The New York, Westchester & Boston Railway

Describing in Detail the Signaling and Interlocking on This Recently Completed Road

By MATTHEW H. LOUGHRIDGE

This is the second of Mr. Loughridge's articles on the signaling and interlocking of the New York, Westchester & Boston. The first article included a general description of the road, and an explanation of the signaling and interlocking which had to be installed in anticipation of traffic requirements. The apparatus used was also described. This article treats of the power supply, distribution, and construction.

THE POWER FOR THE SIGNAL SYSTEM.

The propulsion current for operating trains on the New York, Westchester & Boston is obtained from the New Haven system, the power house of which is located at Cos Cob, Conn. The power generators consist of three-phase units in which one phase is connected to the trolley system, another is grounded to the rails, and the third or power phase is used for controlling and regulation. These generators furnish current at 11,000 volts, 25 cycles, in each of the phases which are 120 deg. apart. Trains operate on single phase between the trolley and the track, the operating current being stepped down to 250 volts by a transformer underneath the car. The current is so distributed that energy may be applied to any particular section of the trolley system between any two of the anchor bridges independently.

The power for the signal system is obtained from the same source as that used for the propulsion of the trains. There is, however, one element that is common to the propulsion current and to the signaling current, viz.: the tracks. As stated, the track forms one side of the propulsion circuit, but the track circuit is also a fundamental part of the block system, with the difference, however, that the propulsion current flows in both rails in the same direction, whereas the signaling current flows in each rail in opposite directions. This is secured by means of an impedance bond placed at the end of each block, forming a path for the propulsion current and impeding the flow of the signaling current so that the latter is confined to the limits of the block joints. It is practically impossible to obtain the same electrical characteristics in each rail, mainly on account of defective bonding at rail joints, with the result that the propulsion current does not distribute itself equally in both rails, and thus there may be a flow of propulsion current, as well as signaling current, between the rails, which will, of course, flow through the track relays and transformers. This is known as unbalancing of the track circuit.

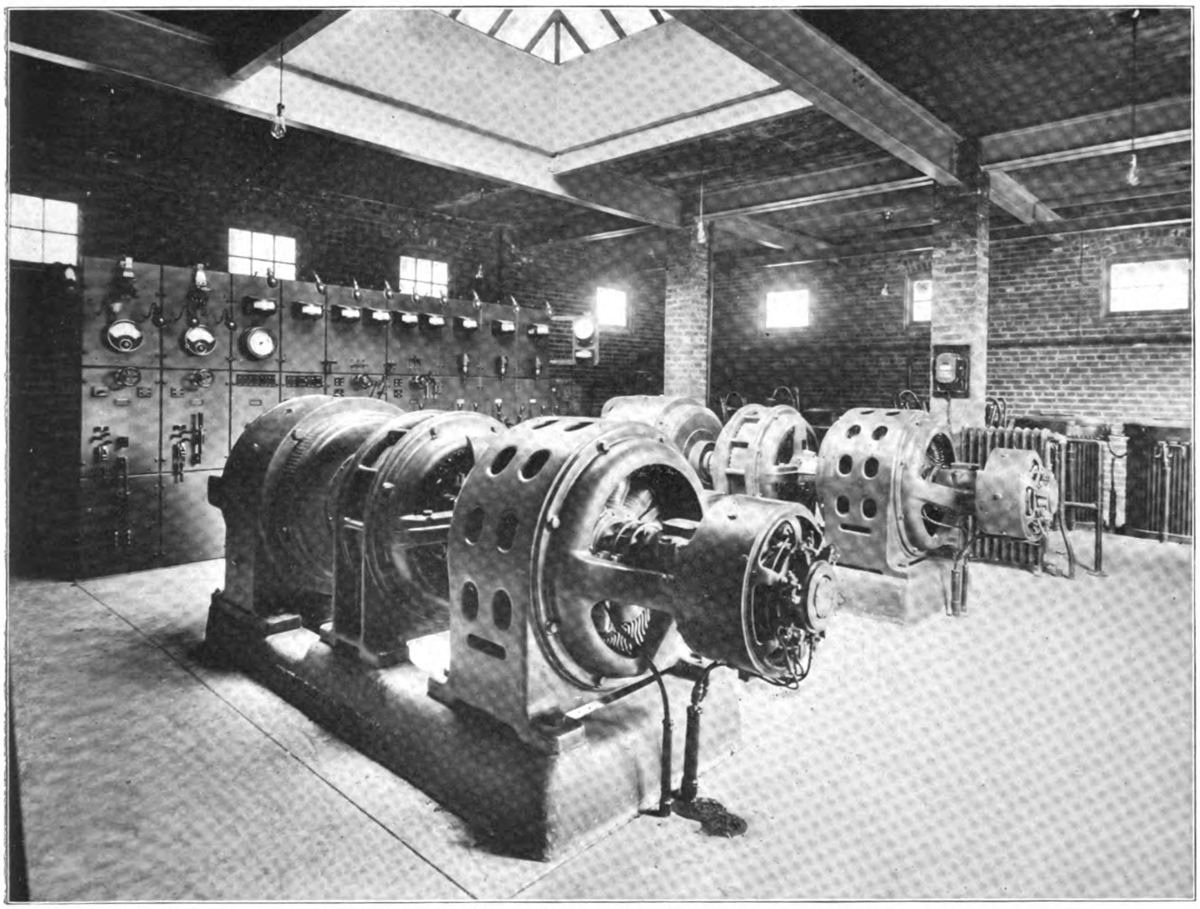

Fig. 12. Interior of the Signal Sub-Station, Showing the Main Switchboard, Machines, and Transformers.

In order to differentiate between the signaling current and this propulsion current it is necessary to obtain current of different characteristics, and to design track relays responsive only

Fig. 13. The Signal Sub-Station, Showing the Entrance of the 11,000-Volt Mains.

to the characteristic of the signaling current. This is secured by using a frequency relay and operating the signal system at a frequency of 60 cycles per second, to which frequency this relay is responsive. Since it is necessary to have current of 60 cycles frequency to operate the track circuits the entire signal system is operated at 60 cycles, using the same transmission lines.

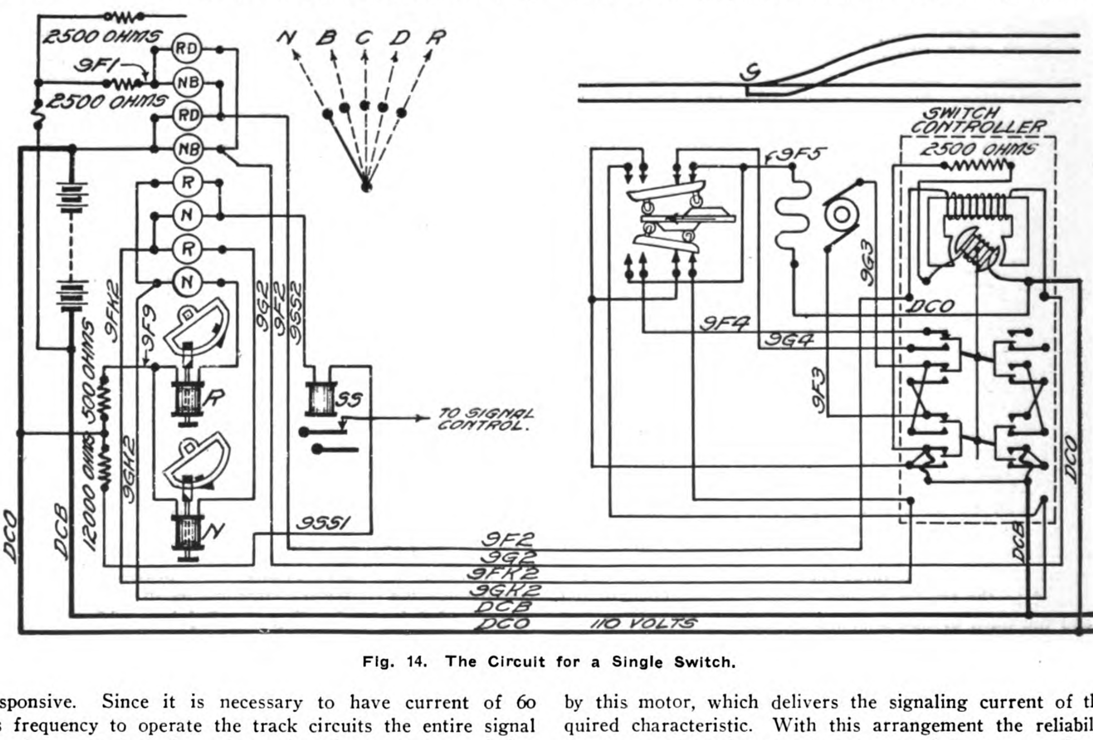

Fig. 14. The Circuit for a Single Switch.

