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DESIGN OF A CENTRAL TELEPHONE EXCHANGE.

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## DESIGN OF A CENTRAL TELEPHONE EXCHANGE.

In designing this plant we have endeavored to meet the requirements of an up-to-date telephone exchange. With the increasing demand for the telephone, comes the necessity of improving the arrangement and the apparatus used in the exchange, to obtain quick and reliable service. Telephone men have been and are still bending all their energies in this direction. Not only is quick service an important factor, but it is of great moment to the subscriber.

As the laying of cables under ground is becoming one of the necessities in large cities, we have assumed that our lines are to be layed in the best possible manner, using only reliable conduit material, and a good grade of copper in the cables. Our purpose in using copper wire rather than iron wire is, that if at any time a change of material was desired the copper would always bring in a good return, while the iron wire would have small value. The use of copper in under ground cables cuts down depreciation to a considerable extent.

Having made the assumption as to the laying of the cables,

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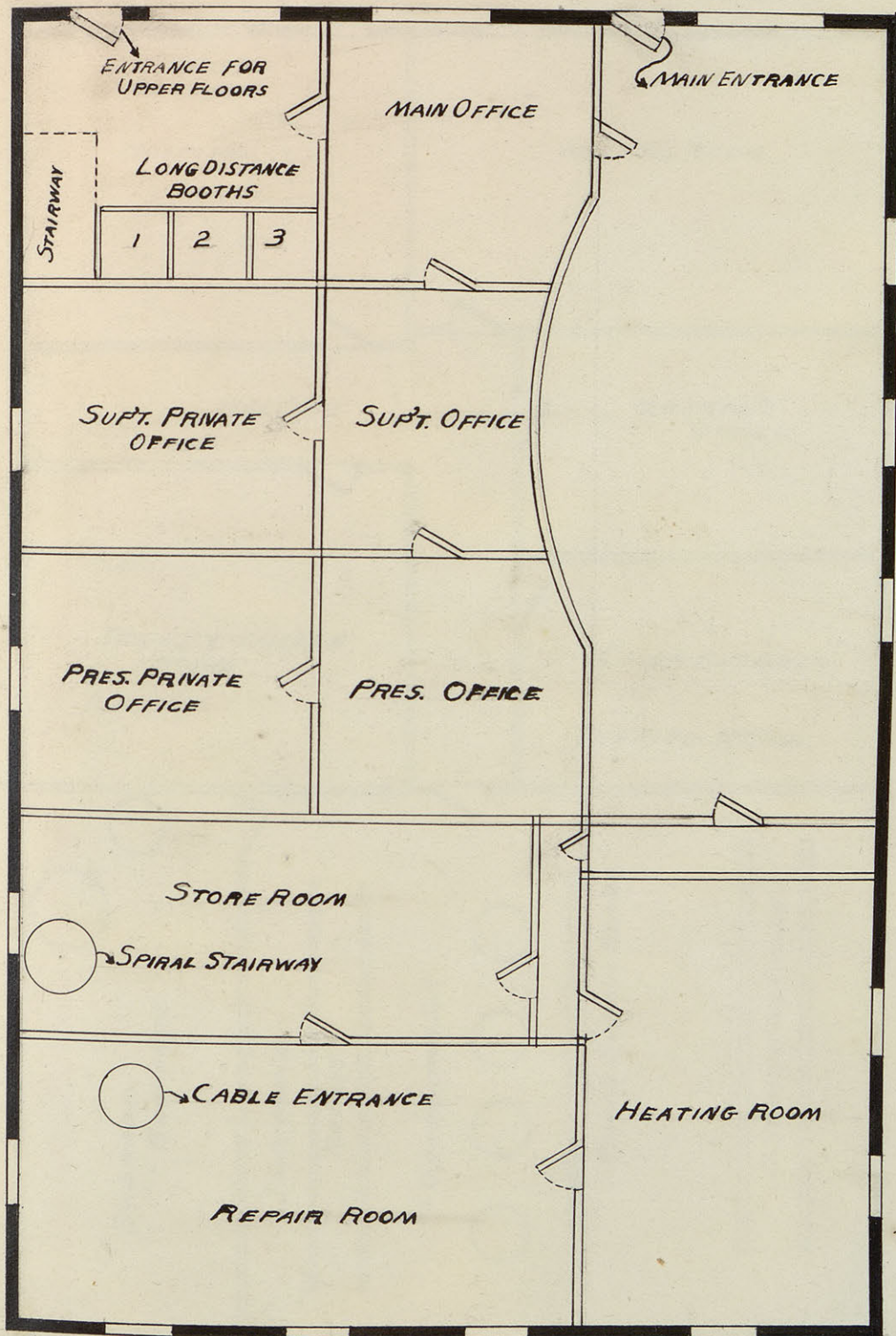
and the location of the building being as near the center of distribution as possible, the next important step is the consideration of the switch board and the operating room.

