately mixed oil




and water as a spray against a surface heated to a temperature sufficient to evaporate the water but insufficient to decompose the oil, whereby the water is vaporised and the oil remains in a liquid state. There are five claims.

Contracts.—Hudswell, Clarke and Co., Limited, of Leeds, have just received an order for six locomotive boilers from the Rhymney Railway Company, South Wales.—The contract for pumping plants for the Alexandra Dock, Newport, has just been let. The pumping plant proper will consist of two main pumps coupled direct to two triple-expansion steam engines, two separate 500 kilowatts generating sets being installed for lighting and power purposes. The pumps will be capable, when working simultaneously, of pumping 50,000,000 gallons of water from the river Usk into the dock extension in a period of five hours, the average quantity of water delivered during this period by one pump being 80 000 gallons per minute. The same pumps will be used for emptying the graving dock, which will be built at a future date. In this case the pumps will work against a total head of 42ft., and will each deliver an average quantity of 100,000 gallons per minute. The main contractors for the whole of the scheme are Cole, Marchent and Morley, Limited, of Bradford, while the pumps are being built to the designs of Jens Orten-Boving and Co., by Willans and Robinson, of Rugby.