To obtain this difference in frequency from the 25-cycle propulsion current it is necessary to reconvert it into mechanical motion again by the use of frequency changers or converters. These machines each consist of a three-phase induction motor driven by the propulsion current and an A. C. generator driven by this motor, which delivers the signaling current of the required characteristic. With this arrangement the reliability of the system depends upon the motor and the 11,000-volt supply. Surges are likely to occur on the latter, owing to fluctuation in the load of such a nature as to cause the protective devices on the 11,000-volt oil switches to trip, thus interrupting the signal system. Moreover it was considered unnecessary to have the constant attention of an operator exclusively for the power supply, and therefore should the switches of the supply automatically open, the signal system would be out of business un-

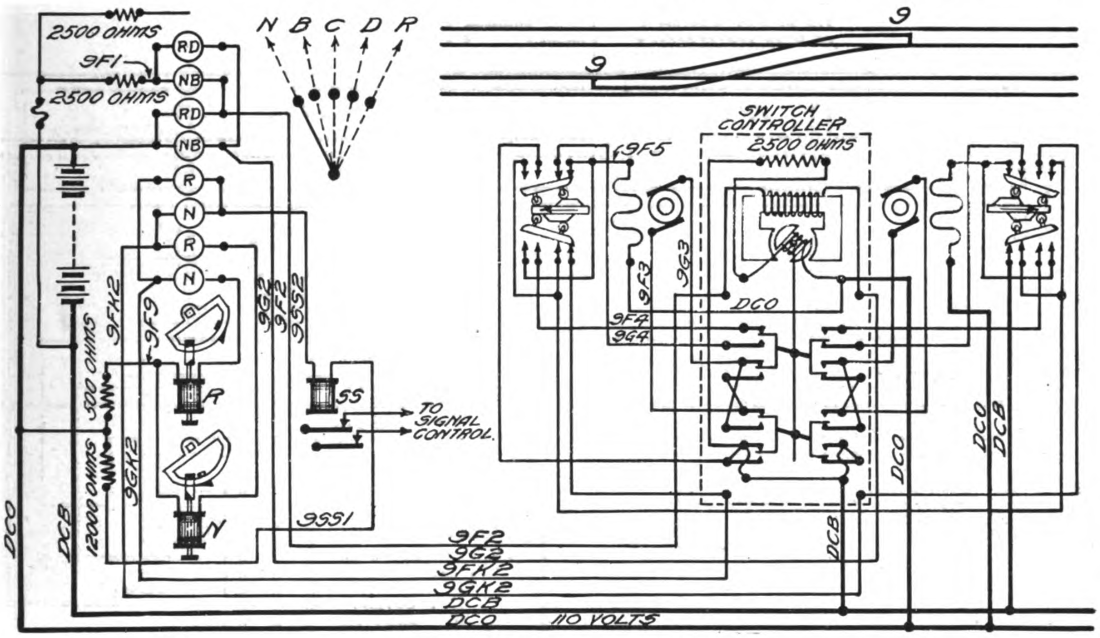

Fig. 15. The Circuit for a Crossover.

til these switches were closed again. For these reasons and also to steady the load a reserve source of energy was provided in a 400 ampere-hour battery of 60 cells. This battery is floated on a D. C. unit connected to the motor, and will

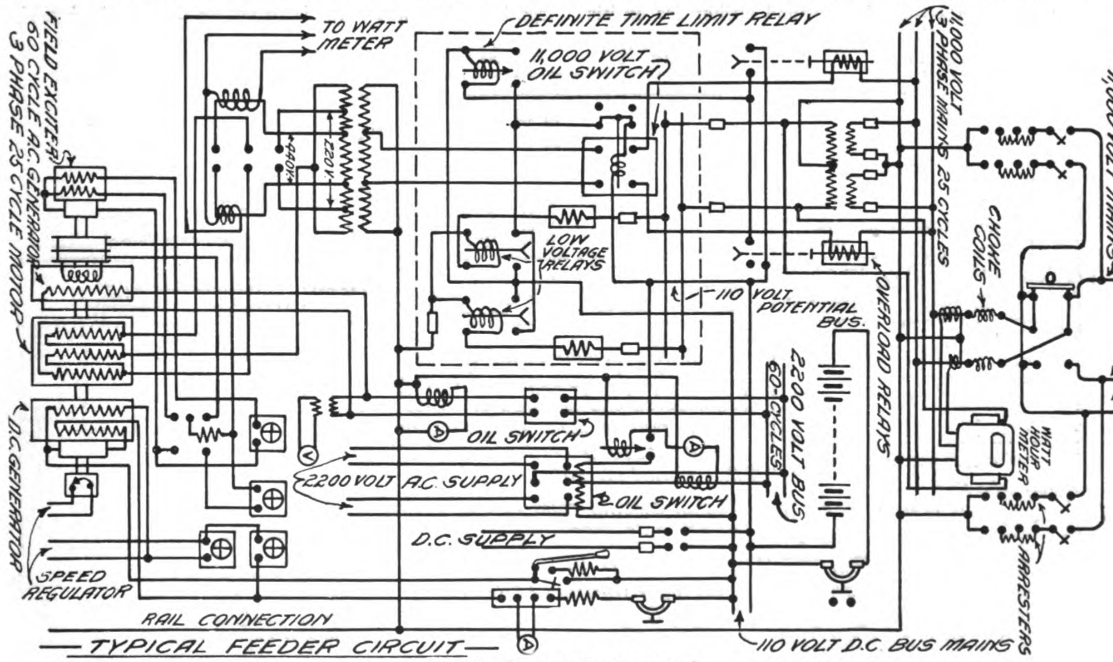

Fig. 16. Typical Feeder Circuit.

automatically take up the load that the latter drops. It has sufficient capacity to operate the entire signal system for one hour.

These machines call for a sub-station in which is located the apparatus necessary for the reliability and efficiency of the current supply for the signal system.

The sub-station apparatus consists of a duplicate set of frequency converters with the necessary high-tension supply apparatus. In detail this apparatus consists of lightning arresters, disconnecting switches, choke coils leading to the remote-controlled oil switches which control the supply from the catenary feeders and the power phase wire, the third phase being obtained from the track which is permanently connected to the transformers. A bank of three transformers, delta connected, each of 35 K. V. A. capacity, steps the 11,000-volt supply down to the operating voltage of 440, with taps at 220 volts for starting purposes. Watt-hour meters are provided on the secondaries of these transformers to record the energy used by the signal system.

The units comprising the frequency converter are mounted on the same shaft and consist of (a) a 75 H. P. 25-cycle, 440-volt, three-phase, induction motor; (b) a 10-pole 67 K. V. A., 2,200-volt, A. C. generator with stationary armature, generating current at 60 cycles per second at a speed of 720 R. P. M.; (c) a three K. W., 125-volt, shunt-wound exciter for exciting the field of the A. C. generator; (d) a D. C. motor-generator which will operate as a motor or generator within a range of voltage from 90 to 160. This is a shunt-wound six-pole machine with interpoles and of 70 H. P.

