ECONOMY OF DRIVING MILLS AND FACTORIES BY ELECTRICITY.

A CORRESPONDENT in a recent issue of *Indian Engineering* calls attention to the interest which exists in the use of electricity for driving individual machines of large factories, and states that the day is not far distant when electricity will become a successful rival of the old-fashioned manner of distributing power by shafting, gearing, cotton ropes and leather belting. The great losses that occur and are unavoidably present in the last-named systems are so important that it becomes a matter of serious interest to those concerned to take note of the constantly increasing application of electricity to such purposes, the use of which tends so materially to diminish the working expenses.

Having chosen the above title for our letter, and the subject being one that we have specially studied, we venture to think that a few remarks pointing out the chief advantages against the existing disadvantages of the older method will be acceptable to many of your numerous readers.

Such extremely satisfactory results have attended electrical driving in England and on the Continent, that doubtless many changes to this method of transmission of power will soon be made in India.

One great inherent advantage in using electricity is that the distributing agent—viz., the cables—conveys the power practically without loss and only in strict proportion to the demand, while in the case of mechanical transmission by shafting, etc., the loss by friction is considerable, being practically a constant quantity, whether full, partial, or light work is being done—in many cases amounting from 20 to 40 per cent. of the power available.

The longer the distance of transmission and the less the load, the greater is the proportion of loss, and in many cases this becomes a most important matter. Moreover, there is always a considerable dead weight to be rotated, the total shafting, gearing, and pulleys weighing in some cases hundreds of tons, entailing extra strength and cost in structural arrangements to withstand the strain.

From the intermittent character of the work carried out in factories and workshops, it is well known that frequently only a very small part of the power produced by the engine is actually converted into useful work at the machines.

In the present systems of mechanical driving, a single accident to the main driving-belt, shaft, or gears brings the whole establishment to rest; to obviate this is one of the chief advantages of electric transmission. A further objection to the old system is the almost insurmountable difficulties of economical extension; for instance, to increase a 500-H.P. plant to one of, say, 700 H.P. or 800 H.P. would need the almost complete substitution of new and heavier shafting, etc., and great increase in the dead load on the structure generally, while with an electrical installation little or no radical alteration is required.

In the advocated new system of driving, outside the engines or prime movers (which are neglected as being common to both systems), all the shaftings, gears, belts, bearings, etc., are replaced by simple fixed conductors of very small weight and by separate motors to each machine or tool; where, however, the power required does not warrant this, a separate motor is used to drive a group of machines from a short line of light shafting.

These shafts or groups of machines can be placed in any position found most convenient for working regardless of their neighbor.

The nature of electrical generation and dynamo working is such that only sufficient amount of current required to do the work in is used, so its economy is at once obvious.

In factories, where the machinery is working intermittently and liable to great fluctuation, the economy of working is even more marked, as the electric current can be switched on or off with the greatest ease and rapidity, after which crossed belts and fast and loose pulleys appear a heavy and clumsy, not to say unscientific, method of utilizing power.

In electrical transmission 80 per cent. of the power generated by the engine is usefully employed in the machines, and where each machine can have its own motor, a unique and highly economical method of using power is obtained.

It is hardly necessary to point out that no hard or fast law can be laid down; each case must be individually considered and that system adopted which gives the best results.

For old and existing works probably the cost of conversion would seldom be warranted, but for new factories or renovations without doubt the question of driving should be most seriously considered.

In these days of fierce competition and when profits are reduced to their lowest ebb, the careful study of every possible means of economical working is of vital importance to the manufacturers.

The use of electricity for driving all kinds of hoisting machinery is extremely satisfactory and more economical; it is easily and instantly controlled, and allows the driver to concentrate the whole of his attention to the work being handled.

For heavy machinery, such as exists in sugar works, electric driving would, without doubt, be very advantageous in effecting economy and give great convenience in working, and the facility with which electric lighting could be adopted is also an incidental but important advantage to be derived from its use.

Lastly, this system for motive power purposes lends itself most admirably to the subdivision of the motive power engines and dynamos into several units, the consequence being that by this multiplication the chances of total or even serious break-down are rendered impossible.

Before concluding we should mention that, where factories and mills, etc., are within a reasonable distance—say 10 miles of waterfalls, reservoirs, or mountain streams, when water can be relied upon, the motive power could be obtained from them with advantage by generating current at the site and distributing it to the works by the high-tension system.

CONTRIBUTIONS TO PRACTICAL RAILROAD INFORMATION.

Chemistry Applied to Railroads.

SECOND SERIES.—CHEMICAL METHODS.

