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 first of three articles in which Mr. Loughridge will describe the conditions under which this new high-speed road was built, and the scheme of signaling which was adopted, giving details of the apparatus selected for the signaling and interlocking, and explaining in full the power distribution and telephone systems which were installed. This article treats only of the signaling and interlocking.

GENERAL.

The New York, Westchester & Boston Railway, which was formed by the consolidation of an older corporation of the same name and the New York & Portchester Railroad, was recently put in operation. It is somewhat unique in being the first strictly suburban railroad built from the ground up according to the most modern methods and with all the latest approved appliances for high speed and dense traffic.

The completed line includes a four-track section 6.8 miles long connecting with the four main tracks of the Harlem River branch of the New Haven system, near 174th street, New York City, and extending in a northerly direction to Mount Vernon. There it separates into double track lines, one extending eastward approximately 2.1 miles to New Rochelle, where it connects again into the New Haven system, and the other continuing northward for 9.4 miles to White Plains.

As shown in the map, Fig. 2, the main line touches the eastern extremity of Bronx Park, thence follows a line midway between the Harlem division of the New York Central and the Harlem River branch of the New Haven to Mount Vernon.

From Mount Vernon to White Plains the line is almost parallel with the New York Central, and is separated from it about 1.5 miles. It thus taps a country that is practically barren of transportation facilities.

In this territory there are 45 steel railroad bridges, 22 steel street bridges and four concrete arches, which eliminate all grade crossings. There are also three steel viaducts, two of which are on the four-track section at West Farms and Mount Vernon. The other is over the Hutchinson River gorge on the New Rochelle connection. Two of these viaducts and a number of the railroad bridges are of solid floor construction with a deck of water-proofed reinforced concrete surmounting the bridge girders. The other railroad bridges are of the open-deck type, and those with the supporting members above the track level are mostly of the trough type with a filling of water-proofed concrete. The bridges comprise 11 per cent of the roadbed.

In the Pelham Parkway section the line passes through a sub-surface four-track tunnel, 4,000 ft. long. This subway has one line of supporting columns on the center line of the rail-