The main switchboard, Fig. 21, consists of nine panels. Three of these panels are for the feeders to the signal mains, and three other panels are provided in duplicate for the three units of the converters. In addition to these there are synchronizing, regulating, and voltmeter bracket panels attached to the sides. The converters may be started from the storage battery, for which purpose a special starting switch is provided, or they may be started from the A. C. three-phase supply. The synchronizing instrument is to enable them to be brought into phase before they are connected in multiple circuit. Card drawing voltmeters recording the fluctuation in the 25-cycle A. C. supply and the 60-cycle feeders are provided.

The object of the sub-station apparatus is to feed current

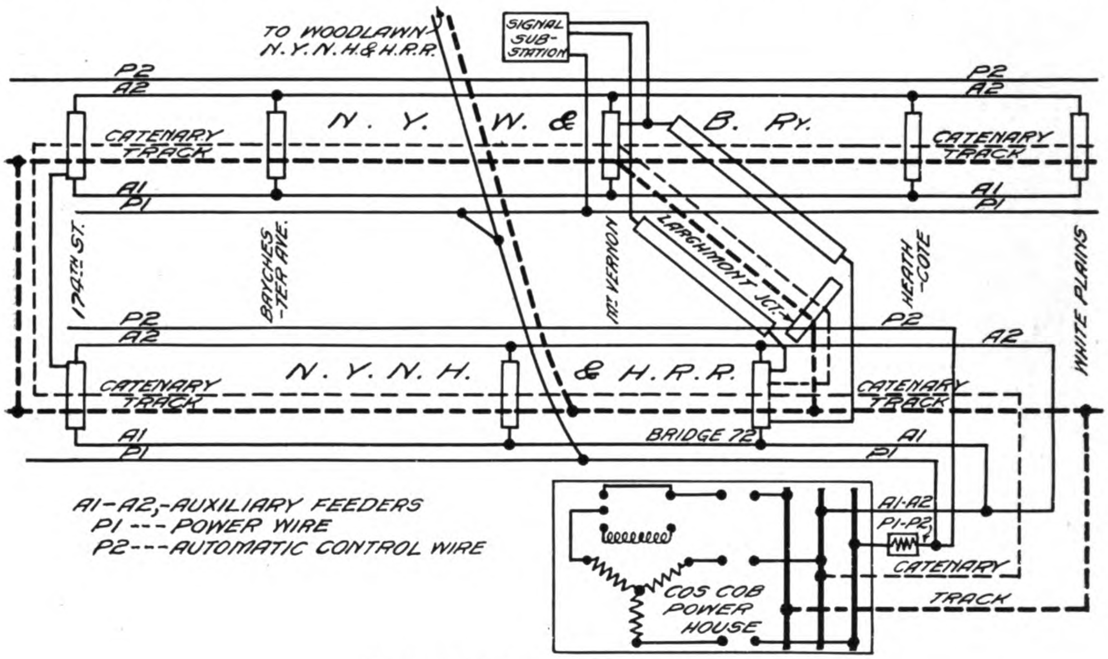

Fig. 17. Power Distribution from Cos Cob.

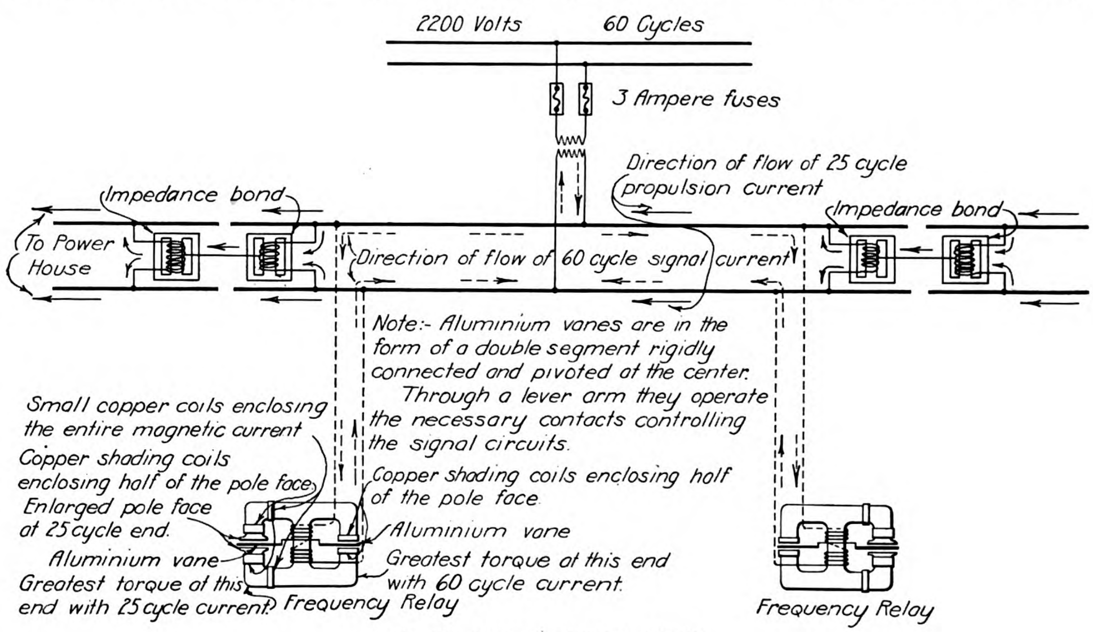

Fig. 18. Diagram of Track Circuit.

at 2,200 volts, 60 cycles, to the signal mains. As stated, there are two sources of supply, one from the A. C. propulsion current operating the induction motor, and the other from the storage battery operating the motor-generator as a motor. A low voltage cut-out relay operates in connection with the A. C. supply, cutting out the charging rheostat and cutting in the field rheostat when the voltage drops. When operating on the storage battery there is a constant drop in its voltage as it be-

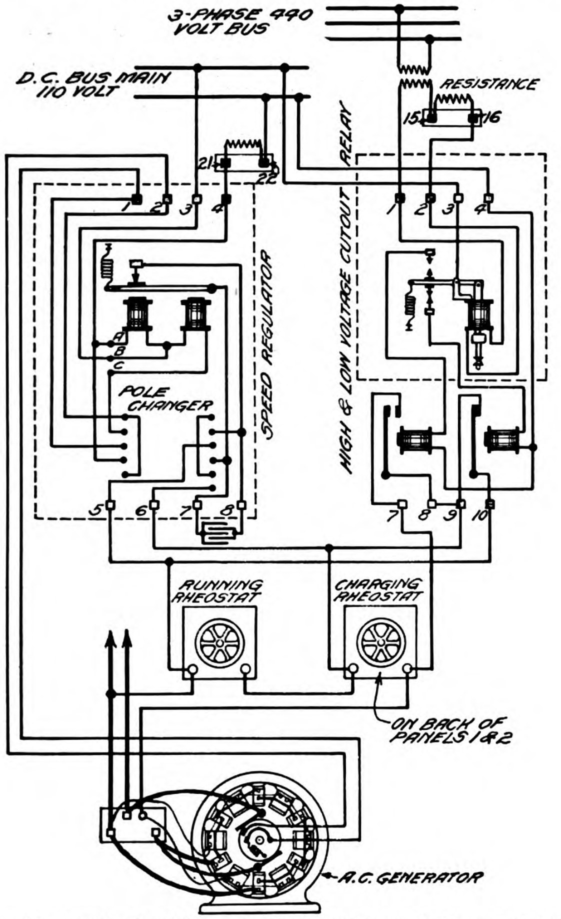

Fig. 19. Speed Regulator and High and Low Voltage Cut-out Relay.

