MERCURY ARC RECTIFIER FOR CHARGING STORAGE BATTERIES

BY A. FREDERICK COLLINS.

In garages it often becomes necessary to convert an alternating current into a direct current for the purpose of charging storage batteries, and heretofore this has only been possible by means of a motor-generator set, rotary converter, synchronous or mechanically driven rectifiers, and chemical rectifiers.

Obviously all the foregoing arrangements, except the chemical rectifier, necessitate moving parts that are subject to wear and hence require frequent adjustment, besides being expensive to install. An attendant who has had some experience with electrical appliances, must also be provided, and this further adds to the operating expenses. As to the chemical rectifier, it has never been developed to any degree of efficiency and has never been a very satisfactory piece of apparatus.

For these reasons there has existed for a long time a demand for a cheap device for rectifying or converting alternating current into direct current that should be at once compact and efficient and not apt to get out of order. The General Electric Company's mercury arc rectifier shown in the illustration fulfills these conditions to a nicety since it is lower in first cost, higher in efficiency, and more simple in its details than mechanical converters. It requires practically no attention, and for charging electric vehicle batteries it is almost ideal.

For a number of years the above company has conducted a special department for the development of apparatus used in storage battery practice, and the present appliance is the outcome of a long series of experiments. The mercury arc rectifier and the equipment furnished with it has been thoroughly tested; and no point essential to safety and economy in charging storage batteries has been overlooked or neglected. It is therefore especially serviceable for the charging of electric automobiles in private garages.

The complete equipment comprises essentially a panel, tube holder, and compensating reactance, and these various parts will be described sufficiently in detail to make their uses clear. On the panel, which is made of slate, are mounted the measuring instruments, namely the ammeter and voltmeter, double pole switches by which the direct and alternating current mains are brought into relationship, and also double and single pole switches for starting and operating the rectifier; fuses and circuit breakers are also provided for protecting the rectifier against heavy overloads.

The panel is mounted on one-inch supporting tubes and these, with braces, clamps, and flanges, enable it to be rigidly set up anywhere in a few minutes; to one of the supporting tubes a starting resistance is attached, as a reference to the illustration, Fig. 1, showing the rear view, will indicate. This resistance is connected in multiple with a pilot lamp mounted on the front of the board. The object of the starting resistance is to permit the rectifier to start before the load or charging current is thrown on. The object of the pilot lamp, which is connected in shunt across the

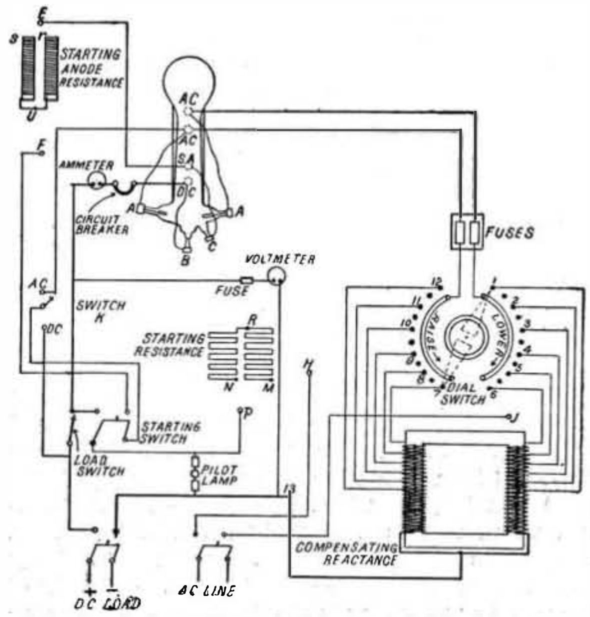


Fig. 4.—CONNECTIONS OF MERCURY ARC RECTIFIER AUTOMOBILE CHARGING PANEL.