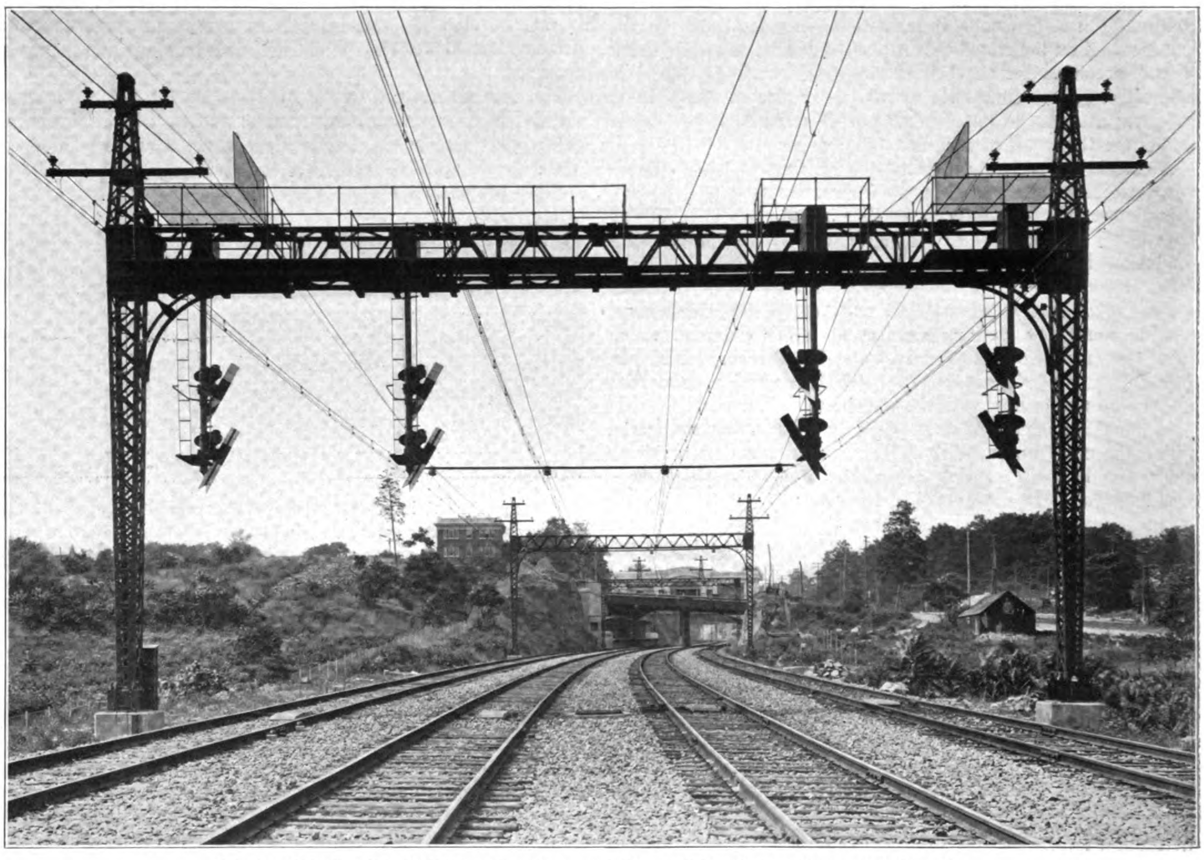

Fig. 1. Showing the Catenary Structure and Some of the Center-Suspended Signals.

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way where the track centers are 15 ft., the outside track centers being 13 ft.

The line is built through a rolling country with scarcely any part of it on the natural grade. The cuts comprise seven miles, mostly through solid rock and of an average depth of 16 ft.

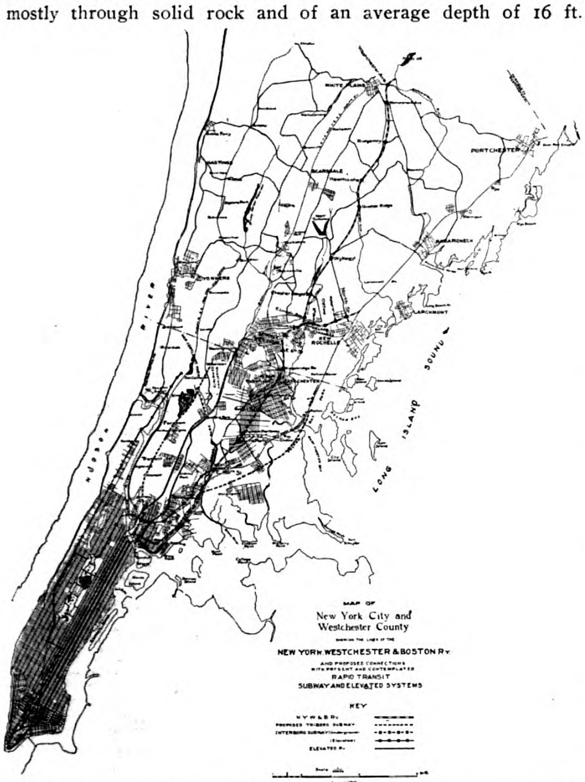

Fig. 2. Map of the New York, Westchester & Boston Railway.

The fills amount to 9.1 miles of an average depth of 14 ft. and are composed of rock in very large pieces.

This railway represents, in its roadbed, stations, equipment and motive power, the highest standard of railroad construction known to date. There are no grades exceeding one per cent except approaching the New Haven connections and the White Plains terminal. Curves do not exceed four-degree except approaching express stations where the speed is reduced. The entire right-of-way is protected by a substantial iron fence.

The track is laid with 90-lb. steel rail on creosoted pine ties. Tie plates are used except on tangents, and the road is rock ballasted throughout. The bridges are capable of withstanding the heaviest possible traffic at high speed, and the multiple unit cars which are used in connection with the passenger service are designed to attain a speed of 57 miles per hour.

The buildings are of steel and terra cotta with a stucco finish and fitted with iron window sash. They are attractive in appearance and absolutely fire-proof. The entrance to stations is on the street level, the station building being under or over the track at railway and street bridges respectively. A number of stations have electric elevators to facilitate traffic between the platforms and the street. High platforms are used, and in most cases they are built of concrete with an overhang of three feet.