X.—METHOD OF DETERMINING COPPER AND LEAD IN PHOSPHOR-BRONZE.

BY C. B. DUDLEY, CHEMIST, AND F. N. PEASE, ASSISTANT CHEMIST, OF THE PENNSYLVANIA RAILROAD.

(Copyright, 1891, by C. B. Dudley and F. N. Pease.)

(*Continued from page 373.*)

OPERATION.

HAVE ready the electrical arrangements described below, or the equivalent of these. Pour the solution of copper and lead salts obtained after the tin has been separated, as described in the Method of Determining Tin in Phosphor-Bronze, into a suitable beaker or electrolyzing jar, and dilute with distilled water to about 200 c.c. Attach the zinc pole of the battery, or its equivalent if other source of electricity is used, to the smaller central electrode, which has been previously carefully cleaned, dried and weighed, and the other pole of the battery or source of electricity to the other electrode, which has likewise been carefully cleaned, dried and weighed. Allow a current of from 0.05 to 0.10 of an ampere to pass from 12 to 24 hours. When it is deemed that the current has passed long enough, add a little water from the wash bottle, taking care not to direct the stream against the pole holding the lead, until the level of the liquid is raised a fourth or half an inch. Allow the current to pass one or two hours longer, and if the bright stem of the copper pole around which the liquid has been raised by the addition of the water, does not show any deposit of copper, it is safe to assume that all but a slight trace of the copper has been removed from the solution. The lead is much smaller in amount, and comes out more readily, and is usually all deposited long before the copper. If the stem of the copper pole shows copper when treated as above, continue the current some time longer, and then repeat the test until the stem remains clean after the current has passed at least an hour subsequent to the last addition of water. The copper being satisfactorily deposited, syphon off the liquid nearly to the bottom of the electrodes, add distilled water and syphon again until about 800 c.c. of water have been passed through the electrolyzing jar or beaker. The current should be allowed to pass during all the time of the removal of the acid, and the washing. The syphoning is perhaps best managed as follows: Have a small glass syphon with a couple of inches of soft rubber tube attached to the longer leg. Fill the syphon with distilled water, pinch the rubber tube shut, and insert the shorter leg inside the copper electrode to very nearly the bottom of the electrolyzing jar or beaker and start the syphon. When the level of the liquid has very nearly reached the bottom of the electrodes, close the rubber tube again by pinching, add distilled water by pouring it inside the copper electrode until the electrolyzing jar or beaker is nearly full again, then syphon off as before, repeating the operation until the required amount of wash water has been added. At the last

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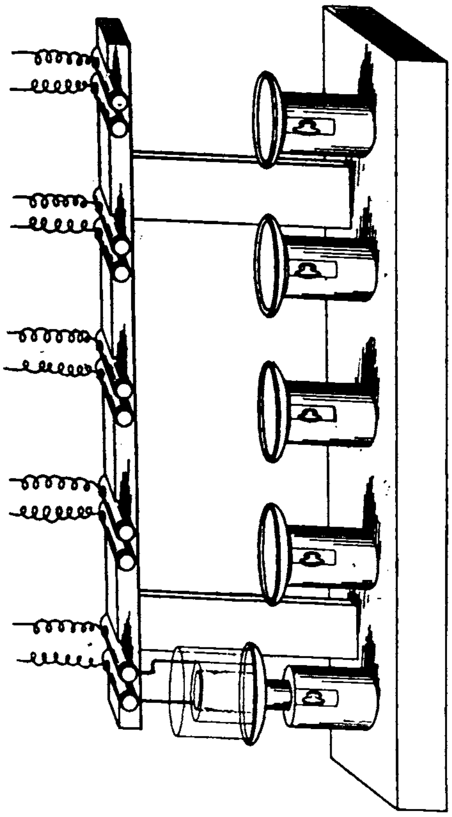

FIG. 4.