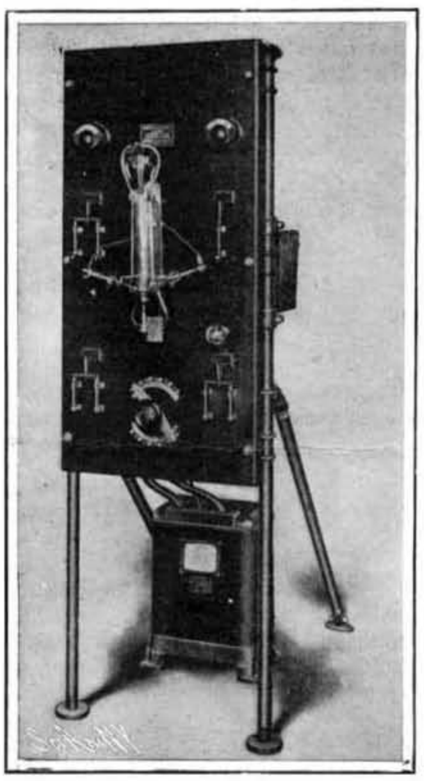


Fig. 3.—FRONT VIEW OF A MERCURY ARC RECTIFIER.

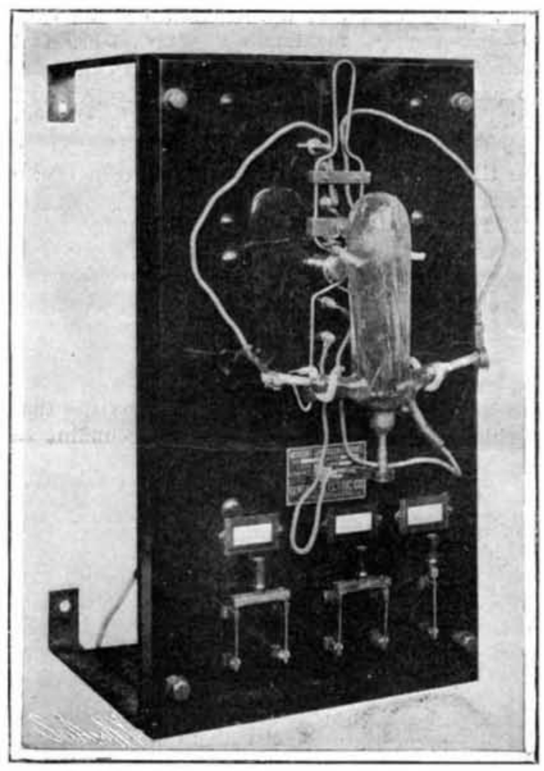


Fig. 6.—FIVE-AMPERE RECTIFIER FOR DENTAL MOTOR.

starting resistance, is to show when the load or charging current takes the place of the starting resistance, the lamp remaining lighted until this substitution is effected.

The rectifier proper consists of a glass tube, Fig. 2, supported on the front of the switchboard, Fig. 3. In the bottom of the tube is placed the mercury, and, after the terminals are sealed in, the tube is exhausted. Two of these terminals, *A A*, are anodes or positive poles. Besides these there is a smaller anode or positive terminal, *C*, for starting the rectifier; the two main anodes, *A A*, lead to the dial switch, and then through the compensating reactance to the main alternating current line. The lower terminal, *B*, leads to the direct current load, that is, to the negative side of the battery to be charged; while the opposite side of the line connects with the compensating reactance. All of this may be plainly observed by referring to the accompanying diagrams, Figs. 4 and 5. The electrodes or poles are provided with metal caps as a protection from burning out as well as for reducing to a minimum liability of breakage. The tube is held in position on the front of the panel with spring clips, while binding posts for connecting the various parts of the tube with the apparatus are mounted on the panel.

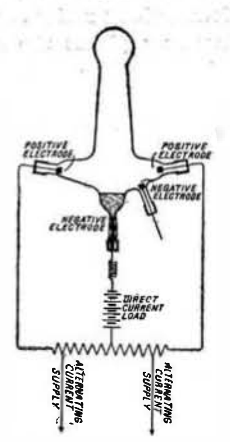


Fig. 5. SIMPLE DIAGRAM OF RECTIFIER CONNECTIONS.

Connected directly across the alternating current supply mains is the compensating reactance; and this is sometimes mounted on the back of the panel or placed under it on the floor. From the reactance leads are brought out and are connected to a dial switch mounted on the front of the panel. The purpose of this switch is to vary the voltage and current within the limits of the rectifier, and the value of the former may be anything from 16 volts to 120 volts direct current. The negative side of the direct current circuit is obtained from the center of the reactance.

Three different sizes of the rectifier are now ready for installation, i. e., 10, 20, and 30 amperes, while any voltage found in commercial use on alternating current circuits can be employed with the mercury arc rectifier. Outfits of standard sizes have been designed and these work on either 110 or 220 volt alternating current, 60 cycle, single-phase circuits. It has been found that for batteries requiring a range of voltage from 45 to 115 volts direct current, 220 volts alternating current will give the best results, while for smaller power having a range of from 16 to 45 volts direct current, a 110-volt alternating current gives the best results.

According to the arrangement of the connections, the direct current voltage will be found to range from 20 to 55 per cent approximately of the alternating current taken from the supply mains, while the alternating current under similar conditions is from 40 to 65 per cent of the delivered direct current. The standard outfits will operate on any frequency from 25 to 150 cycles very satisfactorily. They are, however, designed especially for 60 cycles, but when used on higher or lower frequencies suffer but little in consequence.

The efficiency of the mercury arc rectifier depends largely on the voltage of the direct current used, since there is about 15 volts constantly lost in the arc. Thus, although it is only about 60 per cent at 30 volts output, it reaches a maximum efficiency of 80 per cent at 115 volts. The shape of the efficiency curve differs from that of the motor generator set formerly employed, in that its efficiency at partial loads is as high as the full load efficiency. This is true also of the power factor, which is extremely high for a converting apparatus of this capacity and seldom falls below 90 per cent, while it frequently exceeds to a considerable extent this value.

Should it be desirable to charge at a higher rate than 30 amperes, two or more rectifiers can be connected in circuit and the capacity can in this way be doubled. The panels on which the instruments are mounted are arranged so two sets may be thus coupled up in multiple, although it is pointed out by the manufacturers that a single set especially designed for the current strength to be used is preferable since it is simpler in construction and easier to operate. These rectifiers may be used with any kind of storage batteries and cannot possibly do any harm. According to the president of one of the largest storage battery companies in the country, charging by a recti-

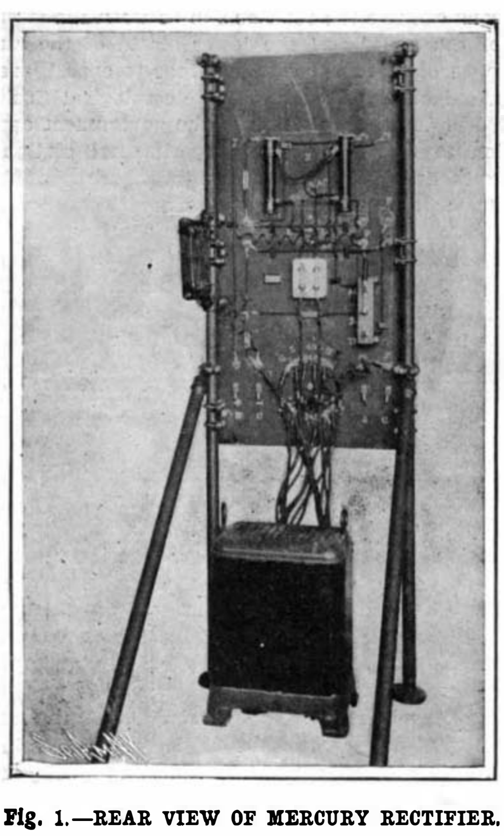


Fig. 1.—REAR VIEW OF MERCURY RECTIFIER.

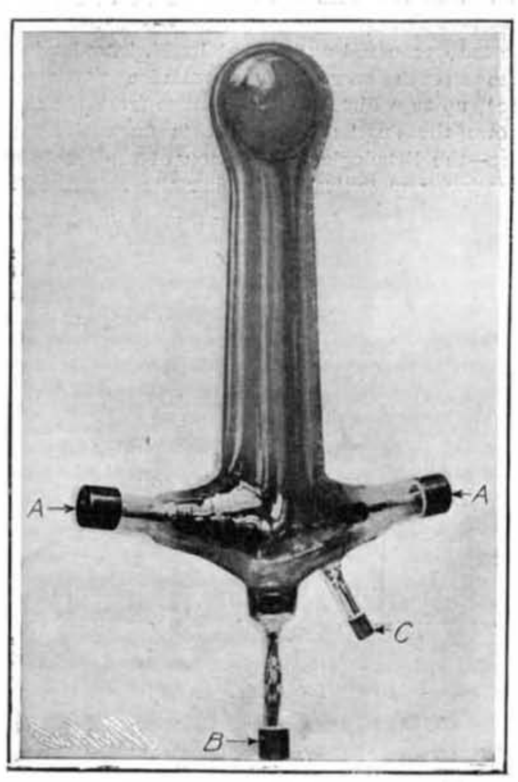


Fig. 2.—TWENTY-AMPERE MERCURY ARC RECTIFIER TUBE.

fier is more efficient, that is, there would be less loss of energy than with a continuous current, as the charging is carried on at a lower rate, more time is allowed for the chemical action to take place, and the gassing of the battery is less.