The stations on the four-track section and on the New Rochelle extension are approximately one-half mile apart and on the White Plains branch they average one mile apart. The express stations, of which there are seven, are approximately two and one-half miles apart. The running time of express trains between 180th street and Mount Vernon is nine minutes, New Rochelle is 13 minutes and White Plains is 24½ minutes; the average speed being 37 miles per hour, allowing 25 seconds for each stop. The running time of local trains to New Rochelle is 24½ minutes and to White Plains is 39 minutes; allowing 15 seconds for each stop. This gives an average speed of 21.6 miles per hour.

The franchise requires that 60 trains be run on the main line in each direction daily, and at no time, either day or night, shall there be greater headway than 30 minutes, except that, during the first five years after the commencement of operation, trains shall not be required to run between the hours of one o'clock and four o'clock a. m. It requires also that trains be operated by power other than steam locomotive.

To handle these trains safely and expeditiously it became imperative that the road have a block signal system and a communicating system affording every facility to meet the conditions of operation. According to the established policy behind the construction of the road it was decided to have, not merely a signal and communicating system, but the safest and most modern systems known to the art and fully in compliance with the other work as to permanency and durability.

THE SIGNALING.

In designing a signal system for a new road which has not reached the stage of operation, the signal department is left to anticipate the requirements that the operating conditions may impose. On this account, perhaps, more thought was given to these conditions than if a mere abstract statement of requirements had been obtained from an operating department.

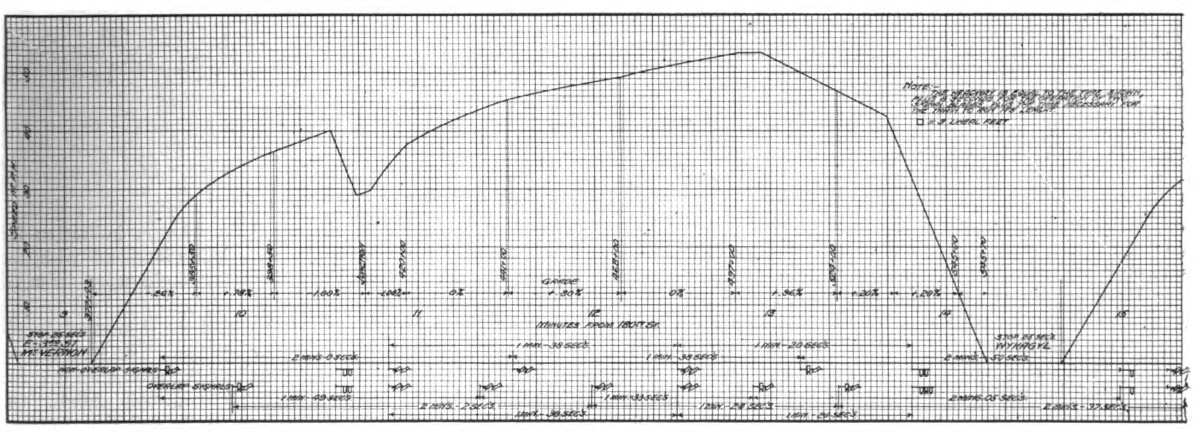

Fig. 3. Express Train Speed Curve.

One of the chief considerations in this connection is the minimum headway or the density of traffic. This fortunately works out with other conditions affecting the safety of the system very satisfactorily. A new road has, however, a unique ad-

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vantage in that it can profit by the experience of others in selecting that which is best suited to its needs, without being hampered by prejudice or precedent in any form. It has been the object of the railroad to obtain a system that is uniform throughout, and the use of apparatus that is standard. In this way the maintenance is greatly simplified; the maintenance force have only to familiarize themselves with one type of apparatus, similarly installed. The amount of stock apparatus necessary for maintenance use can be reduced to a minimum and supplies are readily procurable. This object has been thoroughly attained by having one contractor handle the entire block signaling and interlocking installation and another contractor handle the entire telephone installation.