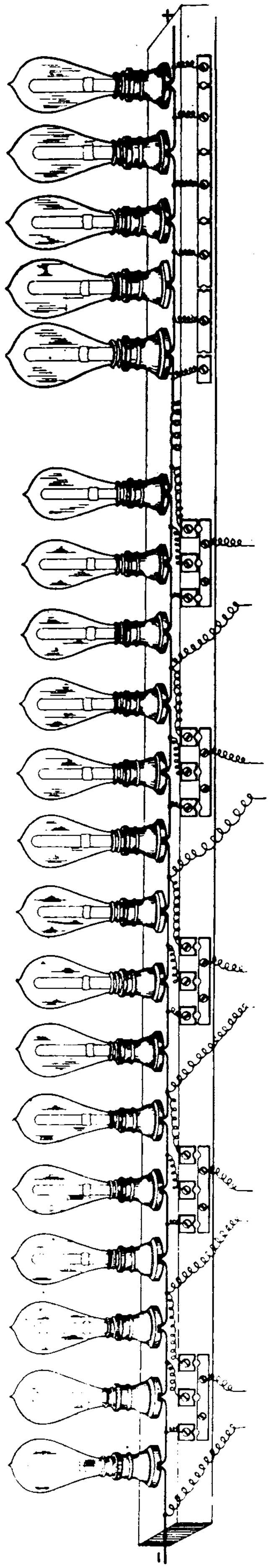

FIG. 5.

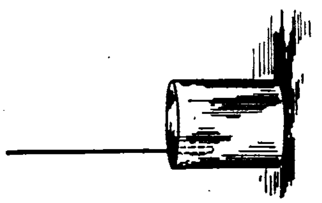

FIG. 3.

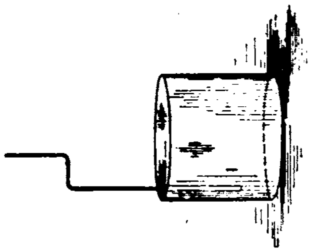

FIG. 2.

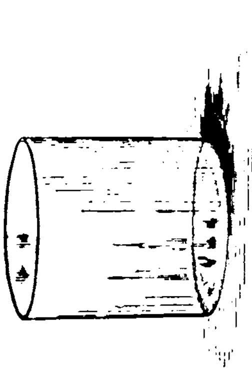

FIG. 1.

draw the liquid down so as to break the circuit. Now lower the electrolyzing jar or beaker, remove the electrode containing the lead carefully, dip it once in a small beaker containing enough distilled water to cover the cylinder, place it vertically on a clean watch glass, set in a warm place for half an hour to dry, and then put in the desiccator; allow to cool and weigh. Remove now the copper electrode, dip once in distilled water and then into a beaker containing enough alcohol to cover the cylinder. Burn off the alcohol remaining, cool in the desiccator and weigh.

If it is desired to determine the zinc and iron which may be present in the phosphor-bronze, they will be found in the electrolyzing jar or beaker and in the liquid syphoned off from this.

APPARATUS AND REAGENTS.

A small beaker about 2¼ in. in diameter at the bottom and 3½ in. high can be used for the electrolysis; but a jar made for the purpose, shown in the cut fig. 1, of the dimensions given above, and about 2¾ in. in diameter at the top, avoids the flange and lip of the beaker, which are apt to be in the way.

The lead electrode shown in fig. 2 is a cylinder of platinum foil open at both ends, 1¾ in. high and 2 in. in diameter. The wire support is $\frac{3}{32}$ in. in diameter, and is riveted to the cylinder. It has an offset to adapt it to the binding posts of the electrical arrangement. The wire projects about 3 in. above the cylinder. This electrode weighs 15 to 18 grams.

The copper electrode shown in fig. 3 is likewise a cylinder of platinum foil open at both ends, $1\frac{5}{16}$ in. in diameter, and same height as the lead electrode. The wire support is same size wire, projects same distance above the cylinder, and is likewise riveted to it. The copper electrode weighs about 12 grams.

The supports for holding the electrolyzing jars during electrolysis are shown in fig. 4. The material, except the set screws and binding posts, is wood. The length of the base is 2 ft. and the width 6 in. That part of the support for the electrolyzing jar which has the set screw is 2 in. in diameter and 3½ in. high. The movable part of the support for the electrolyzing jar is 3 in. in diameter at the top, and the stem is 5½ in. long. The distance from the top of the base to the bottom of the support for binding posts is 11 in. The support for the binding posts is 1 in. thick and 2 in. wide, and the binding posts are so arranged as to support the electrodes symmetrically in the electrolyzing jar. The loose ends of the wires in fig. 4 connect with the loose ends of the wires in fig. 5.

