THE ELECTRIC LIGHTING OF DRURY LANE THEATRE ROYAL.

Considerable comment having been made lately in the daily Press regarding the risk of fire in the historic playhouse known as Drury Lane Theatre, it may not be out of place to review briefly the electric lighting arrangements, and to describe in detail the improvements which have just been completed. Some time ago the directors became alive to the fact that the installation was not in such perfect condition as it might have been, and immediate steps were taken to provide a remedy. Those who have had experience in theatre lighting know only too well what rough treatment the various appliances are subjected to, and that specially designed apparatus have to be employed to withstand the wear and tear. Until the present alterations were commenced all leads, both on the stage and in the auditorium, were carried in wood casing, and although this was excellent in many respects, yet there was a certain element of danger in this method, as far as the stage lighting was concerned. Of course, the matter was on quite a different footing as regards the auditorium; the casing was on the surface, easy of access, and, being fitted very substantially in the first instance, was satisfactory in every respect. New distribution boards and quick-break switches have, however, been fixed, and all are quite fireproof.

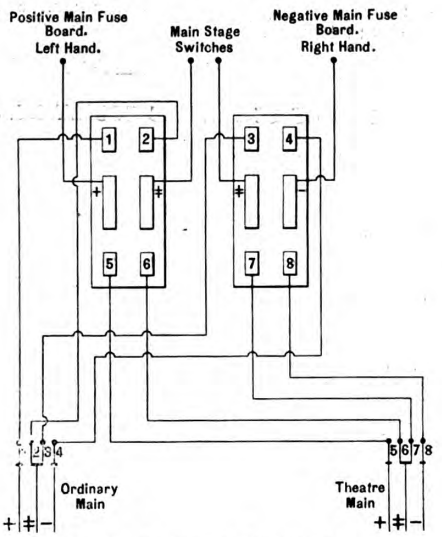

FIG. 1.—DIAGRAM OF CONNECTIONS.

The stage, on the other hand, has been re-wired from the point at which connection is made to the company's mains to the lamps themselves. And the work has been done in such a way as to eliminate risk to the greatest possible extent. Every safeguard known to modern engineering has been adopted, no expense has been spared, and it is difficult to imagine how a fire could occur. It is perfectly safe to say that Drury Lane Theatre will never be destroyed by fire originating from an electrical source, so complete are the precautions. But, so as to make assurance doubly sure, an elaborate system of fire alarms has been installed, and, side by side with the glass-covered alarm boxes, are water hydrants all ready equipped with hose. A staff of professional firemen is always in attendance, and the breaking of a glass causes signals to be conveyed to various parts of the building, amongst them being the theatre fire station. The point of the outbreak is automatically indicated to the attendant, and he merely has to proceed to that point and turn on the hydrant. On this occasion, however, we are chiefly concerned with the electric lighting of the building, for which current is obtained from the Charing Cross and Strand Electricity Supply Corporation's mains.

There are two separate and distinct sources of 2×100-volt main supply to the theatre. In an underground fireproof brick chamber there are fixed all the main switches, disconnecting fuse and distribution boxes, meters, &c. On the right-hand side of this chamber are the special theatre mains of the Charing Cross Company, and on the left-hand side are those taken off from the ordinary distributing network of the same company. These mains are brought in from the street through separate earthenware conduits, and at no point do they come into contact with each other. They are encased with sheet-iron boxes, fastened to the wall and filled with sand, and in this chamber, at least, there is absolutely nothing inflammable, with the exception, of course, of the cable insulation, and as this is all buried in sand it may be considered non-inflammable. Referring to Fig. 1, it will be seen that immediately on entering the building the middle wire of each set of three is divided, fuses, marked 2, 3, 6 and 7, being inserted in the branches. Two separate two-wire circuits are then taken to the main two-way switches, and pass from thence direct to the stage switchboard. By means of this arrangement it is possible to obtain the entire supply for the theatre from either the special theatre mains or from the ordinary network, and if one of the middle wire fuses should go only half the lights are extinguished. Moreover, by inserting the fuses in the middle wire *after* it has been divided, dangerous rises in pressure on one side of the system, due to failure of a single middle wire fuse, are avoided. There is also the possibility of obtaining supply for, say, the positive side from the ordinary network and the negative side from the theatre mains, or *vice versâ*, but, as a matter of fact, such an expedient is never resorted to, the entire supply usually being taken from the special theatre mains. The main two-way switches have a capacity of 1,000 amperes each and were made by the Electric and Ordnance Accessories Co. The two pairs of main cables consist of 91/12 gauge 2,500 megohm cables, and are arranged for a working density of 600 amperes per square inch. From the time that they leave the main two-way switches, all conductors are encased in steel conduit, screwed and earthed. Stranded cables containing 61/14's are employed for the rest of the house, and the distribution boards for these, as well as the battens and batten boxes, were supplied by Messrs. Pinching and Walton.