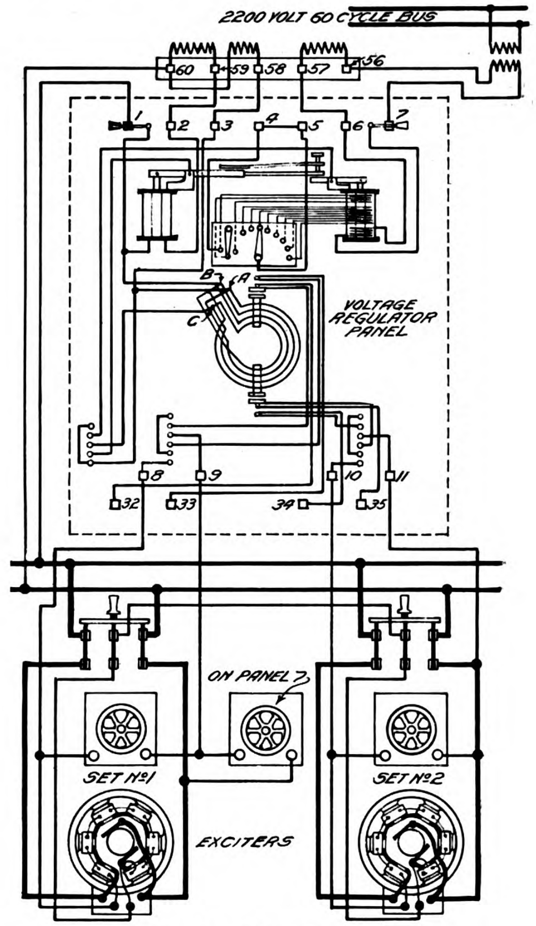

Fig. 20. Voltage Regulator.

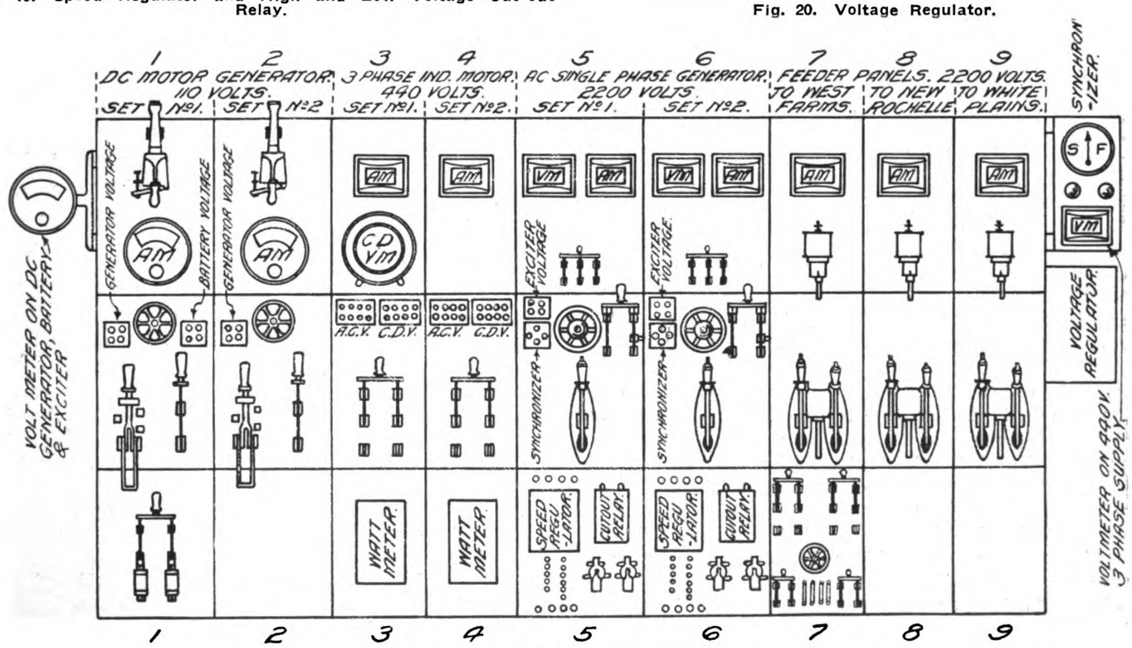

Fig. 21. Main Switchboard.

comes exhausted, and in order that this may not reduce the speed a regulator is provided which reduces the intensity of the motor-field when the speed is slow, and increases it as the speed approaches normal. This is secured by means of a relay shunting the field rheostat in response to a centrifugal circuit breaker on the shaft, thus maintaining a frequency of 60 cycles per second. Circuits for the low-voltage control and speed regulator are shown in Fig. 19.

To maintain 2,200 volts pressure in the signal mains under a load that is subject to considerable fluctuation requires a further regulation which is secured indirectly by regulating the field of the exciter. In this way the regulator controls but

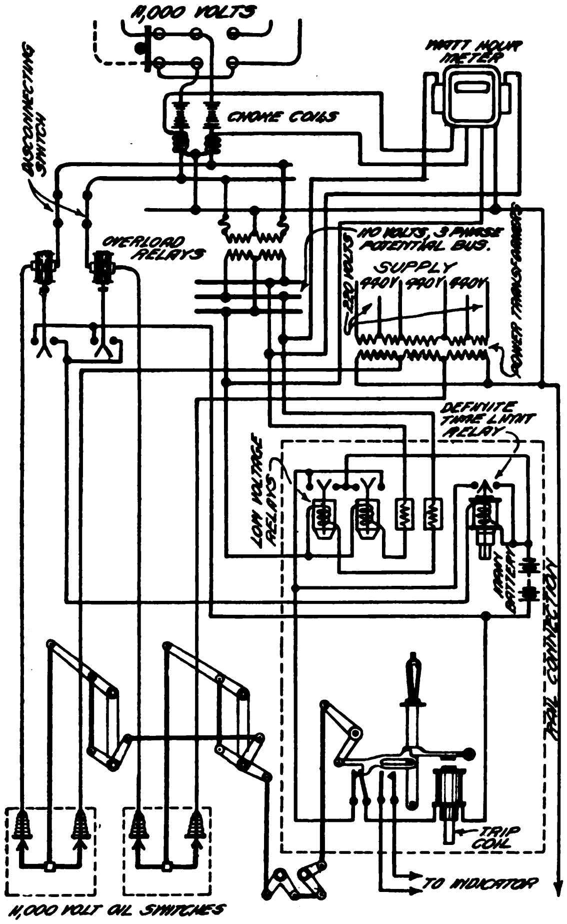

Fig. 22. 11,000-Volt Oil Switch.

a small current and varies the voltage on the feeders accordingly.

This consists of a means of increasing the intensity of the exciter field by shunting the field rheostat as the voltage in the feeders drops. As shown in Fig. 20, this regulator consists of two relays having a floating contact between them which is open when they are normally energized. One of these relays is connected to the exciter bus mains, the other relay is connected to the feeder mains. The latter, however, has a potential and an opposing or compensating winding so arranged that the potential winding holds the floating contact open, but an increase of current will cause it to close. The closing of this contact operates a differential relay of circular shape which closes contacts shunting the exciter field rheostat. The floating contacts keep constantly vibrating, maintaining a constant potential in the signal mains.

In addition to these automatic regulating devices the switchboard is, of course, provided with the usual regulating rheostats that go with the machines.