In Fig. 6 is shown a small rectifier outfit designed to meet the demands of dentists who are often confronted with the problem of operating dental motors where only an alternating current is available. This consists of a small 5 ampere tube arranged to operate on 110 volts, 40 to 140 cycles, and to deliver approximately 5 to 15 amperes at any direct current voltage up to 45 volts. The panel is not equipped with either meters or regulating devices, since it is the customary practice to provide dental motors with these.

THE TUNNEL UNDER THE SEINE RIVER.

BY L. RAMAKERS.

Work has been commenced on the construction of line No. 4 of the Metropolitan Underground Railway of Paris, the north-and-south cross town line, extending from the Clignancourt gate to the Orléans gate, and crossing both branches of the Seine.

The construction of a railway tunnel under the Seine at any point constitutes so difficult a problem that the Prefecture of the Seine deemed it expedient to invite competitive solutions. The commission in charge of the competition, which included both plans and methods of construction, selected the solution offered by L. Chagnand, one of the ablest of Parisian contractors, according to which the cost of construction will amount to 15,614,000 francs ($3,203,000) for a tunnel 1,093 meters (0.68 mile) long, with a station at each end.

In the plan annexed to the announcement of the competition the tunnel descended 40 millimeters to the meter (4 to 100) to a point vertically under the bank of the Seine. The next section of the tunnel was to be horizontal, with the rails 14 meters (46 feet) below the surface. This section was to extend from the Place du Chatelet to a point two-thirds of the distance across the small arm of the river, beyond which point there were to be two rising grades of 40 millimeters to the meter (4 to 100) separated by a level, corresponding to the Place St. Michel, the Boulevard St. André and the Place St. André des Arts.

The tunnels and stations were to be of the following types:

The tunnels were to be two in number, circular in section, excavated by the compressed-air method, and lined with metal. Each tunnel was to have an internal diameter of 5 meters (16.4 feet) and an external diameter of 5.30 meters (17.38 feet), the axis of the tunnel being situated 1.40 meters (4.6 feet) above the rails. The stations, also constructed with the aid of compressed air, were to be short, metal-lined tunnels of circular cross-section, with an internal diameter of 6.50 meters (21.32 feet) and an external diameter of 6.90 meters (22.63 feet). The center of the section was to be placed 1.534 meters (5.03 feet) above the level of the rails and 1.190 meters (3.8 feet) distant, horizontally, from the middle line of the track. This eccentricity would leave room for a landing platform made of armored concrete.

The advantages presented by the Chagnand project and which led to its adoption are of two kinds.

1. Instead of employing twin tunnels of small bore, it keeps the two tracks together in a single tunnel of the same dimensions as the other sections of the Metropolitan.

2. The construction of the tunnel under the Seine by means of caissons sunk vertically makes it possible to raise considerably the level of the rails under the river and, consequently, to diminish the grades of the approaches and the depth of the stations. In the plan adopted the lowest level of the rails is level 16.05, or 11.15 meters (36.57 feet) below the surface of the Seine, while in the original plan it was level 13.10, or 2.95 meters (9.67 feet) lower.

In the Chagnand project the grade of 4 per cent., which is the maximum grade allowed in the Metropolitan system, is employed only in order to pass under the Metropolitan line, the Orléans railway, and the Bièvre collecting sewer.

The internal section of the tunnel differs very little from that of a masonry tunnel of the ordinary type. Except under the bed of the Seine the tunnel will be excavated with the aid of a shield of special design. The walls will be composed of cast-iron rings 60 centimeters (2 feet) broad, the rings themselves being built up of voussoirs of varying curvature, according to their positions and the pressures to which they are subjected. The pieces are to be bolted together, the joints being made water-tight by the interposition of strips of creosoted wood. Cement will be injected behind this iron tube to fill any cavities that may exist between its exterior and the surrounding earth.