After leaving the underground chamber the main cables pass to a switchboard on the stage level, which is a great advantage over those situated in the flies or some other inconvenient position. The board at Drury Lane is so placed that the operator commands a full view of the entire stage, and owing to the fact that a new recess has been built for it there is no inconvenience caused to any of the company or stage operatives. At the end of the recess is fixed a polished slate board (Fig. 2), carrying three quick-break switches which control all the white, red and blue lamps respectively. These switches are in the middle wire. The outer conductors of the three-wire system are taken directly to four distribution boards, fitted with fuses and seen above the regulator shown in Fig. 3. By means of counter-weights, the heavy lids of the iron boxes containing these distribution boards may be held open or kept closed at will, and this is a most commendable feature, considering their position and the conditions attendant upon theatre lighting. From Fig. 1, it will be observed that there are two main circuits running from the underground connecting chamber, and hence the three main switches in the middle wire on the stage board have each two poles, one for each middle wire, but both poles are, however, at the same potential. And as the whole of the switchgear and regulators are in the middle wires, there is no difference of potential between any parts of them, and hence no possibility of obtaining accidental short-circuits. The only part of the board at which a difference of potential does exist is at the outer conductor distribution boards referred to above, and as these need only be opened when a fuse blows, it will be seen that the whole arrangement is about as "fool proof" and immune from danger as any apparatus for the purpose could be.

The method of connecting the cables to the board is also an ingenious one. Under the London County Council regulations

it is necessary to have all the connections within sight and at the front of the board. In order to comply with this, the cables are carried from their respective steel barrels to the point of connection in steel conduit of channel section, from which they emerge through side holes efficiently bushed; to the end of each cable is sweated a thimble, and this is fastened, by means of a nut, to a brass strip on the front of the board, and projecting slightly beyond the edge. Thus no conductors pass through the slate base of the board, but are all insulated by air. All points at which cables enter or leave the steel barrel are also bushed with insulating material, and inspection boxes are fitted at all bends, as well as at frequent intervals in the straight runs. Messrs. Johnson and Phillips supplied all the cable.

The board carrying the various circuit switches and fuses is a very fine piece of work, and consists of polished slate panels It is shown in Fig. 2. There are four rows of quick-break switches, the top row controlling all the white lamps, the second all the red, the third all the blue, and the bottom various colours for special purposes. It is mainly divided into two parts, that on the left controlling all the lamps on the positive side of the system, and that on the right all those on the negative. It should be remembered, however, that all these are in the middle wire. On the top of the board carrying the three main double-pole switches are two voltmeters and two ammeters. The bottom row of switches serves a very useful purpose; it is frequently necessary to leave one particular set of lamps on in a certain position, when all the rest of the stage is in darkness. Imagine that, during what is called a "dark change," it is required to keep the blue lamps alight in the float, and that all the rest of the stage is to be plunged into total darkness. Under ordinary conditions the circuits would have to be switched off separately, and this would spoil the effect. To overcome this difficulty a separate 'bus bar has been fixed, which is not controlled by the main