An installation of this kind requires suitable automatic protecting devices that will save the apparatus against over and underloads on the supply and overloads on the feeders. It is undesirable, however, that a momentary rush of current on the supply should trip the 11,000-volt oil switches, but if the voltage drops they should trip promptly. This is secured by the circuit shown in Fig. 22. Two feeders connect through series relays which close the circuit of a definite time limit relay if the load is abnormally increased, and if this abnormal load remains longer than the time these relays are set for, then it will operate the oil switch disconnecting the supply. If the

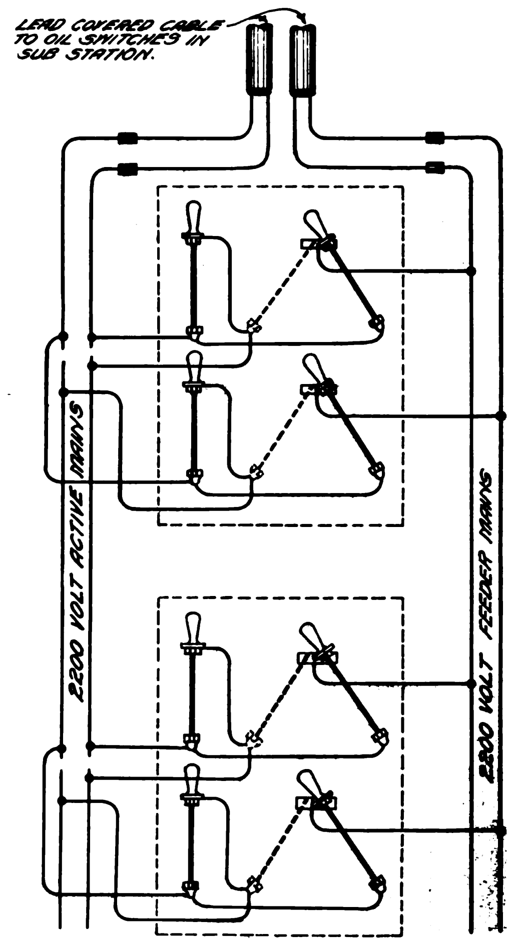

Fig. 23. Sectionalizing Switches.

voltage of the supply should decrease, as when the current is turned off, the relays connected to the potential transformers will cause the oil switches to open.

In the feeder circuits it is only necessary to guard against an overload of a definite duration. The circuit in Fig. 25 shows how this is done. A current transformer operates the ammeter and the time limit relay, the latter responding only with an abnormal load for a greater interval than for which it is set.

Overload circuit breakers are provided in connection with charging the storage battery, to protect the generators, and an overload-underload circuit breaker is provided to protect the battery when the system is being run on it. The battery, therefore, cannot be injured in case of an overload on the feeders, and when by exhaustion it drops to 90 volts it automatically cuts out.

In order to facilitate the operation of the switchboard, especially by those who may not be familiar with the layout, an indication in connection with an alarm in the tower is provided to show the tripping switch that opens. Thus the towerman can

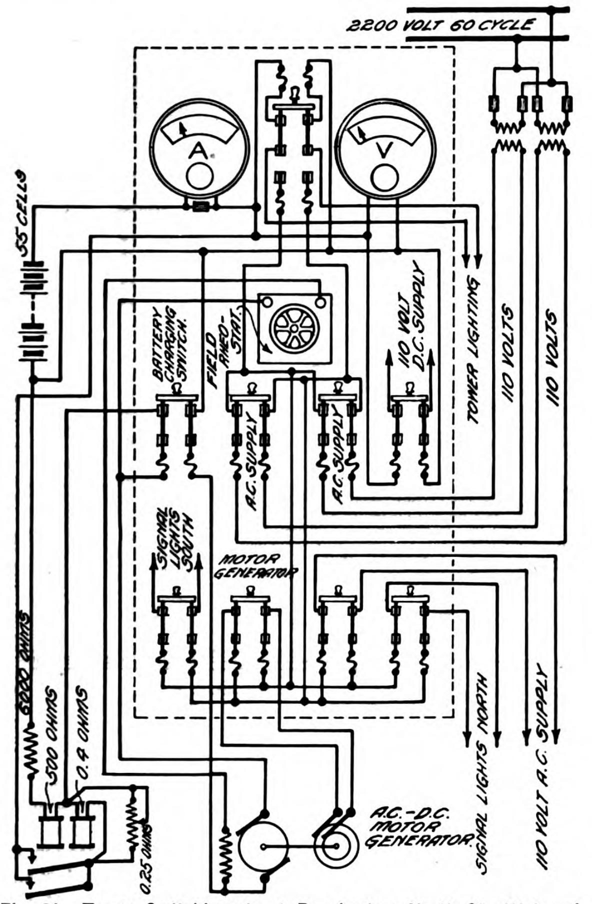

Fig. 24. Tower Switchboards at Baychester; North St., Wykagyl; Heathcote; and White Plains.

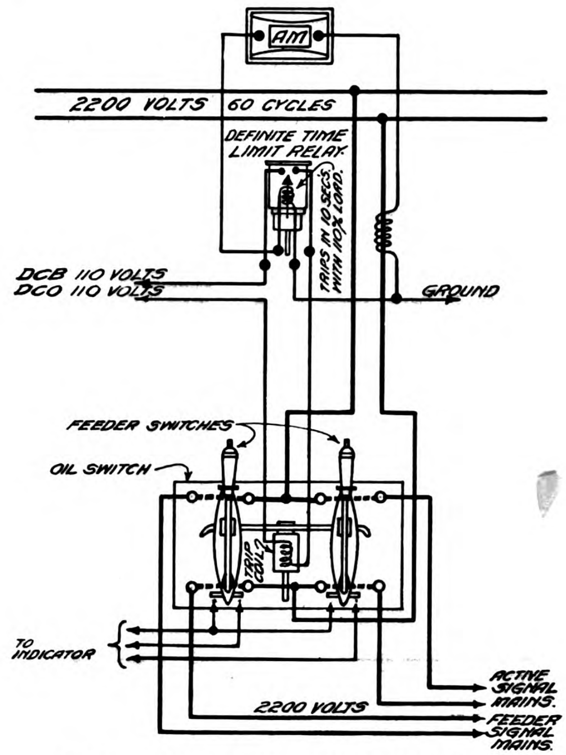

Fig. 25. Diagram of Overload Protection Circuits.

call the maintainer, or he himself can close the switch that trips.

POWER DISTRIBUTION FOR THE SIGNAL SYSTEM.

The sub-station is located at the junction of the four- and the two-track sections at Columbus avenue, which is almost

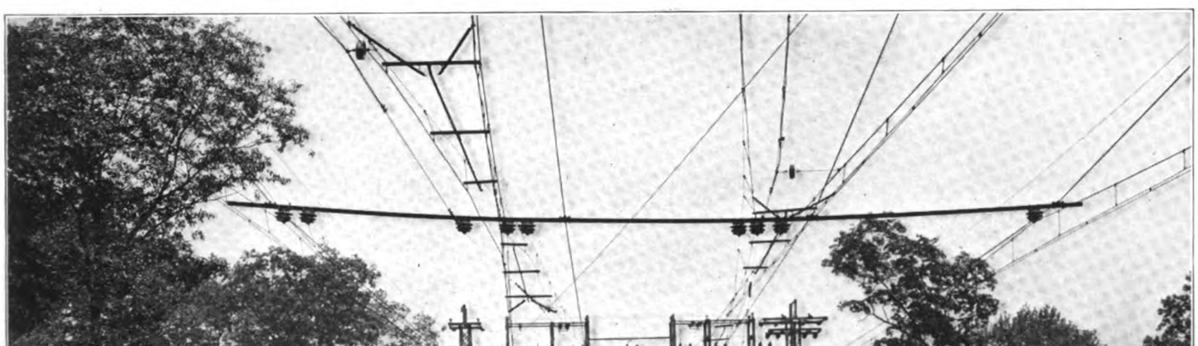

Fig. 26. Columbus Avenue Junction, Showing the Anchor Bridge, Interlocking Station, and Signal Sub-Station.

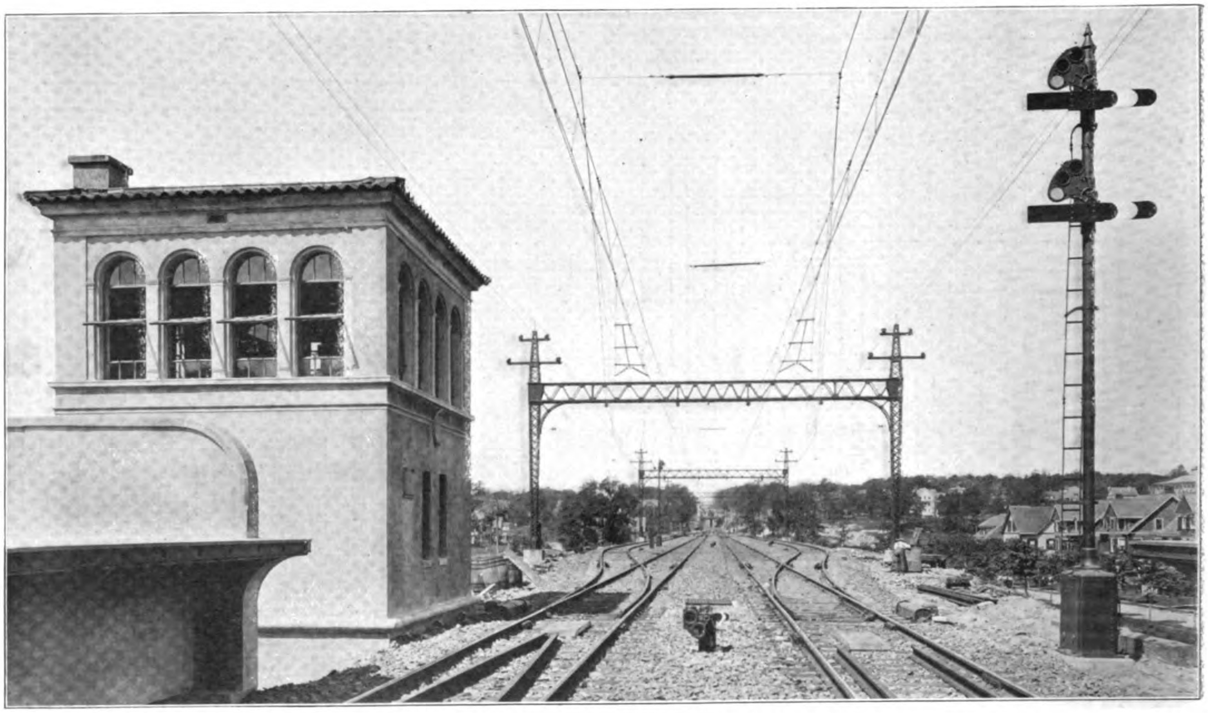

Fig. 27. North Street Interlocking Station, New Rochelle.

the central point of the system. The power feeders are available here, both from New Rochelle and West Farms, and if power is available for propulsion purposes it will also be available for the signal system.

Duplicate signal mains are provided throughout, consisting of No. 3 B. & S. gauge bare copper strand. All the signal apparatus is connected to one of these mains, known as the active main, and the other main is used as a feeder. In order to facilitate maintenance and repairs on the active mains with the least possible interruption of the system, these mains are sectionalized so that it is possible to disconnect the section at any interlocking plant or between interlocking plants and maintain the signals in operation on either side by means of the feeder mains. In this way it would be possible to keep the

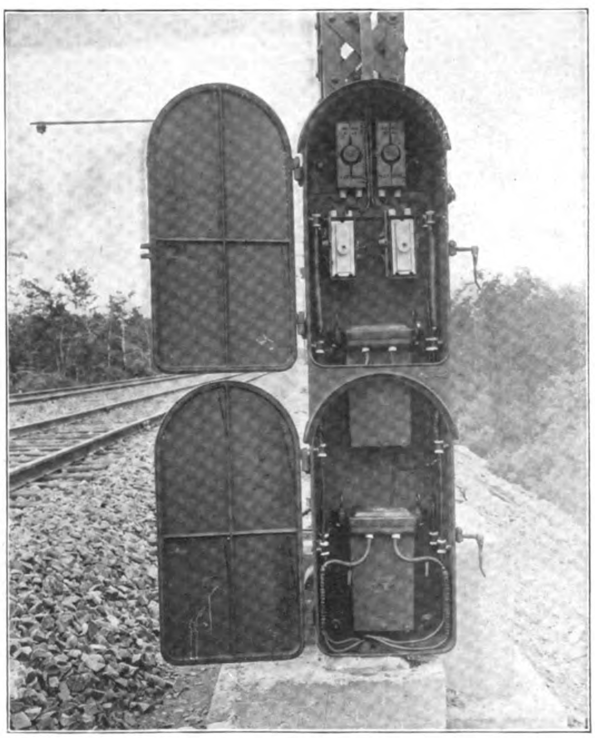

Fig. 28. The Iron Housings for the Transformers.

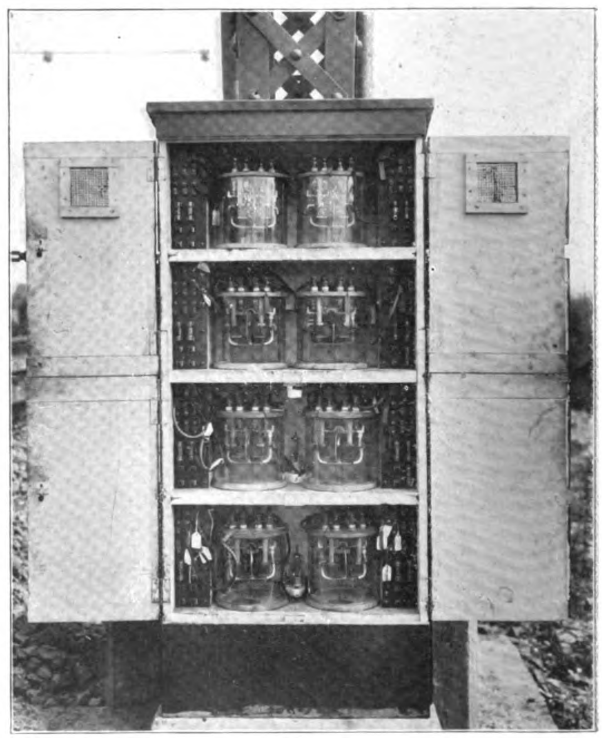

Fig. 29. A Relay Case, Showing the Frequency Relays.

interlocking plants working alone in cases of failure of part of the power supply. The sectionalizing is provided for by special plug switches as shown in Fig. 23. At interlocking stations a source of direct current is necessary for operating the switches. This is obtained from the signal mains by a duplicate set of transformers stepping down the voltage to 110 and an A. C. D. C. motor-generator which is "floated" on a 110-volt storage battery. This motor-generator runs continuously when current is in the signal mains, a protecting relay being provided to secure this effect, as shown in Fig. 25.

Fig. 30. Interior of Operating Room, Columbus Avenue Tower.

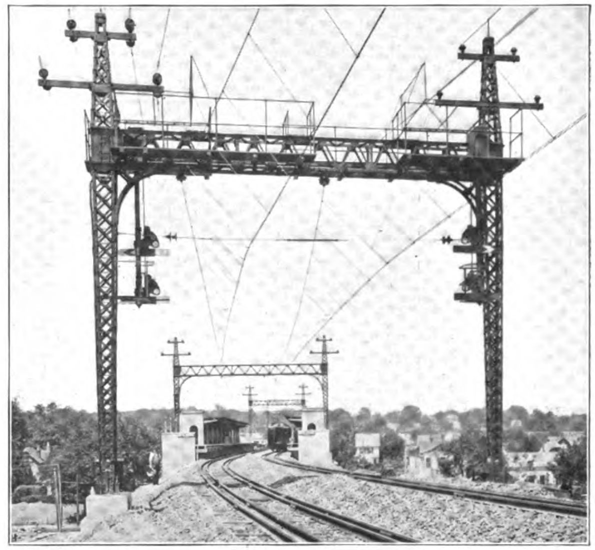

Fig. 31. A Double Signal Location on the New Rochelle Branch.

The entire apparatus for the power system was supplied by the General Electric Co.

TRACK CIRCUITS.

The track circuits for the automatic signals are center-fed. An adjustable filler transformer is used for each circuit, stepping the 2,200 volts on the signal mains down to the voltage necessary for the operation of the track relays.

The track relays are of the frequency induction type, having a double vane and a double magnetic circuit with a single winding. The magnetic leakage is made unequal in the two branches of the magnetic circuit by the adjustment of the air gap and the cross-section of the shading coils, which coils produce the effect of a rotating field upon the vane, causing it to operate the contacts. In consequence of this adjustment one side of this magnetic circuit has a stronger pull at 25 cycles, while the other side has a stronger pull at 60 cycles, due mainly to the choking effect of small shading coils which encircle the laminations of the magnetic circuit at the 25-cycle end to the current of higher frequency. (See Fig. 18.)

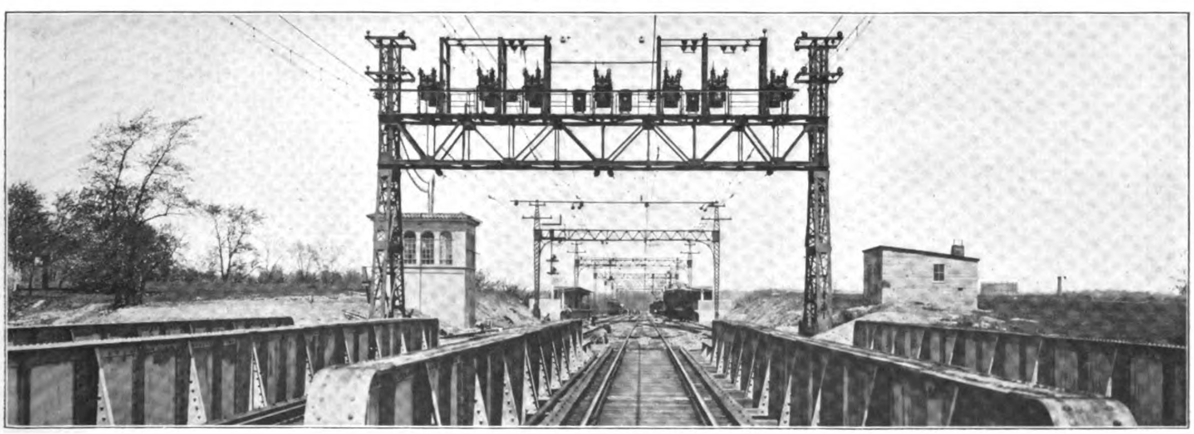

Fig. 32. Baychester Interlocking and Anchor Bridge.

If the two frequencies of 25 cycles and 60 cycles are present simultaneously the pick up due to the 60 cycles is of course somewhat diminished by the counter effect of the 25-cycle current which tends to give a negative torque, hence, if the signaling current is absent, any voltage due to the propulsion current will only assist in holding the contacts open.

When the relay is normally energized with signaling current it will stand an unbalancing of from nine to 12 amperes of the propulsion current through its windings before its contacts will open. Owing to the small amount of return current, consequent on the high-voltage transmission and the auto-transformer action of the impedance bonds tending to balance the circuit, an unbalancing to this extent is such as would be caused only by a very bad power bond or by a broken rail.

End-fed single-rail track circuits are used for the short track sections on the ladder tracks; that is, circuits in which one rail only is used for the power return and the other rail used in conjunction with it for the signal circuit. The power return rail is continuous through the interlocking and, therefore, the impedance bonds which would be difficult to locate are not necessary; also, better fouling protection can be obtained by single-rail track circuits. The circuits are fed through a resistance from one transformer connected to the 110-volt A. C. supply, and stepping this voltage down to that which is necessary for the operation of the track relays.

CONSTRUCTION.

The catenary bridges are built with a sufficient margin of safety to support the additional load of a signal for each track. The superstructure for the signals is supported by "I" beams

The relay boxes are of wood and are provided with hard rubber panels for the terminals and fuses which make connections to the cables at the back through a side opening. A lamp socket is provided in each case for a portable lamp at night.

The transformers for operating the signals are placed on the bridge truss. The track transformers are housed in dust-proof cast iron cases placed adjacent to the bridge leg, and are readily accessible.

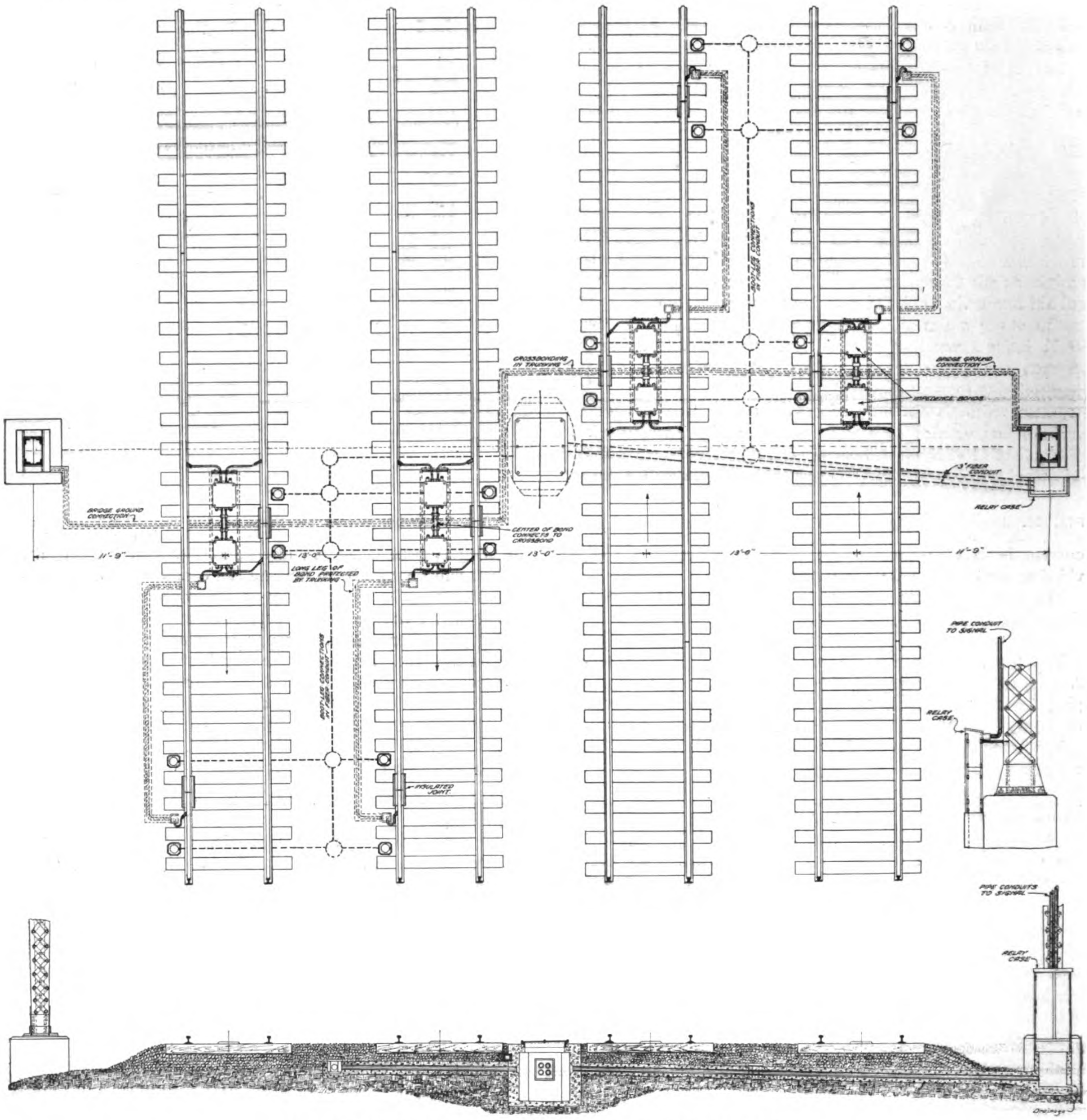

Fig. 33. The Cross Bonding and Bridge Grounding Connections.

placed across the bottom chord, which consists of a walk on one side of the truss and the signal platform on the other side reached by stepping over the truss. Trap doors are provided in the foot walk to get to the signal ladders. The foot-walk and signal platforms are provided with pipe railings, and the high-tension lines are protected by wire screens. A minimum clearance of 15 inches is provided between the signals and the pantagraph, the signals being offset on curves for this purpose.

Impedance bonds are placed between the rails, the ties being spread to let the case of the bond sit between them. Bonds are protected by a sheet-iron cover which does not rise more than two inches above the ties and offers practically no obstruction. The rail joints are staggered to the extent of half a rail length. The long leg of the bond is of 0000 bare copper strand protected by wood trunking placed below the ballast. The cross-bonding between tracks and the grounding of the bridge legs are carried out in a similar manner.

Wire protection has been carried out to an extent that is only to be found in the most up-to-date terminals. This has been made possible at interlockings on account of the improbability of future changes in track layout that have not been provided for, and is desirable in order to insure permanency. Where the wire is exposed above ground, as in leading to the signals on bridges, iron pipe conduits are used. These are also used for protection on the lead-covered high-tension connections to the transformers.

All underground wiring is run in fiber conduit laid in concrete. A main conduit line of four-duct section, referred to hereafter, built ostensibly for the telephone system on the center line of the railway, has one duct reserved for the signal cables with, of course, manholes at each signal bridge. From these manholes to the foundations of the relay boxes a double run of fiber conduit is laid in concrete under the tracks and opens into the foundation. (See Fig. 33.) The main cables are led from the duct line in these laterals to the terminals in the relay boxes. The track connections are also laid in fiber conduit, and are accessible from distributing boxes set in concrete. The bootleg outlets at the rail connections are made of reinforced concrete fitted with a weatherproof cap, being substantial and presenting a neat appearance. Handholes having dust-proof iron covers are provided at interlockings as necessary for distributing wires to the apparatus. Connections to the switch movements where there is considerable vibration are protected by flexible armored conduit.

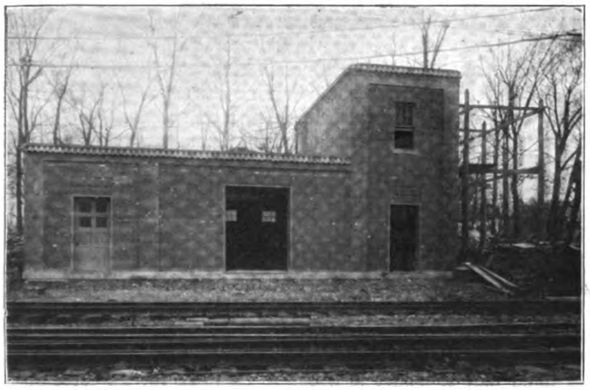

Fig. 34. The Sub-Station.

This results in an installation where there is no unsightly crossing of wood trunking to mar the appearance of the track. The wires are placed in a zone where they cannot be injured, and will require little attention, and where the depreciation on them will more nearly equal that of the rest of the system.

BUILDINGS.

The tower buildings are of hollow tile with stucco finish, and have iron window sash in conformity with the stations. The operating floor is finished with kompolite over reinforced concrete beams, having a hollow tile filling. A hot water heating system is installed in each tower, and a coal bunker, which can be filled from the track, is inclosed within the building. The relay cabinet, which is of wood, has a double row of terminals on the back of the shelf, mounted on asbestos board. The wire connections are made from the wire chase to these terminals on the back, and the connections to the relays are made in front and are visible through the glass doors.

The storage batteries and motor-generators are inclosed in separate compartments with ventilation for the former through a tile flue leading to the roof.

Behind the interlocking machine is placed a slate panel on which is mounted the ammeter, slow releases, ground detector meter, and audible announcers, thus bringing all the signal apparatus within easy reach of the operator at the machine.

The apparatus, including the interlocking machine, has been finished in a mahogany stain to match the interior decoration.

The signal sub-station is of brick and consists of four compartments. One of these, the high-tension room on an upper floor, is only accessible by a vertical ladder. In this room the 11,000-volt feeders are led into the building and the disconnecting switches, lightning arresters, potential transformers, and overload relays associated with the high-tension feed are placed. The transformer compartment is immediately below the high-tension room, and in it are placed the 11,000-volt transformers (two banks of three transformers each) for the three-phase supply and the oil switches. These latter are remote-controlled from a panel placed outside the railing which separates this room from the converter room. The transformers for the adjacent interlocking connected to the 2,200-volt feeders are also placed in this room. The frequency converters and main switchboard are located in the center of the building, a large sliding door being provided for the purpose of replacing the machines. This room is lighted by a skylight in addition to the regular windows. The switchboard stands six feet from the wall, and a clear space of not less than five feet is provided around the machines, affording every facility for making repairs. All connections to the switchboard and to the machines are run in pipe conduit built into the floor. A one and one-half ton triple block, hung on a trolley from an "I" beam over the apparatus, is provided in this room, and in the transformer room, so that the heaviest part may readily be removed. The battery room is separated from the machine room by a single brick wall and double doors. It has a tile floor and is ventilated by copper louvers in the wall and by a tile flue through the roof. The electric lighting fixtures are protected against the fumes by porcelain and glass shades and lead-covered connections Provision has been made to maintain a temperature of not less than 60 degrees in this room by a hot water heating supply obtained from the heater in the interlocking tower, and distributed by radiators protected with acid-resisting paint. A locker and toilet room is also provided as part of the building.

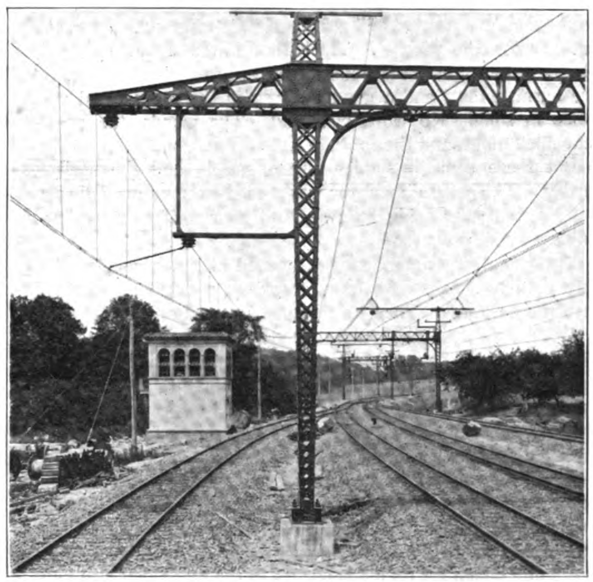

Fig. 35. Heathcote Interlocking Station.

The most interesting figures in connection with the entire installation to a railroad official are the results obtained and the cost. The former has been dealt with at length at the beginning, and the latter is within the usual price for apparatus similarly installed. A great number of the special features that have been referred to, while contributing an important part to the efficiency of the system, are comparatively inexpensive to purchase.

The entire signal installation was installed under contract by the Union Switch & Signal Company.