The metal lining will itself be lined, successively, with a layer of armored concrete of thickness equal to the height of the ribs, and with a coat of Portland cement. In the sections beneath the two branches of the Seine the metal tube of the tunnel is to be constructed as described above, but surrounded by a metallic framework which shall serve as the caisson, thus enabling the tube to be sunk vertically into place. The sides of the caisson are composed of sheets of iron attached to the framework surrounding the steel lining of the tunnel. These sheets rise to the level of the foot of the arch and form a water-tight box which can be transported by floating. The entire space inclosed between the sides of the caisson and the tunnel will be filled with cement concrete, in which the framework will be buried and which will form a layer of strong and indestructible masonry surrounding the metal lining of the tunnel.

Three caissons will be used for the larger and two for the smaller branch of the Seine. The ends of these caissons are closed temporarily with sheets of steel which must be removed when the sections carried by the several caissons are joined to form a continuous tunnel. These junctions will be effected by small caissons operating in the intervals, 1.50 meters (5 feet) long, which will be left vacant between the ends of the sections of the tunnel. By sinking two of these small caissons two masonry walls will be built, connecting the bases of the large caissons and rising to the level of a horizontal ledge at the end of each. Upon these ledges and walls will rest a third small caisson, within which the sections will be connected and the temporary sheet-iron ends removed.

The two stations included in the plan, situated at the "Cité" and the Place St. Michel, will also be sunk by means of caissons similar to those employed for the tunnel under the Seine, but of greater dimensions.

The execution of the entire project of crossing the Seine will involve the employment of three very different methods of working:

(a) Compressed air and a shield will be used for the construction of three sections of the running tunnel.

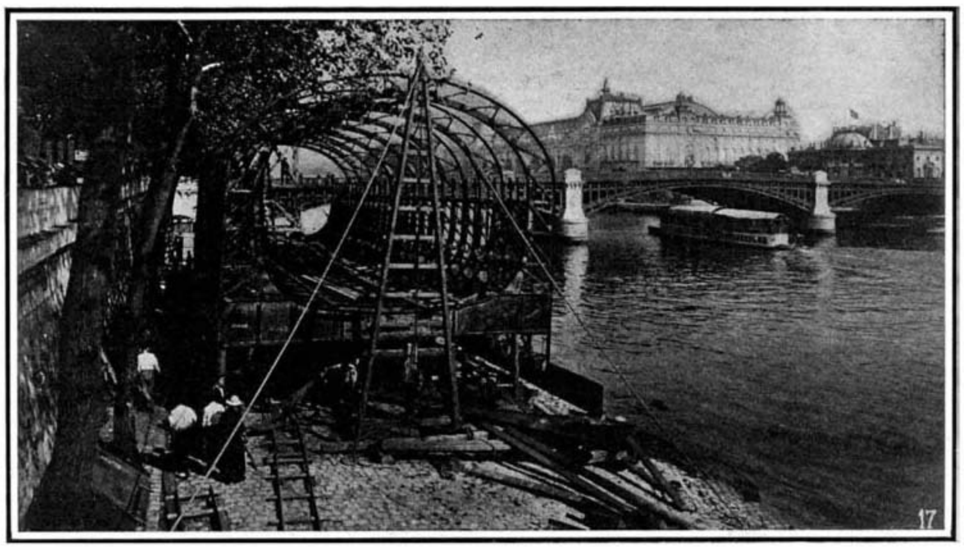
(b) Compressed air caissons will be employed for the tunnel under the Seine, part of the underground tunnel and the Cité and Place St. Michel stations, with their entrance shafts.

(c) Excavation by freezing process will be employed in the passage under the Orléans railway, in order to avoid the possibility of an interruption of traffic due to settling.