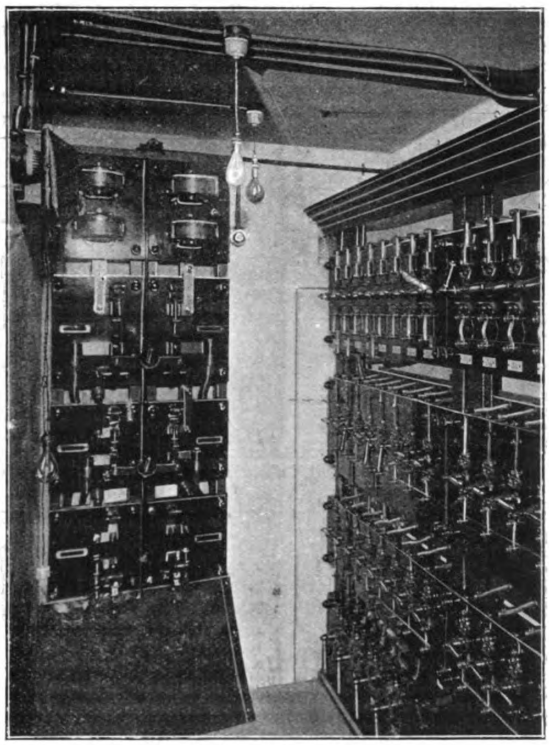

FIG. 2.—STAGE SWITCHBOARD.

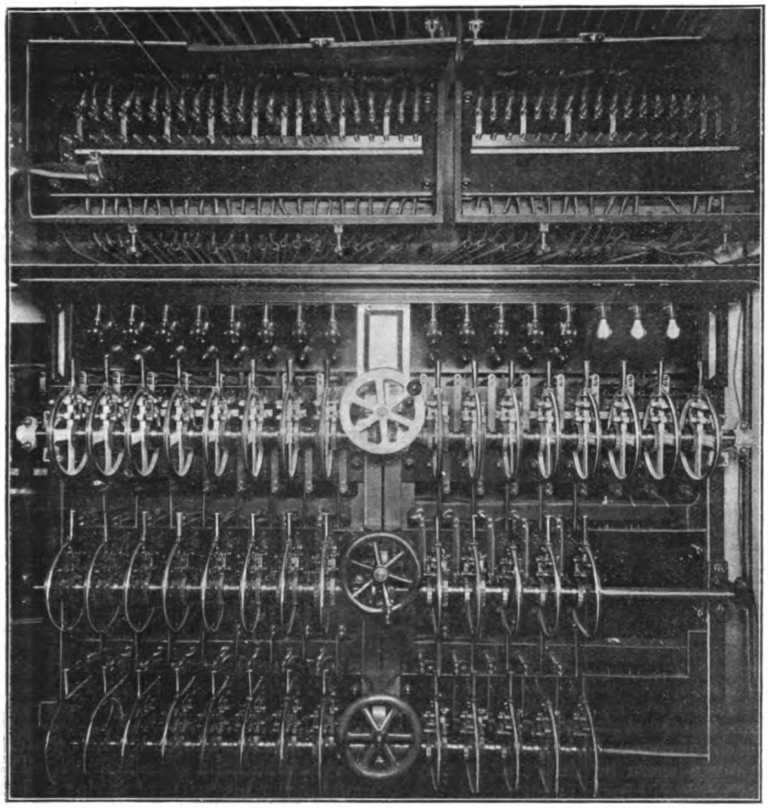

FIG. 3.—REGULATOR.

switches, and is, therefore, always alive. Before receiving the order "lights out," the attendant puts the "float blue" auxiliary switch on, and then, during the time the main switches are off, he has time to re-arrange the ordinary switches for the next scene. On receiving the order "lights up" he merely has to close the main switches, and the desired effect is obtained.

To the right of the switchboard is the regulator (Fig. 3), which possesses several features of unusual interest. Similarly to the board, the regulator is divided into two main parts—one for the positive circuit and the other for the negative. The wheels for the individual circuits are also arranged in positions corresponding to those of the circuit switches, the top row controlling the white lamps, the second row the red lamps, and the third the blue. Fig. 4 shows the general arrangement of the regulator, and Figs. 5 and 6 one of the movements in two different positions. In principle, the whole apparatus consists of a number of wheels mounted upon a common shaft, it being possible to operate the "dimmers" or liquid resistances either collectively or individually by rotating the wheels simultaneously or singly.

Referring to Figs. 5 and 6, it will be seen that each wheel is fitted on the shaft between a pair of ratchet wheels with teeth set in opposite directions. The ratchet wheels are fixed to the shaft by keys, but the wheels are mounted so that they rotate freely on the shaft, but are kept in position by the two ratchet wheels, which therefore act as collars in the usual manner. Each wheel carries two pawls, mounted one on each side and pointing in opposite directions, and these pawls are arranged to engage with the ratchet wheels, but their movement is so controlled that when the shaft is rotated with both pawls engaged, a rotary movement in one direction will turn the wheel with the shaft by transmitting the motion through one ratchet

wheel and pawl, and when the shaft is rotated in the other direction, the motion will be transmitted by the other ratchet wheel and pawl. The pawls are fitted with springs which cause them to engage with the ratchet wheels, and the wheels each carry two levers which are connected to the pawls by links. The levers act as stops on the wheel, and limit its rotation in either direction by coming into contact with two fixed stops, suitably mounted upon the frame of the regulator. These fixed stops are in the form of an inclined plane, and are so placed that when the ends of the levers engage with them, motion is imparted and the pawls are lifted by means of the links and are disengaged from the ratchet wheels, one set of parts coming into action at each end of the movement of the wheel. By means of the arrangement described, the wheels are automatically disconnected from the shaft as soon as they have reached the limit of their movement, although they may be locked to the shaft in different relative positions, and the shaft may continue to rotate. On the other hand, if the direction of rotation of the shaft is reversed, the motion will again be transmitted to the wheels, as only one set of pawls is lifted at one time, and the other set is ready to take up the motion on the direction of the rotation being reversed. In order to allow for any regulator being operated independently of the remainder, each wheel is provided with an arrangement for lifting and holding both pawls clear of the ratchet wheels simultaneously, this ingenious arrangement taking the form of a quick pitch screw, at right angles to the shaft, carrying a nut which engages with the two pawls by means of their respective connecting links, the screw being fitted with a small lever by which it is turned and which projects from the side of the wheel. This arrangement also allows for any wheel or wheels being left in one position while the remainder are operated by means of the main shaft. The wheels are fitted with short-circuiting switches in the usual manner. The shaft is fitted with worm gearing so as to obtain a steady movement of the generators. Both the switchboard and the regulator were made by Messrs. Ernest F. Moy (Ltd.).

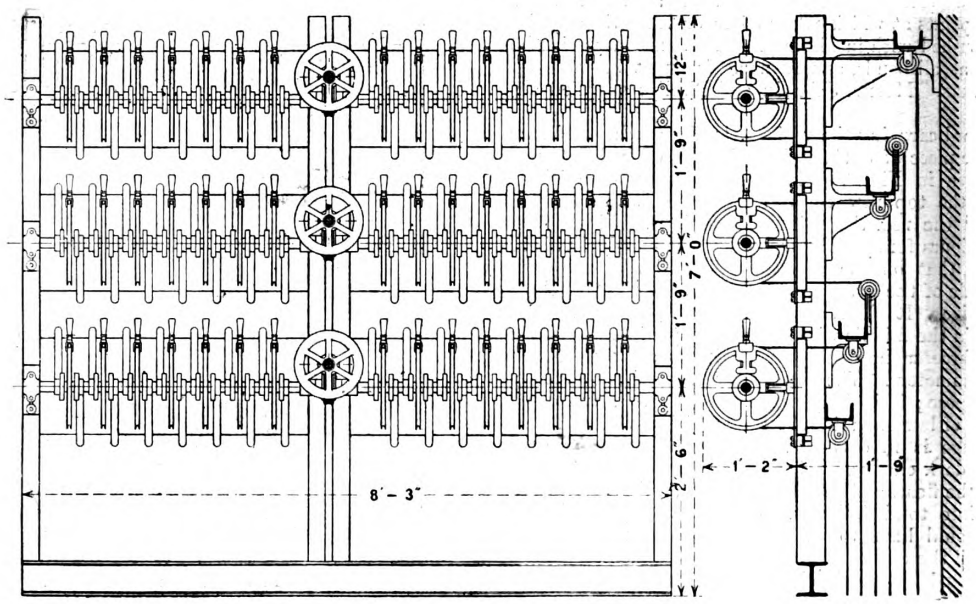

Fig. 4.—General Arrangement of Regulator.

Fig. 7 is a photograph of the dimmer room, which is situated immediately under the regulator, and Fig. 8 is a section of one of the new type of dimmer shown on the left-hand side of Fig. 7. In the old type it was necessary to make the connection to the lower electrode in the liquid itself, and as this frequently led to trouble, Messrs. Moy have introduced the new pattern, in which, as may be seen, the connection is made in air. This arrangement also eliminates the necessity of boring a hole near the bottom of the vessel, through which to pass the conductor, and thus a fruitful source of leakage is done away with. The terminals to which the flexible leads are connected are

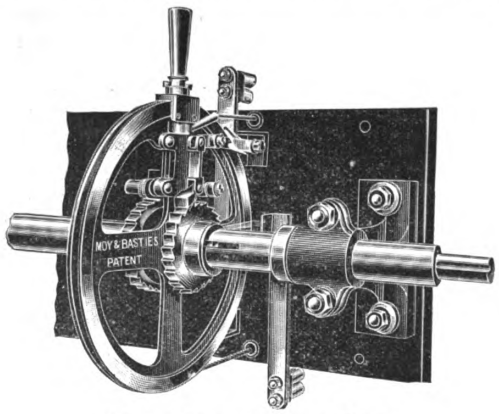

Fig. 5.—Single Regulator Wheel.

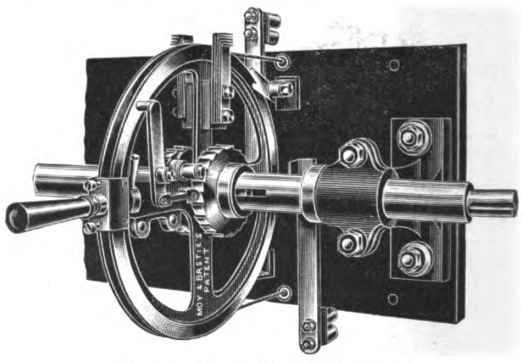

Fig. 6.—Single Regulator Wheel.

mounted upon solid pieces of porcelain fastened to the wall. When the movable electrode reaches its lowest position it makes metallic contact with the fixed electrode, but as the electrical contact is not absolutely perfect a short-circuiting switch is provided on each regulating wheel, as described above.

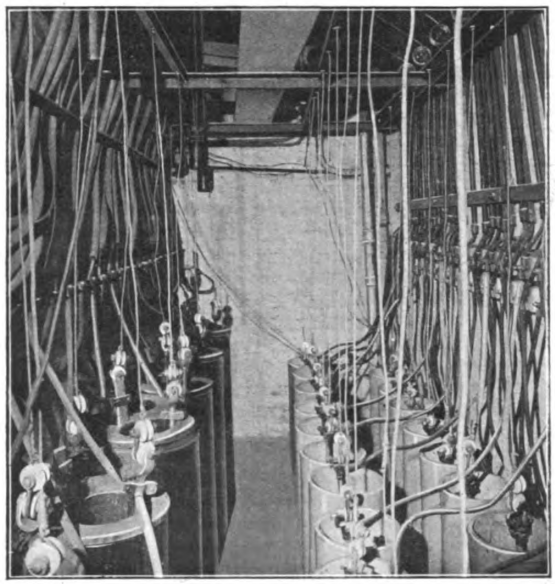

FIG. 7.—"DIMMER" ROOM.