The block signaling was worked out on principles that are well understood in signaling; that is, that when approaching a stop signal the motorman traveling at maximum speed shall have an advance indication in proper time to stop his train before reaching this signal. The deceleration with the service application of the brakes was given as equal to a reduction in speed at the rate of one mile and a half per hour per second on level track, and the emergency braking equipment will cause almost twice this deceleration. The cars are fitted with a speed controller which cuts off the power from the car motors when the speed exceeds 57 miles per hour. This speed may, however, be accelerated, by coasting on descending grades, to 62 miles per hour. The braking curve showed that this advance indication, where trains attain maximum speed on level track, should not be less than 1,820 ft., and on one per cent descending grade should not be less than 2,200 ft.

In most cases the signals can be seen for a considerable distance, but in a few instances, on account of curves and buildings, they cannot be seen until the train is quite close to them—a condition which, of course, applies to all signals in foggy weather. It was thus assumed that the indication of the distant signal would be taken when the train is at the signal. The braking distance, therefore, was lengthened to such an extent as will give the motorman ample time to act on the indication and prepare to stop at the next signal. The extent to which the blocks should be lengthened for this purpose involves the personal equation of alertness in the motorman. On this account, and to provide a factor of safety, the blocks are arranged at approximately 200 per cent of the service braking distance, which at maximum speed allows the motorman an interval of 21 seconds, in addition to the time necessary to stop the train, in which to bring it under control. The usual practice was adopted of combining in one signal the advance indication for the succeeding block with the stop indication, and with the braking distance as determined above the blocks were arranged for the closest headway.