The difference of potential between the binding posts to

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which the two electrodes are attached, some two or three volts, is such that with the size of electrodes and volume of solution given above, a current of from five to eight or ten hundredths of an ampere results. This difference of potential may be obtained from a battery of two or three gravity cells; but since batteries are so difficult to keep in good order, especially if they are not in constant use, and since the Edison current is so common, it is much more convenient to use this current. But the lighting system has a difference of potential of 110 volts between the two wires, and consequently some devices are necessary to bring down the voltage. The arrangement illustrated in fig. 5 has been worked out from the suggestion given in Dr. E. F. Smith's manual of "Electro-Chemical Analysis." It is perhaps more elaborate than is necessary, but where a good deal of work must be done it has been found to be very serviceable. It is fitted up, as will be observed, to carry on five determinations at once. The base of the arrangement is of slate, 4 in. wide, 1 in. thick, and of sufficient length to carry five 16-candle-power 110-volt incandescent lamps and fifteen 12-candle-power 110-volt lamps. It is not essential to have the slate base all in one piece. It will be observed that all the lamps are connected in series, the right-hand end having the positive wire of the Edison circuit attached to it, and the left-hand end the negative. The five lamps grouped at the right of the cut are 16 candle power, and so connected, as is readily seen, with the plugging strips on the edge of the slate that any one, two, three, four, or all of them, can be cut out by simply inserting plugs in the holes made for them. The other 15 lamps are grouped in sets of three each, and are so arranged with plugging strips under each group, as is readily seen, that, when the two free wires are connected through the electrolyzing solution and a plug is in one of the three holes of the group, a shunt circuit is formed. If the plug is in the right-hand hole, the shunt circuit takes in three lamps; if it is changed into the next hole the shunt circuit takes in two lamps, and if to the next hole one lamp. This arrangement makes it possible to secure a very wide range of difference of potential at the binding posts above the electrolyzing jar. For example, if there is a plug in each of the five holes below the 16-candle-power lamps, and also one in the right-hand hole in the first group of 12-candle-power lamps, the differences of potential at the binding posts connected with this group will be about 23½ volts. Again, if all the plugs under the 16-candle-power lamps are taken out, and the plug under the first group of 12-candle-power lamps is transferred to the left-hand hole, the difference of potential between the binding posts will be about one volt. By varying the plugging, almost any desired voltage between these two extremes can be obtained. It is evident that by using lamps of different capacity, or by using more or less of them, still wider variations of voltage may be obtained. A switch, not shown in the cut, makes it possible to shut off the current when the apparatus is not in use. It is difficult to give positive directions about the plugging necessary in using the apparatus described above, since the voltage in the mains is apt to vary a little with the distance of the apparatus from the central station; also the switch, the wires and the plugging devices used vary with the different constructions, with corresponding effect on the voltages in the shunt circuits. Still more important also is the variable introduced when one, two, three, four, or five determinations are being made at once. Each new determination introduced changes the voltage at the binding posts of all the others which are in circuit, with a consequent change in the current passing, and hence a change in the plugging becomes necessary to counteract this. The best course to pursue, if an arrangement as above described is made use of, is to connect a delicate ammeter in circuit with the determination and make a schedule of the plugging required when one, two, three, or more determinations are being made at once. It may be said, however, that if the apparatus is approximately as described above, and one or even two determinations are being made at once, successful results will be obtained if there are three plugs in the group of 16-candle-power lamps and the right-hand hole of each group of 12-candle-power lamps has a plug in it. The lamp arrangement is supported on a wooden frame not shown, with the support for holding the electrolyzing jars underneath it. It is desirable to use porcelain sockets for the lamps, as they are not corroded by the fumes in the laboratory, and of course insulated wire should be used throughout for the connections. The plugging arrangements are made of brass, and should be kept well lacquered. Turning the plugs in the holes occasionally keeps the contacts good.

CALCULATIONS.

Atomic weights used: Copper, 63.4; lead, 207; oxygen, 16; molecular formula for lead oxide, PbO_2. The copper being weighed in the metallic state, no reduction is required, consequently the per cent. or amount in 100 parts will be found by multiplying the weight found, expressed in grams, by 100. This may be briefly stated as follows: Move the decimal point of the weight of copper found, expressed in grams, two places to the right. This result will be the percentage of copper in the bronze. Thus, if the weight of copper found is 0.7964 gram, the per cent. of copper in the bronze is 79.64 per cent. The lead is weighed as binoxide; and since 86.61 per cent. of the binoxide is metallic lead, the weight found expressed in grams, multiplied by these figures, gives the amount of metallic lead in one gram of the bronze. Then the amount in 100 grams, or the per cent., will be found by multiplying this figure by 100. This may be briefly stated by the rule: Express the weight of binoxide of lead found in grams, move the decimal point two places to the right, and multiply by the decimal 0.8661. The product will be the per cent. of lead in the bronze. Thus, if the weight found is 0.1462 gram, the percentage will be [14.62 × 0.8661] 12.66 per cent.

NOTES AND PRECAUTIONS.