The system we have decided upon is the Kellogg modification of the multiple system. In using this method we have assumed that we have at the present time 9000 subscribers. Subscribers of this number has been proven in practice as impossible to handle in one exchange using the ordinary multiple system, which has for its maximum 6000 subscribers. If this number is exceeded, branch offices must be used. But this would require a central office and a branch office, connected by means of trunking lines. A message sent would have to be handled by at least two operators, which causes delay and gives greater chance for error than when one board is used and one operator handles the message. In such cases the expense of operating an exchange is nearly two-fold.

In the Kellogg system all the good qualities of the single multiple system are to be found, with an addition to cutting down expense by using one building and one set of operators. All the subscribers' lines are divided into four divisions designated as the A, B, C, and D lines.

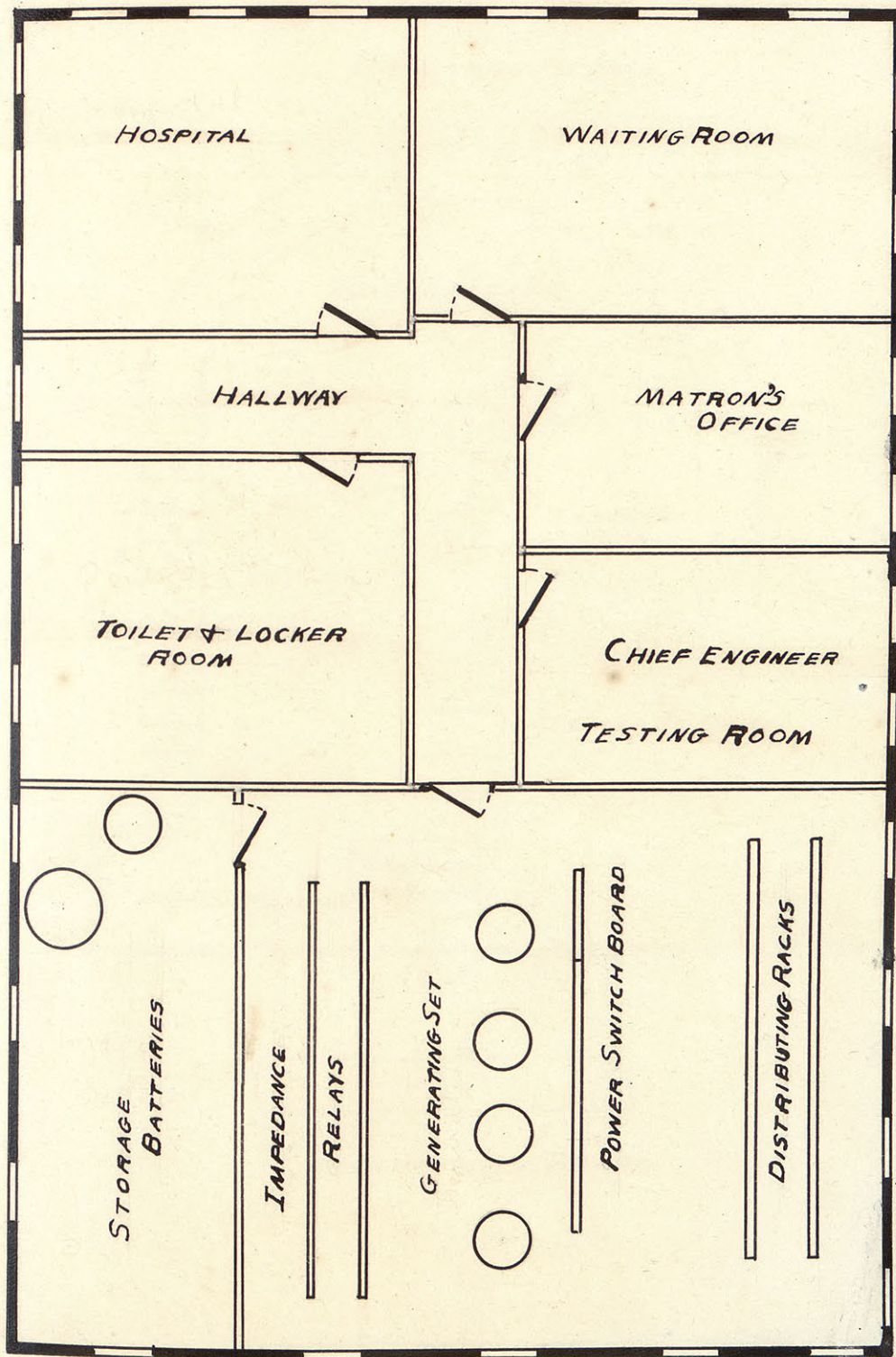
The multiple switch board is divided into four corresponding divisions. Each division consist of ten sections, containing three operator's positions for each section. Each section has in multiple one fourth the number of lines entering the exchange. Thus each (A) subscriber line appears at a terminal called a spring jack on every section of the A division. B, C, and D lines are connected in like manner as the above. These jacks are the multiple or outgoing jacks.

FIRST FLOOR

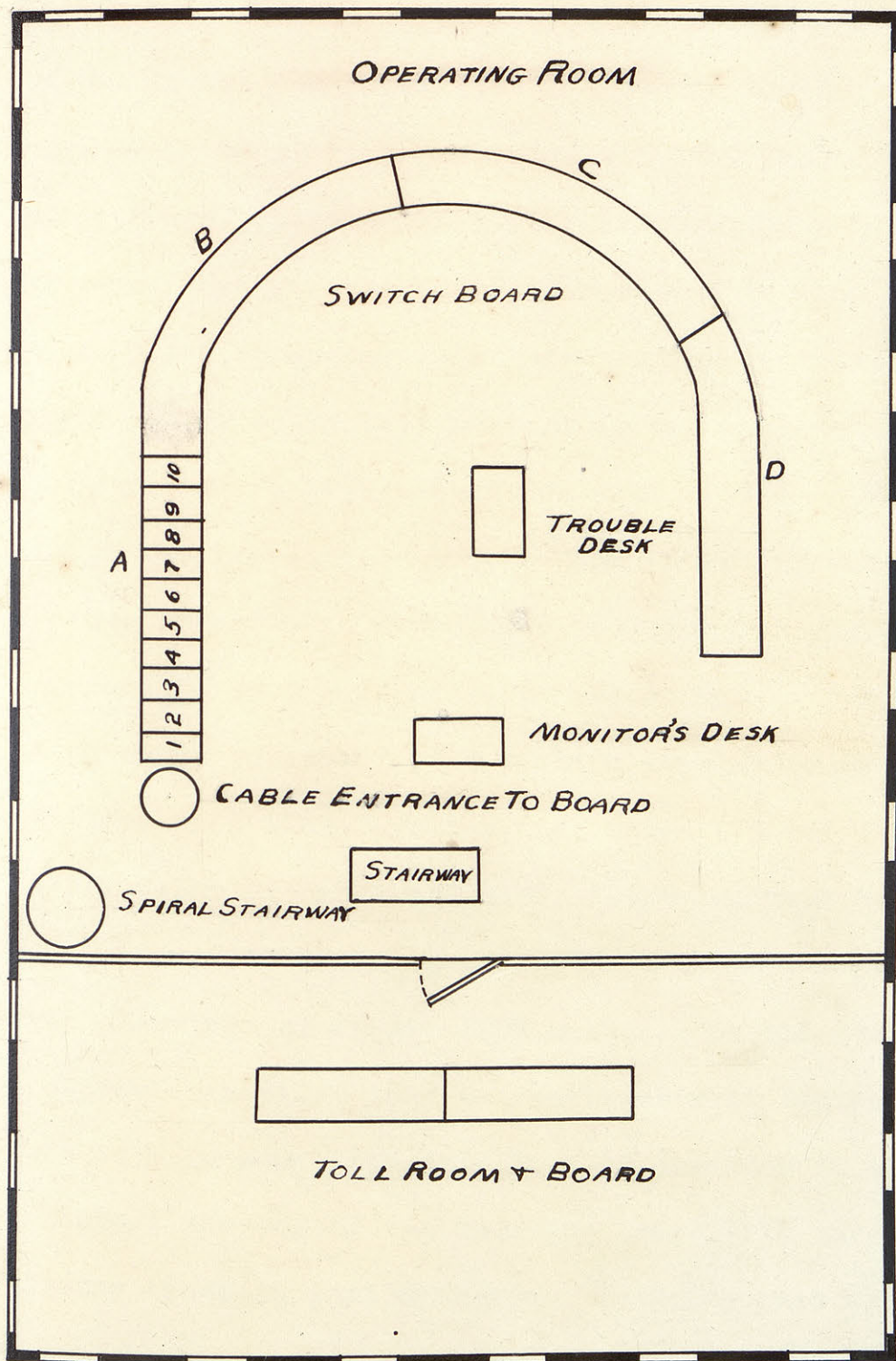


SCALE  $\frac{1}{8}'' = 1'$

SECOND FLOOR



THIRD FLOOR



If for instance we have 9000 subscribers, each section of each division of the board has 2250 outgoing call jacks, or one fourth the total number of lines entering the exchange. In addition to the multiple jacks, each division contains incoming call jacks equivalent to the entire number of lines. Each of the ten sections of the division will therefore be equipped with 900 jacks representing the incoming lines. Located in a tier immediately below the incoming call jacks, and corresponding in position to them are the polarized annunciators or drops, each representing an incoming line and responding when the subscriber signals to the operator for connection. A drop for every line appears on each of the four division of the board. In the lowest tier before each operator, are the clearing out drops intended to signal the operator for disconnection. Each drop corresponds to a pair of plugs and cords.

A complete equipment of a section consisting of three operators positions will therefore include, three transmitters, three receivers, thirty pairs of plugs and cord, thirty ringing keys, thirty listening keys, 900 incoming call jacks, 900 polarized annunciators, thirty clearing out drops, 2250 multiple or out going call jacks and a supervisory pilot lamp to readily attract the operators attention. It will be seen from this that an operator in any one section may connect any one of the incoming lines with any one of the 2250 outgoing lines in that division. In using this system the subscriber's apparatus consist of a magnet-generator and four keys with a commutator spring and connection for operating any one of the four annunciators at the exchange switch board. These four

keys are designated by letters corresponding to the divisions at the exchange; each division containing one of the four keys.

When a subscriber desires to connect with another he calls up central by depressing the key corresponding to the alphabetical designation of the number of the desired subscriber, causing the drop of that division to indicate. The operator then inserts the switch plug in the answering jack corresponding to the indicated drop and communicates with the subscriber by throwing over the listening key, thus bridging the lines. When the number is known the operator makes a "busy test", by touching the ring of the multiple jack with the tip of the calling plug. If the line is clear the operator receives a click in her receiver, but if the line is busy no click is heard. If the line is clear the operator puts the mate of the first plug, the calling plug, into the multiple jack of the number called for and the called subscriber is signalled by ringing his bell with the ringing key. When the conversation is over and the receiver up, the operator is automatically signalled, by the clearing out drop, that the conversation is over, and the subscribers lines are disconnected.

In placing the switch board we have kept in mind the need of adding new subscribers. With this purpose in view we have arranged our board as shown in the diagram of the building. The board as there arranged can serve about 24000 subscribers. In placing the divisions as shown, less room is taken up, that is an exchange arranged in this manner can be handled in a building of smaller lengthwise dimension without crowding, than if each division had been placed lengthwise.



At A, is shown the entrance of the cables, coming from the distributing room to the board. At the head of the board and in a position so that she can supervise all the operators, is the Monitor's desk. On her desk is a telephone so connected that she may cut in at any time and ascertain whether or not the operators are making connections in the proper manner. In front of her desk and a little to the right is the trouble desk. To the apparatus of this desk, trunking lines are connected to the switch board. At this point trouble can be located if it happens to be at the switch board. If trouble is located at some other point it must be determined from the distributing room.

If an operator is in trouble over a connection she throws a switch which will light an incandescent light enclosed in a red globe. This attract the Monitor's attention and she goes to the operators aid.

Another important feature of the operating room is the heating and lighting arrangement. It is necessary that there be plenty of light at the back of the switch board, as well as in front of it. For this reason numerous windows have been provided. For lighting the front of the board, the operating room being placed on the top floor, a large sky light has been designed for lighting in the day time and six Nernst lamps have been placed to furnish light by night.

The building is to be heated by steam furnished by a boiler on the first floor.

In order that dust may not accumulate, the back of the switch-board is closed. The floors are of cement leaving no cracks

to collect the dust. These two preventions we believe will keep down the accumulation of dust which is always a source of trouble in a switch board room. To the rear of the operating room is the long distance switch board room. Arrangement is made here for connection to local phones or party lines which are arranged for on the local board.

Power Equipment.

The continuous and uninterrupted service of a central energy telephone system demands that the supply of primary power be constant and sure, and as a means of insuring such service it is imperative that there be two or more sources of primary power and at least two sets of equipment for transforming the primary energy into the proper form for the operation of the system; also a safe means of storing up this energy in sufficient quantity to tide over a temporary failure of all sources of primary power available.

The fundamental division of the power plant are as follows:

- (1) The storage battery, from which current is furnished directly to the lines, relay racks and switch boards, for talking and operating signals.
- (2) There must be a means of charging these batteries by transforming the primary power to the proper voltage for charging the battery.
- (3) Apparatus for generating, ringing and other audible signalling currents.
- (4) Equipment for the control and switching for all the various forms of electrical energy.
- (5) The conduit and conductors system for the transference of the energy.

The power and equipment will be discussed under the preceding heads , in order.

Storage Battery.

The storage battery for this system is to be in duplicate.

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The number of cells to be used varies of course with the voltage required. At the present time there are two standard voltages in use, the twenty and forty volt system, with the forty volt system receiving the preference. The system selected for this exchange, is the forty volt system thus necessitating a battery of forty storage cells, as the battery is to be in duplicate.

The forty volt system has several advantages over the twenty volt system. Only half the current is required for the forty volt system this advantage being obvious in the saving of copper in the lines. Again while the current is halved; induction and cross talk are correspondingly cut down rendering a high percentage of good transmission.

The size of the battery depends on the rate at which the discharge is to take place. This is a problem which has been determined by experience alone. From statistics a general mean can be drawn showing that from .1 to .25 amperes may be allowed for each connection put up, according to the system; and that from 10 to 15 connections per day of 24 hours are allowed for each subscriber, each connection lasting on an average about three minutes. From this data the size of the battery may be determined. Local conditions also enter as an important factor in determining the size of the battery. In some places charging current may be had only about 8 hours per day. But in order to be safe the battery should be able to carry the full load at least 24 hours. The efficiency of storage batteries for telephone purposes should be some where between 75 and 80%.

#### Charging Equipment.

Common use offers two methods of charging storage batteries. They may be charged directly from electric light or power mains

through an adjustable resistance in series with the battery or they may be charged by a special generator, directly connected to a motor or driven by some other source of power. On account of the great loss of current the first method is used only as a last resort. The second method involving the use of a special generator is the one most used and is best adapted for an exchange. The telephone motor generator is to be of the special type, for this purpose, which is manufactured by many of the larger companies. The set consist of a twin motor and generator, mounted upon the same sub-base and directly connected by means of a flexible insulated coupling keyed to the shaft.

Both machines should be well insulated from the sub-base to prevent any electrical connection between them. The charging set is to be in duplicate and a special arrangement is to be made so that they may be connected to any one of the power circuits of the city. A gasoline engine is to be installed, with sufficient capacity to run the charging set should anything happen to cut off the power.

These telephone charging generators are made having long smooth commutators consisting of a large number of segments. The smoothness of the commutator is a necessity owing to sensitiveness of the receivers. These are affected slightly by the storage battery but mainly by the charging generator. As the battery must be charged at the same time that it is giving power to the switch board we can see how the receivers will be affected by a rough commutator. In all cases the commutator should be kept smooth and the brushes kept fitting up closely. The plant may be operated by the generator alone but it is well to have the storage battery to fall back on should anything happen to the generator. The efficiency of these generators

is from 50 to 75%.

#### 1671 Ringing Machines.

Alternating current must be furnished with the required number of cycles to actuate the telephone bell at the subscribers stations and for other signalling currents. A motor generator with a frequency of 20 cycles is to be used to furnish this current. Either a dynamotor or a belt driven generator might be used with perhaps as good results as the motor generator. All three of these are used in exchanges and give the required satisfaction. The ringing machines are to be installed in duplicate so as to have the required current at all times.

#### The Power Board.

The power board is to consist of four marble slabs, mounted on angle irons fastened securely to the floor, and braced by bars extending from the ceiling to the top of the boards. Each slab is to be 6 feet x 3 feet x 1 1/4 inches in size and are to carry the proper equipment for handling all the power circuits. The four panels are to be arranged as follows:-

The first is called the starting panel and carries the motor switches and enclosed fuses for the primary power circuits, the starting boxes, an ammeter and a two-way ammeter switch.

Panel number 2 is called the battery panel and carries the rheostats for the field of the generators, an overload circuit breaker connected in the charging circuit, a voltmeter and a six point switch, and four double throw double pole knife switches for throwing either battery on the charging or discharging circuit, for throwing either generator into service or for floating either or both

batteries on the system.

Panel number 3 carries the various knife switches for manipulating the signalling circuits, fuse bars for fusing the various signalling circuits to the switch board, and a low reading voltmeter with two multiple contact switches for voltage readings on the individual calls of the two storage batteries.

Panel No. 4 carries the various battery fusing and terminal bars for the power leads to the switch board and relay bars, and an ammeter with a multiple switch for reading the discharge on the various circuits, In addition to the apparatus named each panel is provided with an incandescent lamp, at the top of the board, for the purpose of illumination.

The Conduit System.

All power wires and cables between the power boards and machines and the batteries, are to be run through iron armored conduit.

The conduits are brought up in the rear of the power board to a height of six feet and then bent over toward the board. The cables are then frayed out and the connections made. This gives a neat and handy appearance and allows plenty of room to work around the board.