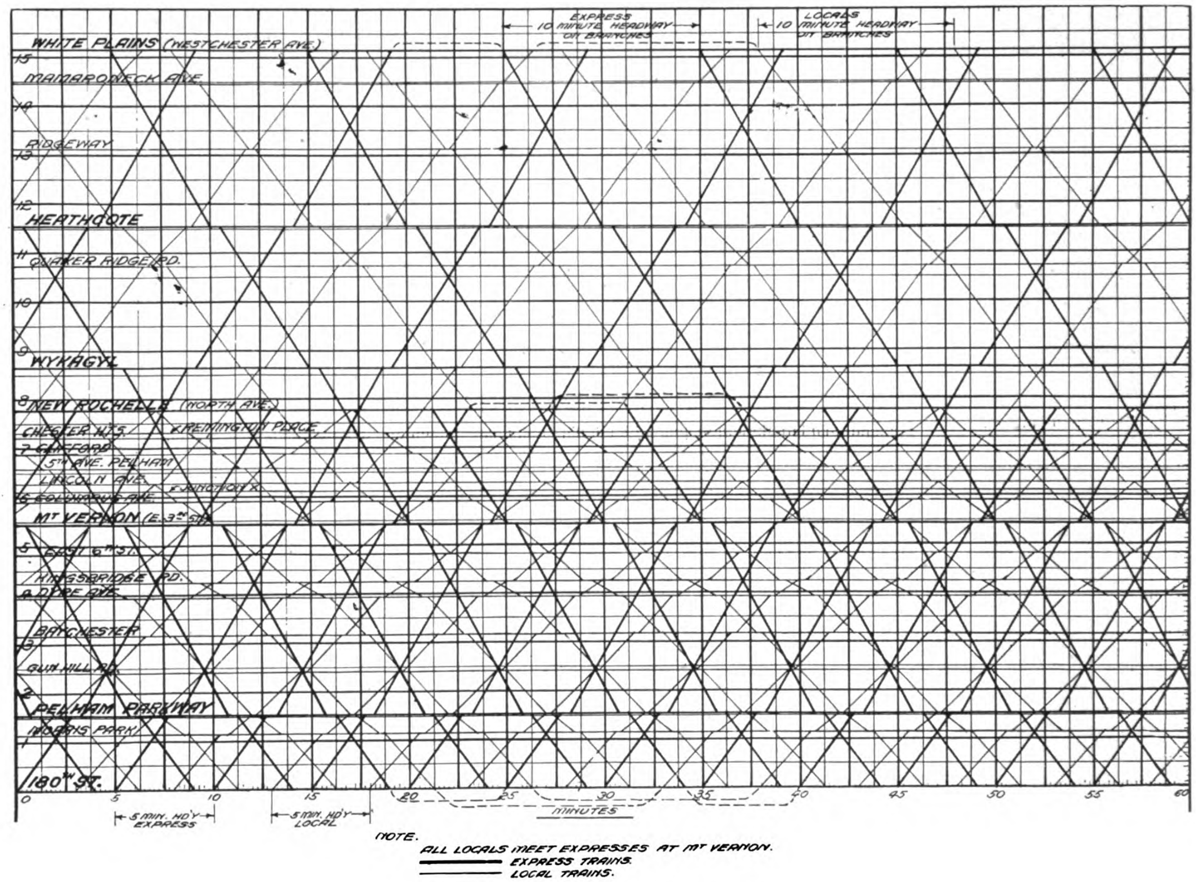

Fig. 4. Proposed Ultimate Schedule.

In most signal installations of this kind the theoretical length of block can only be approached in practice. The locations of interlocking stations and the physical characteristics of the track often influence its length to a considerable extent. On this road the interlocking stations are so located that, happily, the distance between them approaches a multiple of the length of block. In a number of cases, however, the signals had to be so located as to clear the platforms at passenger stations.

The maximum length of block could not be uniformly applied to advantage on account of variations in speed. All scheduled trains stop at express stations, and only at points between these can maximum speed be attained. Moreover, on the viaducts a limited speed is called for. At the passing sidings, which are

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1,500 ft. long, the rear distant signals indicate for both of the interlocking signals at each end of the siding, and a train must travel this additional distance before a clear signal can be obtained for a following train. These conditions call for a shortening of the block so that trains may close in; and this has been adapted as far as a safe operating margin for non-stopping trains at these points would permit.

For reasons of economy the signaling on the local track has

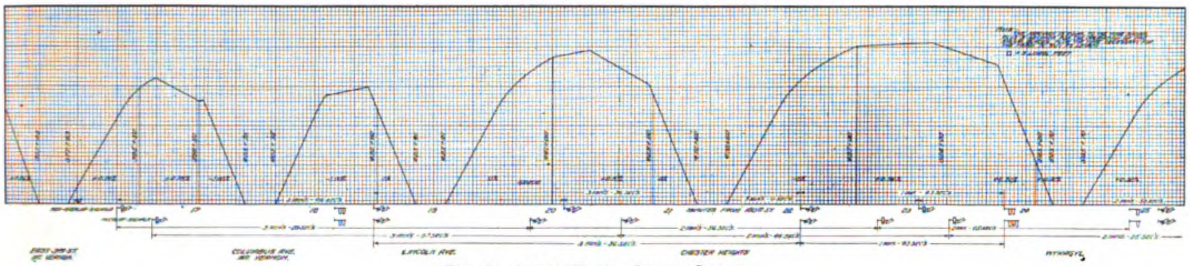

Fig. 5. Local Train Speed Curve.

followed the same arrangement as on the express tracks although the average speed is 15.4 miles per hour less.

In practice an average headway of two minutes and 20 seconds is possible for express trains and three minutes and 45 seconds for local trains, including stops, and at no point is the possible headway for the latter greater than five minutes and six seconds. The proposed ultimate schedule, see Fig. 2, calls for a headway of five minutes for express and five minutes for local trains, which this arrangement of signals can take care of with an operating margin of one minute and 15 seconds.

In Fig. 3 a train speed curve is shown for express trains from East Third street station to Wykagyl on the White Plains