It will be observed that this method separates the copper and lead from nitric acid solution by means of electricity, the copper being thrown down on one pole in the metallic state, and the lead as binoxide on the other pole.

In order to get a proper separation of lead and copper by means of the current in nitric acid solution a certain amount of free acid is necessary. Dr. Edgar F. Smith's manual of "Electro-Chemical Analysis" states that not less than 5 per cent. is requisite. It will be remembered that 15 c.c. of concentrated C. P. acid are added on separating the tin, a little of which is probably evaporated, so that if the bulk of the solution is made 200 c.c. as directed, the amount of free acid is from 7 to 8 per cent.

Notwithstanding the amount of copper to be precipitated is quite considerable, by far the largest portion of it comes out with the appliances as described in about 12 to 15 hours, so that if a rapid result is desired it is safe to begin testing at the end of that time. When a complete analysis of a bronze is being made, the other constituents are usually not obtained sooner than 24 hours after starting, so that no loss of time results if the current is allowed to act for that time, and the certainty of getting the copper is somewhat greater with the longer time.

In burning off the alcohol from the copper electrode, no additional heat beyond that furnished by the alcohol should be used or there will be danger of oxidizing some of the copper.

The separation of the copper from the solution by the current is perhaps never absolutely complete. However long the current may be passed, it is rare that some slight reaction is not given when the acid solution is tested with hydrogen sulphide. The amount left in solution can, however, usually be ignored if the current has been passed 24 hours.

The binoxide of lead adheres to its electrode sufficiently well, so that with careful manipulation there is no danger of loss, but a direct stream of water against this electrode when the oxide is on it will detach some. A severe jar will do the same. The copper adheres well if too strong a current has not been used, and there is little danger of loss with any reasonable manipulation.

The current recommended and that given by the apparatus as arranged is somewhat greater than that stated by the authorities as proper for the precipitation of copper and lead, but no difficulties have been experienced when working with a current of 0.10 of an ampere. Indeed, at the last a still stronger current may be safely used. It is advisable at the start to use not over 0.05 of an ampere, and continue this current until the electrodes are fairly well covered. The plugging arrangement enables this to be readily done.

With a little experience the removal of the acid solution and the washing of the electrodes by syphoning as described is very satisfactory.

It is obvious, since nitric acid is present, in which copper is readily soluble, if the current is shut off before the acid is removed and the washing finished, there will be danger of loss of copper.

If there is any silver present in the bronze, which is often the case, this is thrown down with the copper and weighed as such. This error is usually ignored, the amount of silver being generally not more than six or eight hundredths of a per cent. If there is any bismuth present in the bronze, the largest part of it goes to the lead pole, causing in some bronzes quite a serious error. Consequently, if the lead found by the above-described method exceeds the limits of the specifications on which the metal was bought, a supplementary determination of the lead is always made, the lead being determined as