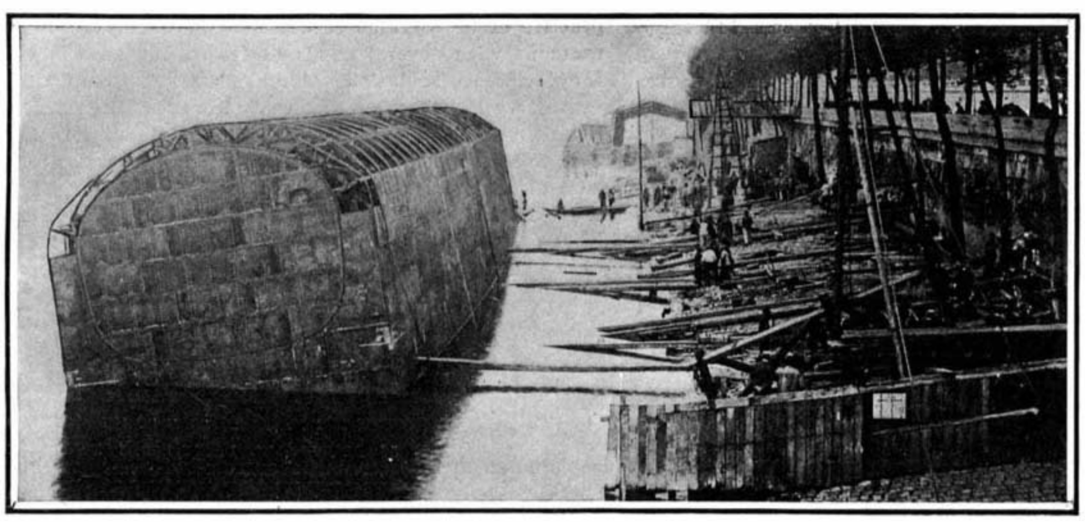
Of these three methods of working the second alone is in full operation. At present the first caisson, on the right bank of the larger branch of the Seine, is entirely submerged and has been sunk to within about half a meter of its final level.

The caissons for the stations will be built on the ground and, when completed and ready for sinking, will present the appearance of huge iron frames, 12.50 meters (41 feet) high, 16.50 meters (54.12 feet) wide, and 68 meters (223.64 feet) long.

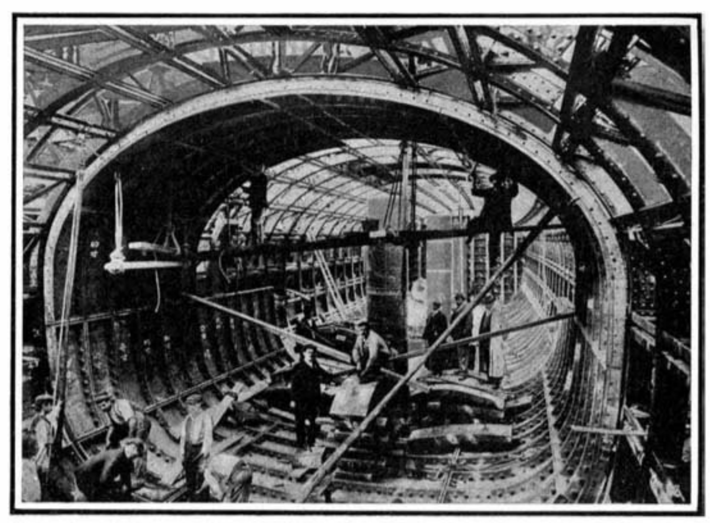
As no suitable ground for the construction of the river caissons was available near the points where they are to be submerged, a construction yard has been established at the Quai des Tuileries. One of the illustrations shows the first caisson at the moment when the framework was completed. Its construction was effected quickly by the employment of improved methods, particularly the method of riveting with pneumatic hammers. The caisson having been built and the plates which make it water-tight riveted around it, it was launched sidewise—an operation which was facilitated by the elevation of its site, 40 centimeters (1.6 feet) above the level of the Seine. The caisson, which weighed 280 tons, was then towed to the point where it was to be sunk. Here the stream had been dredged to a depth of 5 meters (16.4 feet) in such a manner that the caisson could be sunk upon a perfectly horizontal bed. On the downstream side of the emplacement guiding piles had been driven, against which the caisson rested. These piles formed the first part of a solid stockade of piling serving, on the one hand, to protect the caisson and, on the other, to support a broad platform. The first work done after the caisson was in place was, of course, the construction of the iron lining tube of the tunnel. Then concrete was poured between the tube and the exterior envelope until the caisson rested solidly on the bed of the river. Then the shafts which give access to the working chamber and the air locks which surmount them were put in place and the sinking by means of compressed air commenced. When the final level is reached the working chamber will be filled with concrete, the tunnel will be emptied of the water with which it was filled in order to ballast the caisson and facilitate its descent, the shafts will be removed and the openings through which they communicated with the interior of the tunnel will be carefully closed. In this caisson the telephone has been employed—for the first time to the writer's knowledge



Erection of the First Caisson on the Quai des Tuileries.



The First Caisson Launched Sidewise.



Construction of Iron Lining Tube.

THE TUNNEL UNDER THE SEINE RIVER.