There are, on the stage, five front battens, 48ft. in length, each of which contains 250 lamps; these are said to be the longest battens in this country. In addition to these, however, there are also six back battens 38ft. in length. The leads for the battens are taken up from the switchboard to the flies in steel barrel and there enter distribution boards encased in iron and provided with heavy iron lids which are hinged at the top and, therefore, close by gravity. Opposite poles are on separate panels, Mordey fuses are used, and the holes in the sides of the cases, through which the conductors pass, are bushed with insulating material. The 'bus bars are divided for the three different coloured lamps and there is a separate pair of leads for each circuit, no common return being employed. The conductors, which must necessarily be flexible to allow of the battens being raised and lowered, are enclosed by a canvas fire hose. The stage plugs, which are of a very substantial pattern were supplied by Messrs. Moy.

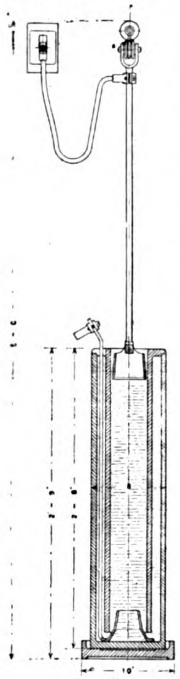

FIG. 8.
SECTION OF "DIMMER."

There are, altogether, about 5,000 lamps on the stage, exclusive of stage arcs, &c. One "effect" is obtained in a very ingenious manner and is due to the theatre engineer, Mr. Chas. V. Bretherton. In the kitchen scene it is desired to represent a very large roaring fire over which certain vessels are suspended. Of course, real flames would be quite out of the question, and to obtain the desired effect two rectangular wooden frames have been constructed, over which wire netting is stretched. Under the netting are fixed 16in. ¼ H.P. electric fans, so arranged as to cause a very strong updraught, and tied to the netting itself are strips of very thin red silk gauze. Some red lamps between the fans and the netting, produce the requisite colour. When the fans are rotated the gauze is blown out vertically, and at a distance of only a few feet it is exceedingly difficult to convince oneself that they are not real flames; added to this is the "whirr" caused by the fans, and the whole result is most realistic. There are many other devices operated electrically, but it would not be fair to divulge anything further.

In the "prompt corner" is a set of small red and green lamps in series with which are similar lamps in various parts of the building; by means of these, visual signals may be conveyed to indicate to operators the precise moment at which certain things should be done. Thus noise is eliminated, and owing to the lamps being in series, the excuse for non-execution of an order, that the signal was not received cannot be advanced.

In *The Electrician*, Vol. XLII., p. 325, there appeared a very complete description of the highly ingenious arrangements whereby practically the whole of the stage may be raised or lowered at will. At Drury Lane there are four "bridges" or lifts, two worked by hydraulic and two by electric power. The former possess a certain advantage over the latter in that they can be moved or fixed at any angle, whereas the electric lifts can only be operated horizontally. Mr. Edwin O. Sachs

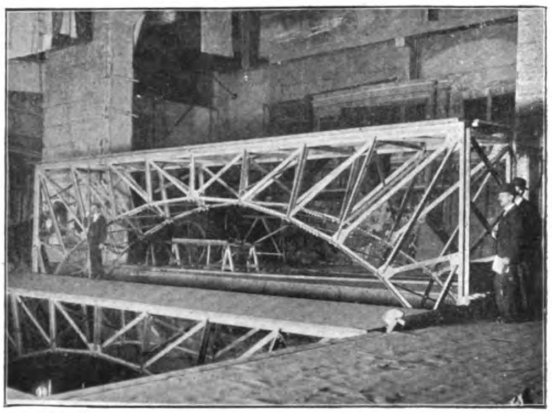

FIG. 9.—ONE OF THE BRIDGES.

was the consulting engineer for this part of the work, which was executed some years ago. Fig. 10 shows the electrical hoisting gear, by means of which the two huge bridges are safely and noiselessly raised or lowered so as to facilitate the setting of scenes without having recourse to the old-fashioned method of building up the stage by means of wooden platforms. The dead weight of the bridges is taken by counterweights, and provision is made for operating by hand in case the current should fail. Each section (Fig. 9) measures 40ft. by 8ft., and the total weight is about 6½ tons, of which 4½ tons is counterweighted. The length of travel is from the mezzanine floor, situated 8ft. 6in. below the stage, to 10ft. 6in. above the stage. The legs of the girders are of considerable length, and slide in angle irons attached to steel stanchions. The mechanism which elevates the bridges is situated entirely below them (see Fig. 11), and each bridge has a set of motors and gear to work it. Energy is supplied to four-pole enclosed shunt-wound motors, each of which develops 7½ H.P. at 520 revs. per min. These machines were made by the Thames Ironworks Co. Speed is reduced in the ratio of 104 to 1 through large worm gearing, the worm wheel being geared to a shaft which carries two winding drums making 5 revs. per min. Upon these drums are wound steel wire ropes, which pass over guide pulleys and are connected at four places to the legs of the bridges—one near each corner. The normal speed of lifting is 16ft. per min., which may, however, be reduced to 6ft. per min. New starters of the "Perfecta" type have recently been fitted, and there is also a magnetic brake.

The re-wiring of the theatre was commenced some considerable time ago, and it was not until a great part of the work had been completed that the London County Council suggested that alterations should be made. As a matter of fact, the London County Council have no legal authority to compel the proprietors of Drury Lane Theatre to comply with their regulations, as the theatre is worked under a Royal patent; but the directors have, in their own interests and in the interests of the public, taken every precaution to make the theatre as immune from fire risk as possible, and they have, in so doing, complied with the Council's regulations to the letter.