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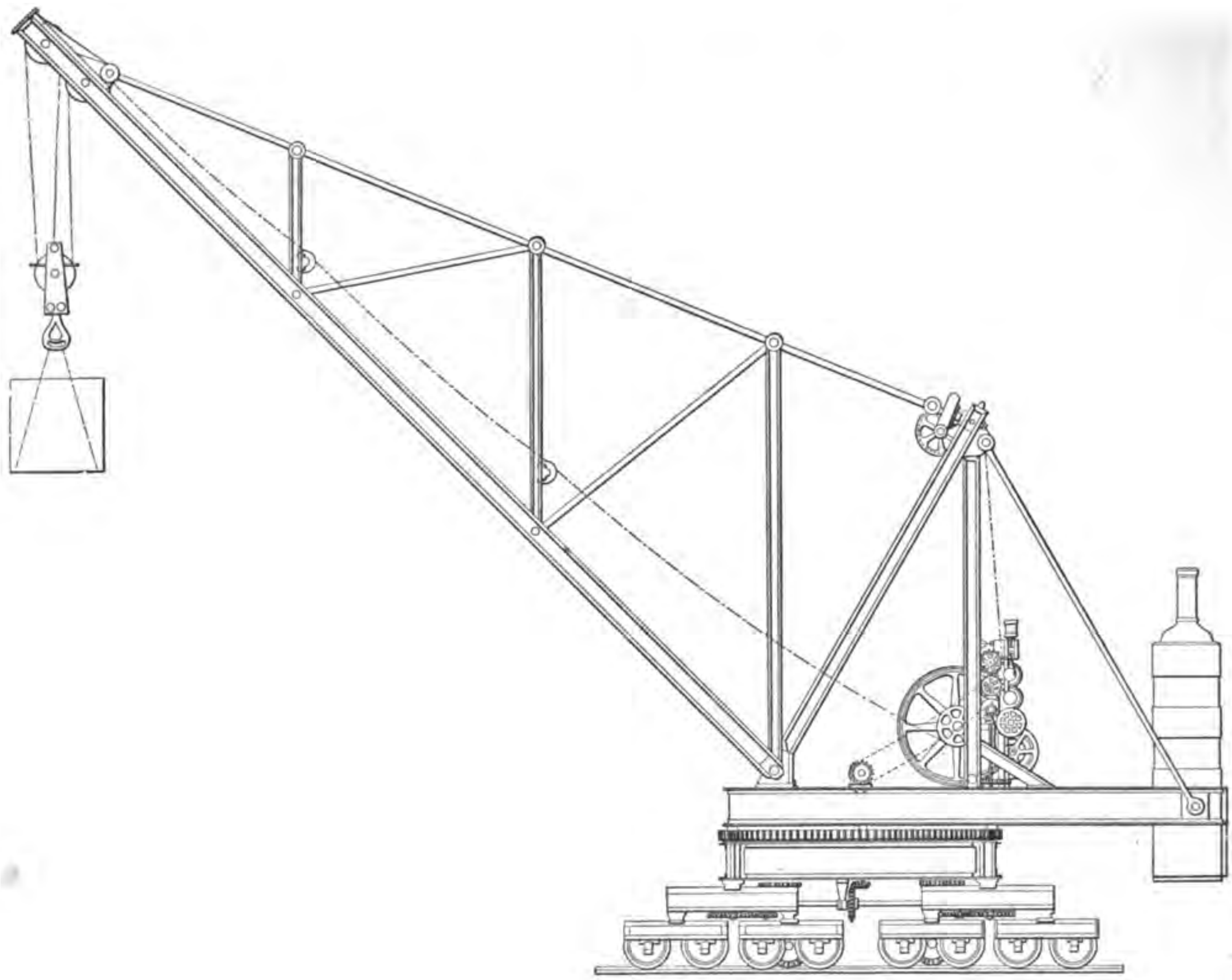