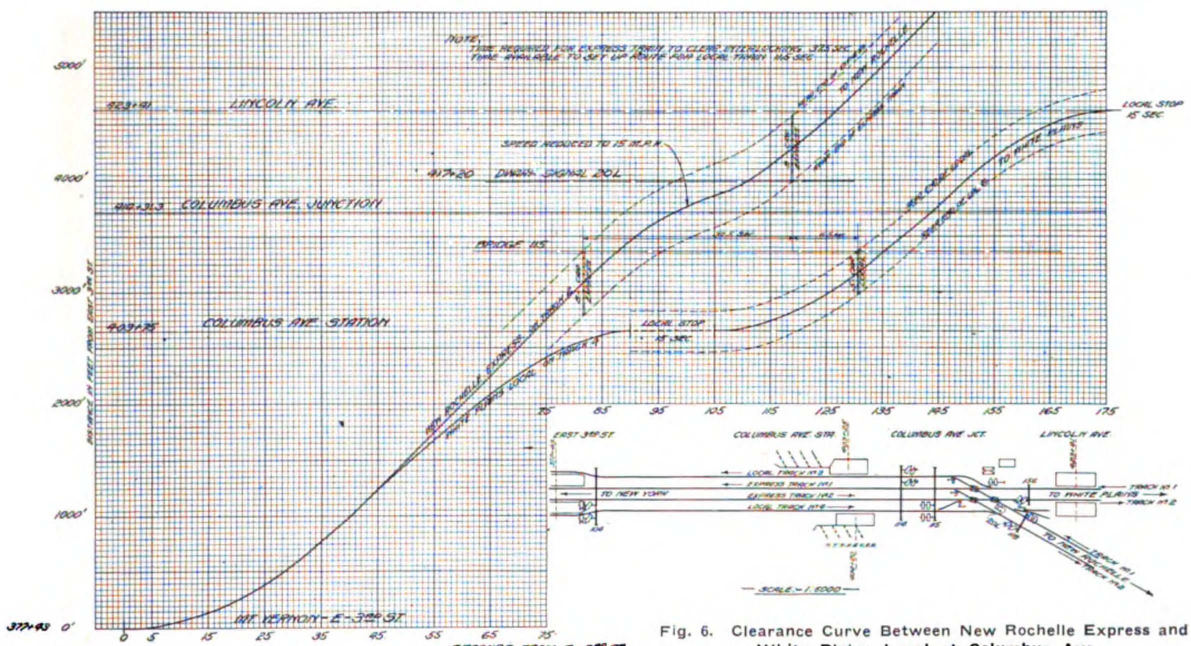

Fig. 6. Clearance Curve Between New Rochelle Express and White Plains Local at Columbus Ave.

branch, and Fig. 5 shows a train speed curve for local trains on the same section. The signals are placed on these curves proportional to the time that the train takes in running through the block. The headway is equal to the time required for a train to run the length of the distant signal indication and its own length, plus eight seconds for the movement of two signal blades. These curves also show the speed of trains at any signal location.

Considerable thought was given to the use of automatic stops, and although it was decided not to install them initially their probable future use was considered of such importance as to make it desirable in the present arrangement to provide the necessary parts on the apparatus for this purpose.

The use of automatic stops requires overlapping the control of the signals, which always secures a space interval between trains, equal to the length of the overlap. On this account the factor of safety on the braking distance can be very materially reduced, and in fact was taken at 40 per cent instead of 100 per cent as in the former case.

From a construction point of view the ideal arrangement for future overlaps would be to place an additional signal in the center of each of the present blocks, thus reducing the distance between signals by half. If this were adopted, however, it would be necessary to reduce the maximum allowable speed. But, without restricting the speed, the present signals may be closed in on account of the reduction in the margin of safety (by 60 per cent) and, by adding additional signals, still maintain a headway that will meet the requirements of the ultimate schedule. An arrangement of this kind has been worked out which will call for relocating 32 signals and adding 36 blocks; admitting the same average headway for express trains and increasing the headway for local trains by 10 seconds. The power for the system has sufficient capacity to operate these additional signals.

THE INTERLOCKING.

The interlocking comprises seven plants in addition to two for the New Haven connections. That at 180th street consists of a 35-lever machine controlling switches to the yard and

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car shops, and a ladder on the four tracks south of the platforms; and that at Baychester avenue, with a 17-lever machine, controlling crossovers for interchanging traffic on express and local tracks; located centrally on the four-track section. The junction of the four with the double-track section at Columbus avenue, Mount Vernon, is handled by a 29-lever machine in which spare levers are provided for the future connection with the New Haven at this point. At North street, New Rochelle, another 17-lever machine is used for controlling the connections to two storage sidings and a crossover; this being the last stop for New Rochelle local trains. These sidings have a storage capacity of four eight-car trains. At White Plains there is a terminal station for White Plains locals consisting of three platform tracks. On a different level there will be a future station on the Westchester Northern tracks. The junction with the latter and the switches to the platform tracks, which are 1,500 ft. apart, are controlled from the same interlocking machine of 29 levers capacity. At the two express stations between Mount Vernon and White Plains, passing sidings are