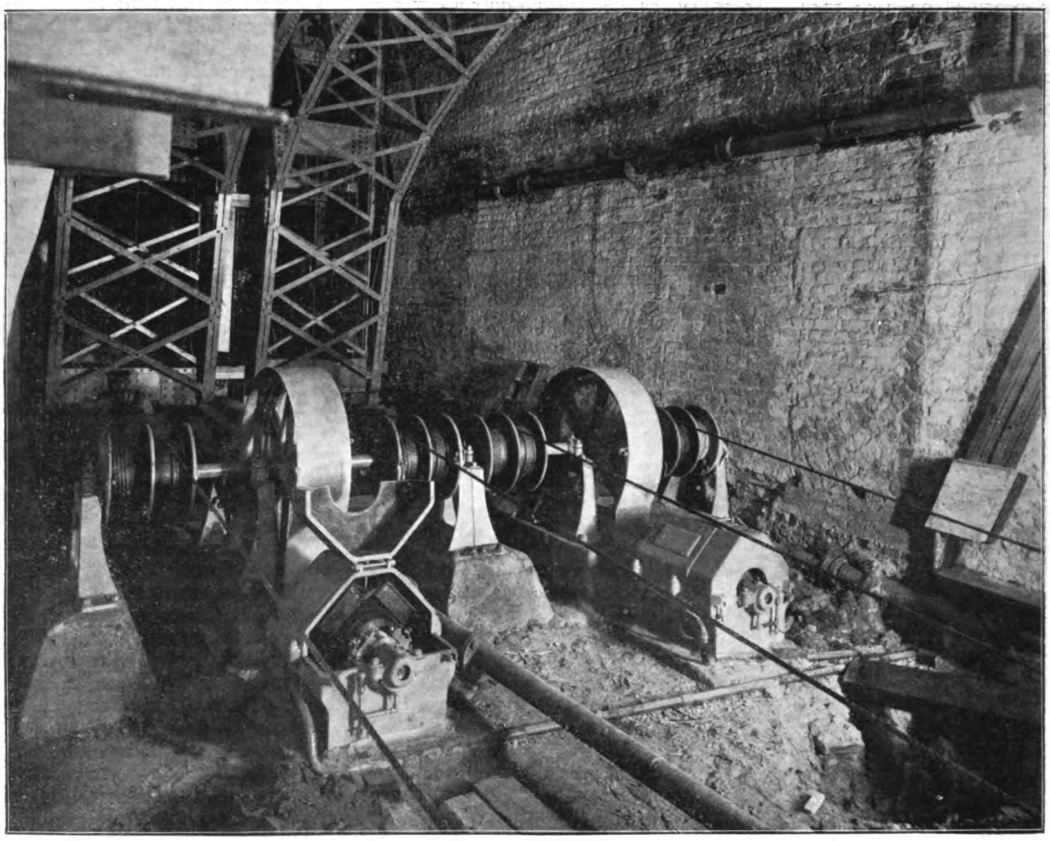

Fig. 10.—General View of Hoisting Gear.

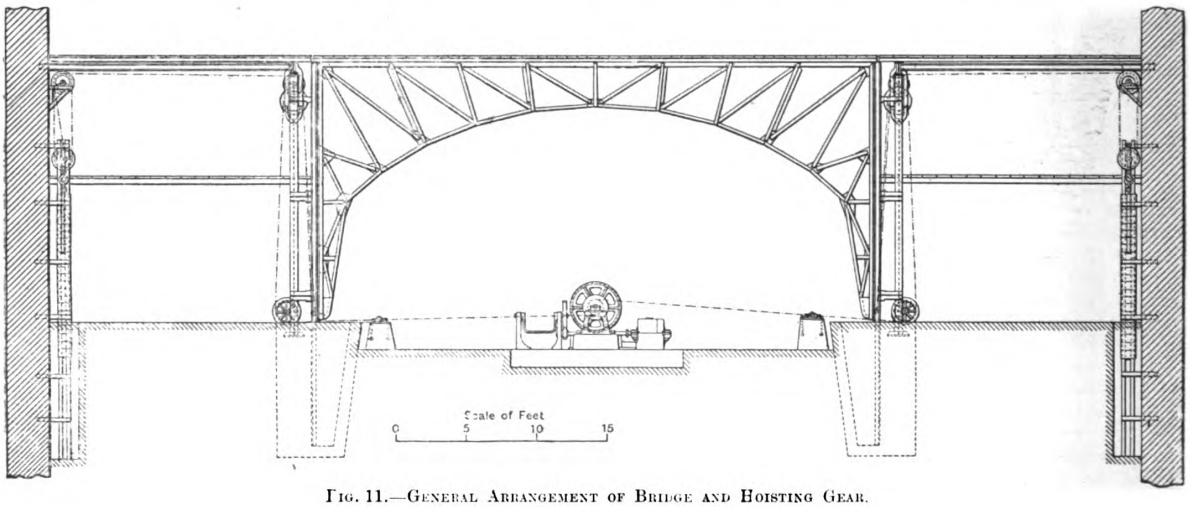

Fig. 11.—General Arrangement of Bridge and Hoisting Gear.

We are indebted to Mr. Adrian Collins, consulting engineer to the Drury Lane Theatre, for his courtesy in showing us over the theatre, and also to Mr. Chas. V. Bretherton, under whom the entire work has been carried out by the permanent staff, and from whom we obtained much of the detailed information contained in this article.