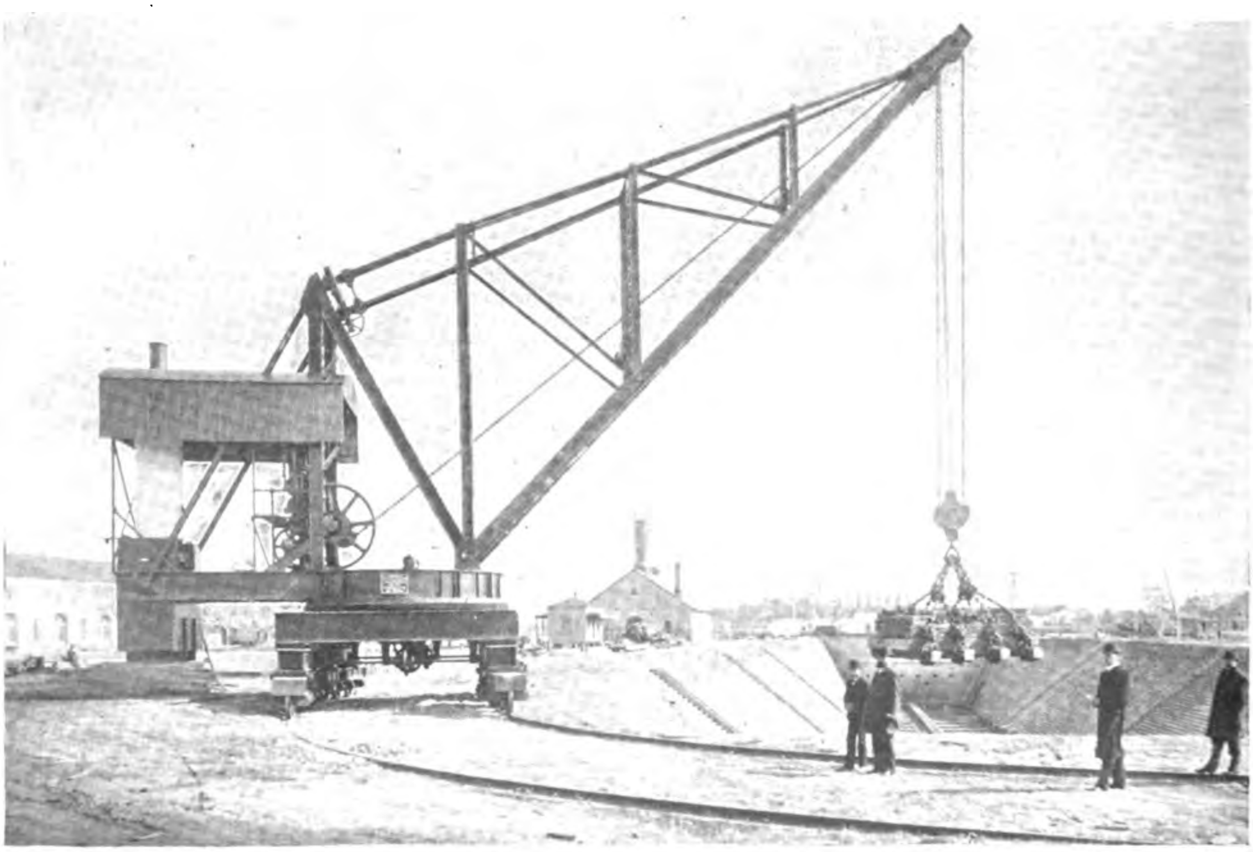

40-TON DOCK CRANE AT THE NORFOLK, VA., NAVY YARD. BUILT BY WILLIAM SELLERS & CO. PHILADELPHIA, PA.

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sulphate before final action is taken in regard to the shipment.

The electrodes are readily cleaned after a determination is finished by immersing the cylinders in a beaker of dilute nitric acid, and allowing the two wires to touch above the beaker. A little battery cell is thus formed which soon dissolves the lead oxide and copper.

In case a little of the lead oxide becomes detached from the electrode and falls to the bottom of the electrolyzing jar, it may usually be recovered by adding alcohol after the syphoning is finished, and washing by decantation several times, and finally transferring by means of an alcohol wash bottle to a weighed watch glass, sucking off most of the excess of alcohol with a pipette, drying and weighing. The lead oxide is quite bulky, and it requires considerable of it to weigh a milligram. Of course, if any serious amount of it becomes detached, the determination should be repeated, using less current.

A small watch glass cut into two equal parts, and each one of the halves put on opposite sides of the wires of the electrodes, makes a convenient cover to keep out dust during the electrolysis.

A 40-TON DOCK CRANE.

The Navy Department have now in use at the Brooklyn and Norfolk Navy Yards a 40-ton dock crane, built by William Sellers & Co., Incorporated, of Philadelphia, which is specially intended for placing armor plates on the vessels built at these yards. The cranes are located on a track running around three sides of the dry dock, the jib of one of them being seen over the stern of the United States battle-ship *Texas*, shown in our engraving on page 149 of the issue for April of this year. The fourth side of the dry dock is left clear for the entrance of the vessel. It was an essential requirement of these cranes that they should go around curves of 84 ft. radius, measured to the center of the outside rail. This necessitated an arrangement of trucks which would compensate for this short curvature. It is very evident, also, that the crane should be capable of being moved about as the work demands, and that it should be preferably self-propelling in order that it may be perfectly independent and moved through longer or shorter distances as the proper adjustments of the plates may demand.

The tracks upon which the cranes run have a gauge of 18 ft. Our two illustrations give a very clear idea of the general appearance and construction; the line engraving having been supplied us by the *Iron Age*, while the half-tone engraving is a direct reproduction of a photograph supplied by the makers. The working capacity of the crane is 40 gross tons, at a radius of 50 ft. measured on the center line of the bearing pins of the jib, and the machinery is so arranged that it is capable of hoisting or lowering, turning or traveling, simultaneously or independently as the work may require; the machinery is also so geared that all of the motions can be readily reversed without reversing the engine. In addition to its load of 40 tons the jib is arranged to a pivot on the upper platform of the car, and is held in place by two large screws, which two can be moved so as to increase the radius of the hook 14 ft., making it 64 ft. from the fulcrum pins of the jib instead of 50 ft., and making the maximum radius from the center of the rotating platform 70 ft. instead of 56 ft. The maximum load at this radius is 30 gross tons.

The rotating platform which carries the machinery, adjustable jib and boiler, is counterbalanced at its outer end by a box containing slabs of cast iron, of a total weight of about 60 tons. This counterweight is so proportioned as to balance the loaded and empty crane, keeping the center of gravity of the mass within the circle of rollers on the crane car.