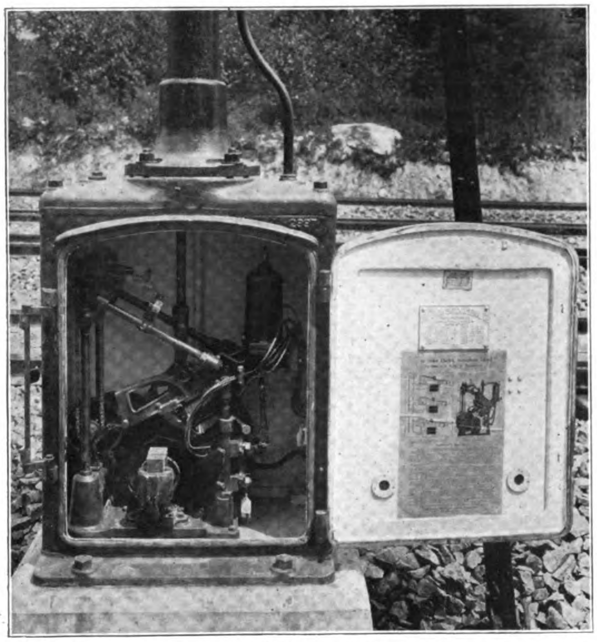

Fig. 7. Style "B" Signal Mechanism.

installed on each track with island platforms between the siding and main track, also crossover on the latter. The switches at these points are controlled by 17-lever interlocking machines. There are, therefore, four 17-lever machines, two 29-lever machines, and one 35-lever machine.

Power interlocking machines are used throughout. Power operation is essential for the rapid and frequent switching necessary at the larger plants and also at the smaller plants on account of the distance some of the switches are located from the tower; and on account of the lower cost of installation as compared with mechanical interlockings, and the advantages of using a type of apparatus that is uniform.

The interlocking plants are installed with the safeguards usual for high speed and dense traffic. Approach locking insures the integrity of the route to a train that has received a clear signal, the arrangement being such that it cannot be changed for an interval of one and one-half minutes. An emergency release, however, is provided in the junction and terminal towers, enabling the leverman on breaking a seal instantly to release the approach locking and change the route in cases of emergency—the breaking of the seal requiring an explanation as to the cause. Route-locking secures the route in front of the train when it is within the limits of the interlocking after the signal lever has been restored to normal. The locking of the switches, however, releases as soon as the train has passed over them. Separate indications are provided for the approach of trains in each of the two blocks in the rear of the first home signal, so as to give separate indications for trains following each other one block apart. These indications consist of lights in a model of the tracks placed over the interlocking machine and a buzzer calling attention to the lights. Light indicators are also provided to show when the signals may be cleared and when the detector switch locks are released. Thus the signalmen have ample indications of approaching trains, and indications of the route that may be set up and of the signals that can be cleared, these latter indications being embodied in the interlocking machine.

It was considered that at the small interlocking plants, it may not be necessary to have a leverman constantly in attendance, there being long intervals in which switching would be unnecessary. To make this possible the signals for the direct movements operate automatically the same as block signals when the lever controlling them is kept reversed. Thus through trains may pass these interlockings without attention on the part of the operator.

The most congested interlocking is the junction at Columbus avenue.

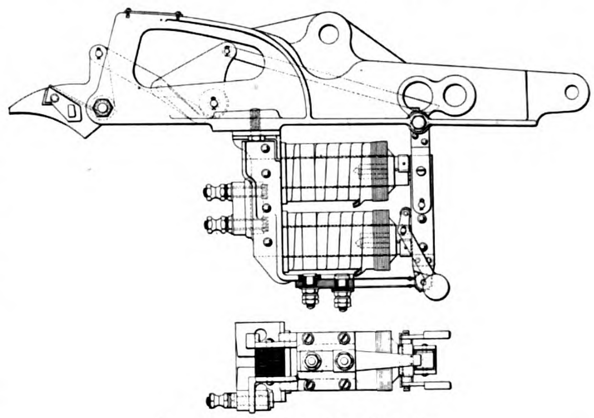

Fig. 8. The Style "B" