FACTORY DRIVING BY ELECTRICITY.

Although the transmission of power by electricity is considered by many engineers to be principally applicable to cases in which energy is to be carried for long distances, yet we are of opinion that, says the London *Engineer*, the day is not far distant in which electricity will become a powerful rival to the systems of belt, wire-rope, and cotton-rope transmission. The great losses which are unavoidably present in the last named systems are so important that it must be of interest to take note of any considerable application of electricity, either here or abroad, which tends to diminish them. The following, concerning the new small arms factory at Herstal, in Belgium, puts the matter very clearly before us. The area covered by the establishment is about 19·8 acres in extent.

The shafting may be conveniently divided into main and counter shafts, and if, for example, there would be 10 per cent loss upon each subdivision of energy, the total loss would be 30 per cent. In all systems of rope or belt driving a single accident may stop the whole establishment, and there is an excessive dead weight to be turned. The counter shafts and pulleys themselves weigh 110 tons, and the rest, without reckoning belts, at least 88 tons. Another great objection to ordinary mechanical transmission is the impossibility of extension. When shafts are put up for 300 horse power, all must be replaced if 450 horse power is to be transmitted. It is obviously best to transmit a large part of the power to distant points, and for this purpose ropes are very cumbersome and inefficient. Besides the pulleys and shafting, about 30 tons of hangers, plummer blocks, etc., must be put up. The idea was therefore accepted that the whole works should be driven by electricity. It was decided to place one dynamo of 500 horse power upon the engine shaft. The engine had already been ordered, and was to run at sixty-six revolutions per minute. A new type of dynamo had therefore to be designed, and the fly wheel was done away with, and the plummer blocks moved further apart. Even if two dynamos of 250 horse power each were used, it would be no advantage, as the work must go on throughout the establishment regularly. The Société Internationale d'Electricité undertook the work in order to compare the efficiency of electrical transmission with other kinds; the most eminent firms were asked for details as to the power necessary at the engine to deliver a given power to the machines, but not one would give a guarantee as to the efficiency of a mechanical method of transmission. There are in all—

9 shafts requiring 12 horse power each = 108
2 shafts requiring 16 horse power each = 32
2 shafts requiring 30 horse power each = 60

Total, 200 horse power.

For these the following motors were put in, to be well above requirements:

9 motors of 16 horse power = 144
2 motors of 21 horse power = 42
2 motors of 37 horse power = 74

Total, 260 horse power.

Of these the guaranteed efficiencies were 16 horse power—87 per cent; 21 horse power—87 per cent; 37 horse power—89 per cent; making 296·9 horse power required; 2 per cent loss in leads, 5·93; total, 303 horse power.

The efficiency of the generating dynamo is 90 per cent, so that the efficiency of the transmission between the brake horse power of the engine and the shafts of the motors is 77·2 per cent. The efficiency of the engine was guaranteed to be 92 per cent, but tests have shown it to be 94 per cent, so that the power delivered by the motors is 72·5 per cent of the indicated horse power of the engine. If we allow another 4 per cent between the motor shaft and the actual counter shafts of the tools, we obtain 69·5 per cent. The use of one dynamo has been criticised, but two dynamos of 250 horse power each could not well have been built to run at sixty-six revolutions only; and if they could, the cost would be £1,200 in excess of that of one large machine. There are, however, two commutators, and these enable the dynamo to run at half load. A noteworthy fact is that, owing to the absence of all belt transmission, the power necessary to drive the engine idle is only 28 horse power instead of 40 horse power. A great advantage in the shops is that the shafts need not be parallel to one another.

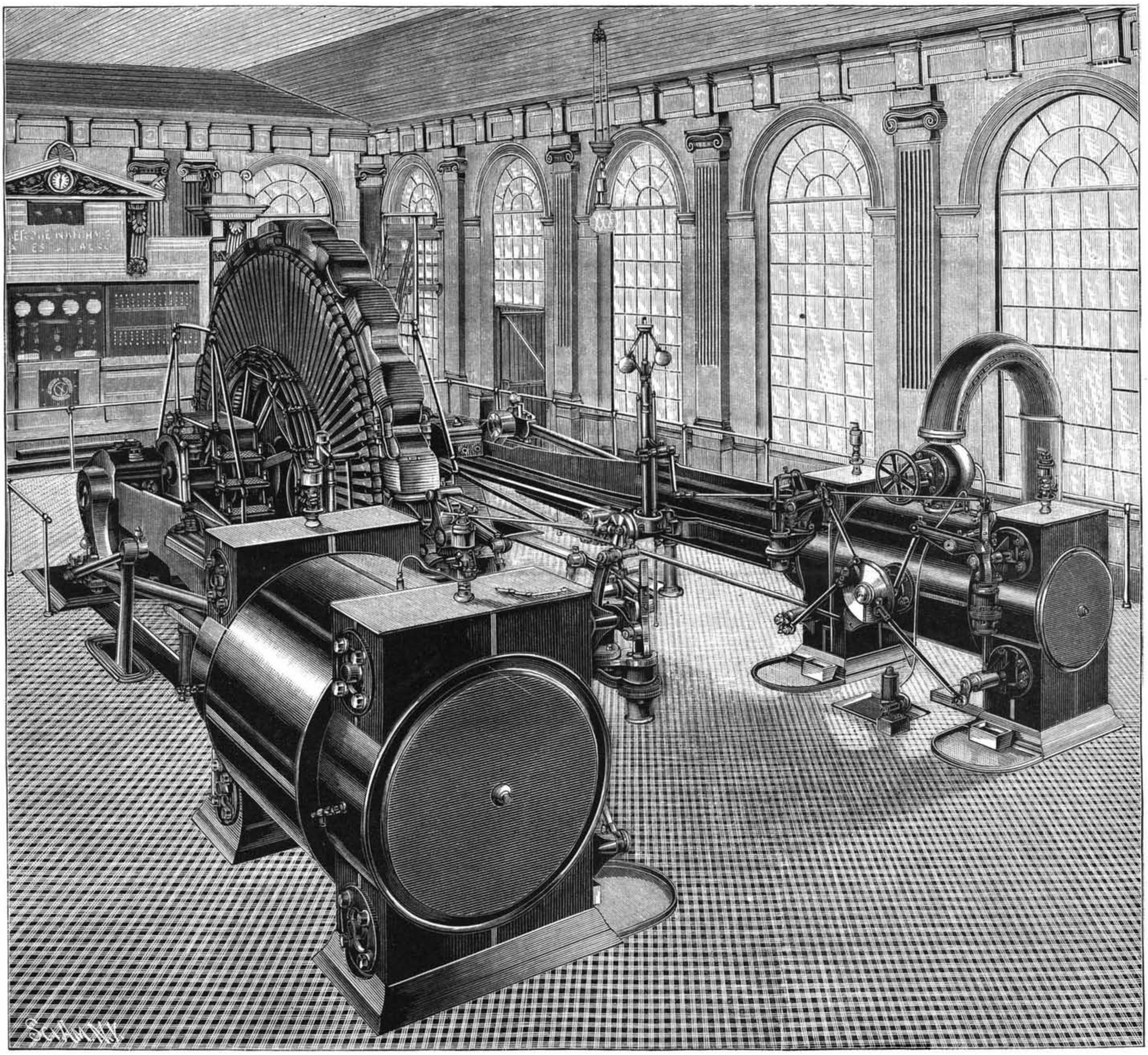


Fig. 1.—COMPOUND CORLISS DYNAMO ENGINE, AT HERSTAL, BELGIUM.

Passing now to the electric machinery itself, we may say that the contractors guaranteed an efficiency of 70 per cent for the whole transmission, knowing well, however, that it would be exceeded. The cables are short, and the total weight of copper in them is 5·14 tons, so that the loss is only 2 per cent. The motors vary in size from 3 horse power to 37 horse power, and are of the usual type. The main dynamo was, however, the object of careful study, as no machine, we believe, has previously been built to run at such slow speeds. The Gramme winding was the only type suitable, and the magnet cores had to be made of mild steel, as the price of wrought iron was prohibitive, and the cast iron would not give good enough results.

Our illustration, Fig. 2, represents the dynamo and part of the engine.

The field magnets are shunt wound, and arranged

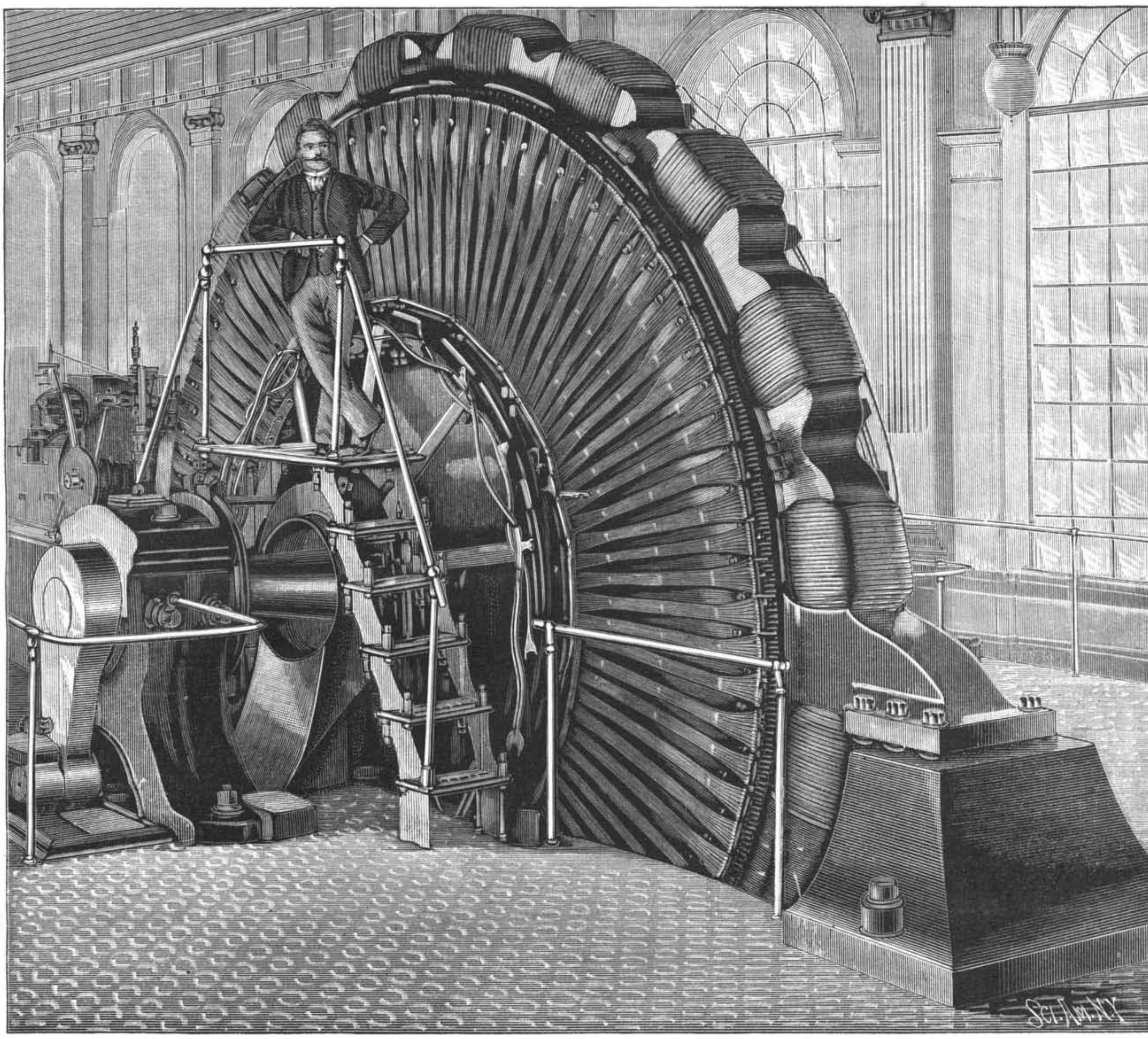


Fig. 2.—THE GREAT DYNAMO, HERSTAL, BELGIUM.

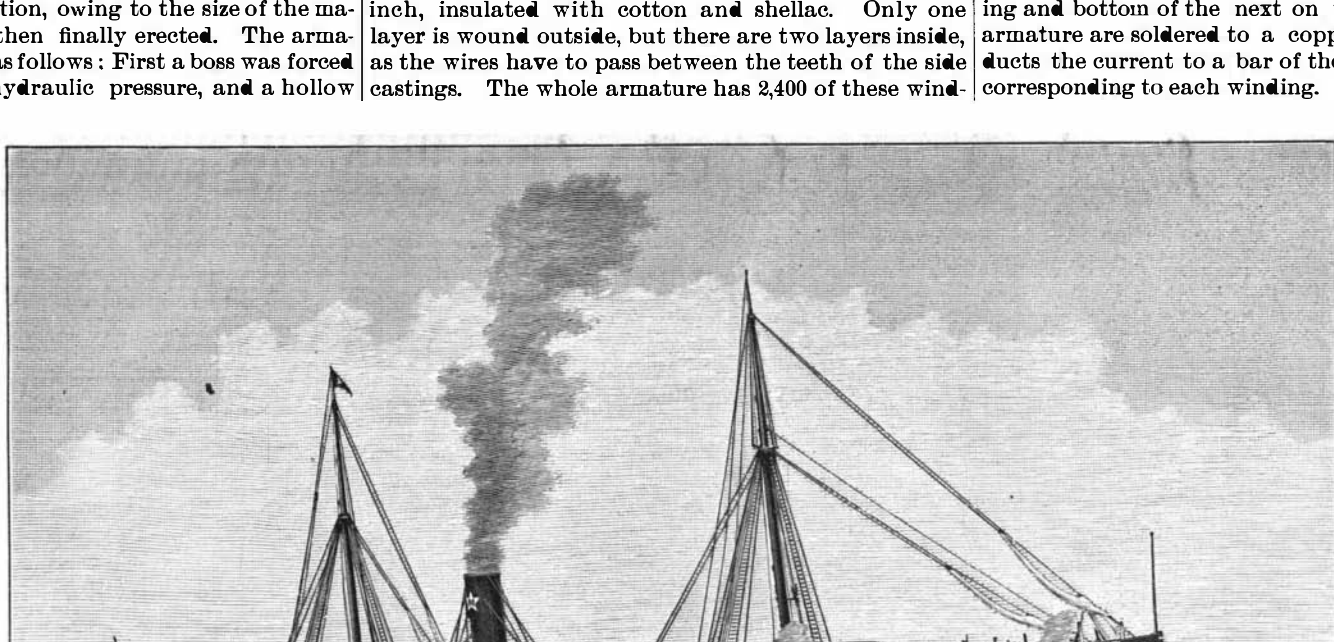
in a ring consisting of ten pieces bolted together and having twenty pole pieces. The air space is 0·245 inch wide. The magnets were fixed in position, then dismounted to allow the armature to be wound; this had to be done in position, owing to the size of the machine; the ring was then finally erected. The armature was constructed as follows: First a boss was forced upon the shaft by hydraulic pressure, and a hollow saucer-shaped casting was bolted to each side to take the place of the arms of an ordinary fly wheel. The circumference of the castings is formed into a hundred teeth, and these grip the core of the armature, which is 15·8 feet diameter, and formed of iron plates 0·275 inch thick; these are placed side by side and make a total width of 15·8 inches; the radial length of the plates is 5·1 inch. This mass of iron forms the rim of the fly wheel, and possesses ample weight to insure regular motion. Through fifty of the teeth bolts are passed to hold the core plates together, while the other fifty support cross bars upon which the plates rest; all are carefully insulated from the plates, and the latter are covered with paper.

The winding consists of flat wire 0·158 inch by 0·196 inch, insulated with cotton and shellac. Only one layer is wound outside, but there are two layers inside, as the wires have to pass between the teeth of the side castings. The whole armature has 2,400 of these windings, and carries two commutators, to which alternate windings are attached.

All the wires were bent to template, and are very easily dismounted and replaced. The top of one winding and bottom of the next on the same side of the armature are soldered to a copper plate, which conducts the current to a bar of the commutator, one bar corresponding to each winding. The commutators are 8·2 feet in diameter. Binding wires of phosphor-bronze, 0·059 inch in diameter, are used for holding the winding in position. Eighty brushes collect the current, and these are lifted and lowered simultaneously by special apparatus, and the lead can be easily regulated.

This machine can develop 2,400 amperes at 125 volts, and four cables lead the current to the switch board. The efficiency, as previously stated, is 90 per cent, and the density of the current is 1,940 amperes per square inch in the armature winding and 1,000 amperes in the magnet windings.

The boss of the



THE NEW STEEL STEAMER EL RIO.—[See page 202.]

armature weighs ten tons, the armature core six tons, the side castings eight tons, the copper in the magnets two tons, and in the armature 1,320 pounds. If a short circuit should occur in the works, the armature will be subjected to an action like that of a brake, but it will not have the bad effect which would be produced if the armature did not itself constitute the fly wheel. There are, as will be observed, only two bearings, one on each side of the machine. The two sets of cables are connected in parallel at the switch board, where the requisite instruments are fitted up, so that the pressure in either half of the machine or in the shops can be noted. and suitable cut-outs are fixed.

Lighting is effected by 116 arc lamps, two in series, using 10 amperes, and by 200 16 candle power incandescent lamps. The current for the latter is taken from a ring main supplied by 24 feeders, and the total loss of pressure is 7 volts when all the lamps are lighted at once. The ring and feeders are of bare wire, except in cable tunnel. All the motors are of the Gramme type, with two windings. The base plate and the top yokes are attached together in casting to allow of boring the interior easily, and the magnet cores are cylinders of wrought iron shunt-wound. Carbon brushes are used on the motors, and have so far given no trouble. The electrician would not be able to occupy his time were it not that he has also to attend to the arc lamps and replace their carbons.

The following is a list of the motors used throughout the works, or rather the list of those which were ordered at first:

Situation.	Horse power.	No. of motors.	Guaranteed efficiency.
Mainshop	16	9	87 per cent.
Wood-working department.	21	1	87 "
Forge	37	2	89 "
Stamping and drawing shop.	16	1	87 "
" " "	7	1	84 "
Feed pump	10	1	85 "
Fans	3	1	80 "

The average efficiency can, of course, be obtained by multiplying the number of motors by their respective efficiencies. Taking this sum and dividing by the total number of motors, this gives 87·2 per cent.

Eventually the 7 horse power motor was countermanded, and a 16 horse power motor put down for the polishing shop and one of 21 horse power for the cartridge shop. On some of these motors the load is very variable, and several are exposed to dust and dirt, so that with 90 per cent efficiency of the dynamos, 98 per cent of the conductors, 87 per cent of the motors, the net result is 76·6 per cent power delivered. As the lost work in belt driving is practically a constant quantity for all loads, or at least is usually, considered to be, the power required to turn the shafting, pulleys, etc., at the normal speed when no work is being done on the machines, it follows that taking 79·4 per cent as the final output in two cases, one of electrical and the other of mechanical transmission, we find that at a load of 20 per cent the electrical system would still give 47·2 per cent useful effect and the mechanical nothing at all. From careful experiments which have been made in actual practice, it has been clearly proved that to drive all the machines idle needs more power than to drive the shops in the ordinary course of work; whereas 11 electrical horse power is required when driving all the tools idle, only about 7 electrical horse power is needed in ordinary work, of which 4 electrical horse power is used to drive the shafts, belts, etc., alone; this clearly shows how small a part of the power produced by the engine is actually used in useful work at the tools.

Such satisfactory results of the application of electricity to factory driving must attract attention and will doubtless lead to great changes in transmission, both in this country and on the Continent. Whether in the case of large machine tools it would not be better to discard shafting and belts altogether, and supply a special motor to each tool, is a question which must be settled for each individual case which may arise; the current could be switched on or off just as easily as the belt is now thrown from the loose to the fast pulley, and *vice versa*.

We give an engraving from a photograph of the engine, which was built by the Société Anonyme des Anciens Ateliers de Construction Van den Kerchove, of Ghent, and erected by them.

It is designed to develop 450 horse power, but gives without difficulty 530. The high pressure cylinder is 19 inches in diameter, the low pressure 32 inches and the stroke 5 feet. The number of revolutions is 66 per minute, with a pressure of 90 pounds. The dynamo, as will be seen, is placed between the high and low pressure engines, the armature being sufficiently heavy to dispense with a fly wheel.

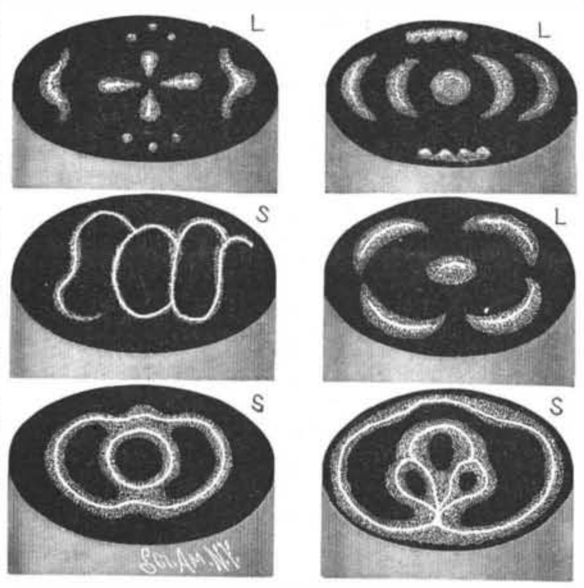
The Compagnie Internationale d'Electricité, of Liege, have put in the electric plant with complete success. The regularity in running of the engine is all that can be desired, the governor keeping it under perfect control. Running light the engine indicates 28 horse power and loaded 500 horse power, which gives an efficiency of 94·7 per cent. The consumption is about 13·25 pounds of water per horse power per hour. We are indebted to the *Engineer* for our illustrations and the foregoing particulars.

DUST AND SAND FIGURES ON MEMBRANES.

T. O'CONOR SLOANE, PH.D.

Some attention has recently been excited by what are known as dust figures produced on the surfaces of vibrating membranes. They are virtually Chladni figures, and the membrane on which they are produced can be made to give good results with sand and lycopodium. Of course, the outlining of loops and nodes on vibrating membranes is old, but by substituting for the violin bow usually employed a more active system of obtaining vibrations, very curious and interesting results have been obtained.

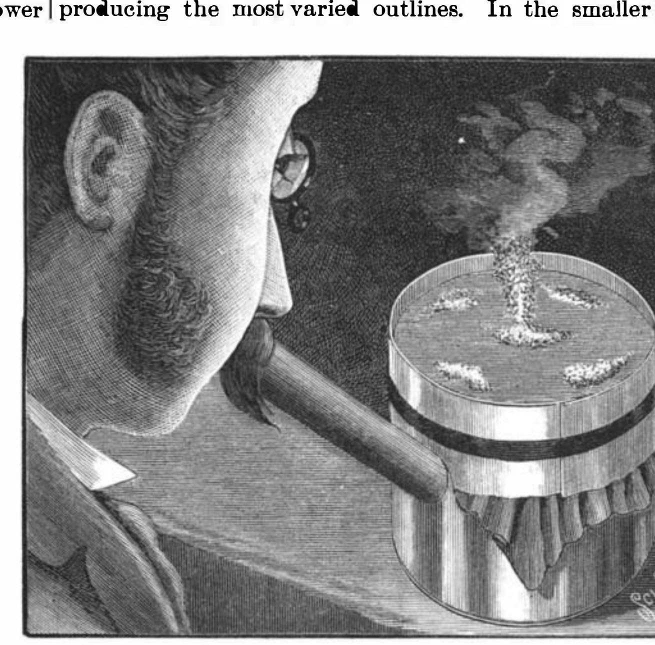
In the cut we illustrate an exceedingly simple apparatus for this purpose. Over the top of a cylindrical box a sheet of very thin India rubber is stretched, and



APPARATUS FOR PRODUCING LOOPS AND NODES ON A MEMBRANE.

held in place by a rubber band. Around the edge is a band of paper, projecting about half an inch above the surface of the rubber so as to form a species of fence or wall. A hole in the side of the box admits a tube. If, now, a note is sung into the tube, the India rubber is thrown into vibration with a production of loops and nodes whose position varies with the note produced. An endless variety of figures can thus be formed.

Lycopodium gives perhaps the most effective results. When the experimenter sings strongly into the tube, if the lycopodium has been scattered over the sheet, it begins to gather itself into most peculiar shapes; sometimes little circular heaps of it form which are maintained in perpetual agitation, the loops and nodes producing the most varied outlines. In the smaller


DUST AND SAND FIGURES PRODUCED ON A VIBRATING MEMBRANE.

cuts, the three diagrams marked L represent lycopodium diagrams.

A great point in producing the figures is to cease the note suddenly and without changing its pitch. One is very apt with cessation of sound to change the pitch and produce confusion. If, while the lycopodium is on the sheet rubber, the intensity of the sound is increased, some of the lycopodium is thrown in the air, and if the sound is made strong enough, a perfect cloud of the dust is maintained, sharply localized over the points of agitation, representing the Chladni figures in a very beautiful and interesting manner.

With sand, three of whose figures are shown in the small cuts under the letter S, the results produced are less impressive, perhaps. At any rate, in precision of outline they do not, as a rule, compare with those given by brass or glass Chladni plates. Like the lycopodium figures, they give results which surpass those of solid plates in complexity and in the prevalence of curved outlines. The usual types of Chladni figures can hardly be obtained.

For the box, any tin or pasteboard box can be used. The rubber should be very light, and for even figures should be evenly stretched, but by stretching it with different tension in different directions the figures can be considerably modified. The appliances are all so simple that the experiment can be recommended as really a very interesting one.

One experimenter is said to have produced fixed relief maps of the curves by the use of plaster of Paris. In such cases the note must be uniform and must be maintained until the plaster sets hard.

In old violins dust balls are sometimes found. The experiments described give the clew to their formation. The vibrating wood of the violin acts to gather the dust into balls. The same action can be seen in the lycopodium on the vibrating membrane.

THE NEW STEEL STEAMER EL RIO.

This new American steamer, built of steel by the Newport News Ship Building and Dry Dock Company, recently made her trial trip in this harbor, when she attained a speed of 17 knots per hour. The vessel has taken her place on the line between New York and New Orleans.

El Rio is a freight vessel of 4,500 tons register and of the following general dimensions:

Length between stem and after side of propeller post, 380 feet; breadth of beam moulded, 48; depth from top of keel to top of upper deck beams of lowest part of sheer, 33·9; length over all, 406.

She has three decks and a partial orlop deck at fore-end of forehold. On the awning deck are steel houses. She is rigged with two steel pole masts and the necessary booms for handling cargo, together with steam hoisting engines located at the different hatches, to work in connection with them. Freight hatches and ports are located so as to handle cargo expeditiously.

The vessel is steered by steam from the forward pilot house or by screw hand gear from the after house.

A steam windlass and steam capstans are provided for handling anchors, hawsers, etc., as well as a steel rope with drum aft for towing.

She is propelled by a vertical triple expansion engine with three cranks, placed at angles of 120°. The cylinders are 32, 52, and 84 inches diameter by 54 inches stroke of piston, working under 167 lb. of steam, which is generated in three double-ended cylindrical steam boilers with three corrugated furnaces at each end. There are two fire rooms and one smokestack.

The vessel is lighted throughout by electricity.

The Newport News Ship Building and Dry Dock Company, at Newport News, Va., is one of the largest and most fully equipped ship building establishments. Several fine vessels of steel have already been constructed, and others are in progress. Among them are El Sud and El Norte, two splendid steamers, each of about 4,500 tons. Another, El Cid, is on the ways, same dimensions as El Rio.

Some idea of the extent of the works of this company may be had from the following:

The ship yard contains 75 acres of land; frontage on the water, 2,600 feet; buildings cover 7 acres.

Dimensions of Dry Dock.—Length on top, 600 feet; width on top, 130; width on bottom, 50; width at entrance, 93; draught of water over sill, 25; time required for pumping water out of dock, 1 hour and 30 minutes.

Dimensions of Buildings.—Office building, 3 stories, brick, 40 × 200 feet; pattern and joiner shop, 3 stories, brick, 60 × 300; machine shop, iron and brick, 100 × 300; boiler shop, iron and brick, 100 × 300; blacksmith shop, 100 × 300; bending shed, iron and brick, 60 × 127; framing shed, frame, 344 × 270; ship fitters' shop, iron and brick, 60 × 320; ship blacksmith shop frame, 120 × 208; pipe fitters' shop, frame, 50 × 208; power house, brick, 40 × 130; lumber shed, 2 stories, frame, 40 × 300; pump house, brick, 43 × 60; paint shop, brick, 50 × 160; fitting-up shop, brick, 50 × 175; stable, 2 stories, brick, 40 × 60; timekeeper's house, frame, 50 × 40.

Piers.—No. 1, 60 × 900 feet; No. 2, 60 × 350; No. 3, 80 × 350; No. 4, 60 × 550; outfitting basin, 900 × 500.

Ship Ways.—Nos. 1 and 2, each 400 feet long; Nos. 3 and 4, each 450: Nos. 5, 6, 7, and 8, each 650.

The various shops are fitted with machinery of the latest pattern, and are capable of handling the largest work known in ship building.

The machine and boiler shops are supplied with power-traveling cranes of 50 tons capacity, and the appliances throughout the yard for handling material are of novel design, enabling work to be done with dispatch and in an economical manner.