The crane is driven by a pair of 10 in. × 12 in. engines, and the various changes and motions of hoisting and lowering, turning and traversing, is accomplished by means of friction clutches. The load is also automatically sustained at all points by a patent retaining device, without attention of the operator, it being necessary to lower by power. The load is carried upon three parts of chain, the free end being wound upon the drum with a single coil without overlapping. This chain is made of tested links of 1⅜-in. round iron. The drum upon which it is wound is of wrought iron; the bearing ring for the rollers, which required a harder material, has been made of steel castings. The circular web is of two plates, and all angles are in one length, the ends of no two of them meeting in the same vertical plane.

The maximum speed of the crane is 50 ft. per minute. There are two hoists, one being a slow speed of from 5 ft. to 7 ft. per minute, while the other is a rapid hoist, for weights running up to about 15 tons, and has a speed three times that of the first. The operating clutches are arranged in pairs upon the horizontal shafts, each pair being controlled by a single lever, so that in a central position no motion will result. The forward movement of the lever will produce a corresponding motion of the crane in one direction, while the backward movement of the lever produces motion in the opposite direction. The work is thus perfectly under the control of the operator at all times and by very simple means.

Such a crane as this is not only an advantage, but absolutely necessary to an economical performance of such work as the location of armor plates and heavy work of a similar character about our battle-ships and cruisers, and this one has been so designed that its working has given the utmost satisfaction.

RECENT EXPERIENCES WITH CYLINDRICAL BOILERS AND THE "ELLIS AND EAVES" SUCTION DRAFT.*

By F. Gross.

At the last summer meeting Mr. Ellis read a paper on "Some Experiments on the Combination of Induced Draft and Hot Air Applied to Marine Boilers Fitted with Servé Tubes and Retarders." So much special attention is being given to boilers for ships at the present time, that it will perhaps interest the members to be informed of the experience which has been gained to date with this system applied to marine boilers on land and at sea. The boilers which have been working longest with this combination are at the Atlas Works, Sheffield. Nos. 7 and 8 are now three years old; Nos. 9 and 10 are two years old; Nos. 11 to 16 have since been gradually added. These 10 single-ended marine boilers, placed together in one shop, furnish part of the steam required by the works, and are at work day and night. Their ordinary work is to maintain a regular combustion due to 3 in. vacuum at the fan inlets, corresponding to a combustion of 35 lbs. to 37 lbs. per square foot of grate, which is uniformly 5 ft. 8 in. long in all the boilers. For short periods, at certain intervals during the day, the quantity of steam required is appreciably greater than the regular quantity, when, by increasing the number of revolutions, the rate of combustion is immediately raised to 40 lbs., 45 lbs., 50 lbs., or even 60 lbs. per square foot of grate, and as promptly reduced when the demand for the extra steam has passed away. It will be evident that, unlike boilers with natural draft, the boiler is the constant quantity, while the draft is varied largely according to the requirements for the time being.

For the purpose of obtaining data on suction-draft fans, different diameters and widths are used. Moreover, some fans work one boiler only, and are placed above the boilers; others work two boilers, and are placed on the ground floor, sucking the gases downward, and discharging them into short funnels, which just clear the roof of the building. The success of boilers Nos. 7 and 8 led to the construction of Nos. 9 and 10, and the satisfactory experience with the four, to the subsequent further six, partly for the sake of space, partly for economy and absence of smoke. The 10 boilers, 10 ft. 6 in. by 10 ft. 6 in., displace three to four times as many Lancashire boilers of about 28 ft. by 6 ft. 6 in., while the evaporation per pound of South Yorkshire coal is 9 lbs. actual from cold feed —or 10¼ lbs. from and at 212°—when burning at 30 lbs. per square foot of grate, or 8¼ lbs. actual feed—or 10 lbs. from and at 212°—when burning at 45 lbs. per square foot of grate, as against 6½ lbs. actual from cold feed in the Lancashire boiler burning at 19 lbs. per square foot of grate with a chimney 130 ft. high. Very recent careful examination of the boilers shows that the Purves flues, tube plates, and Servé tube ends in the oldest are as good as new; and it is worthy of special note that the feed-water comes cold from the river, unfiltered, and that the draft is not shut off when the doors are opened for firing, slicing, or raking. The dampers are used only when the fires are being cleaned—every six hours. The fans likewise continue to work satisfactorily, as anticipated, because the gases when entering the fans do not exceed 450° at the highest rate of combustion, the air heated by the waste gases then entering the furnaces at 320°. For these boilers, owing to the steam pressure being as yet unavoidably only 50 lbs. per square inch, the fan engines are simple engines.

The International Company's steamship *Berlin*—better known under the old name of the Inman Company's *City of*

* Paper read before the Institution of Naval Architects on July 26, 1894.

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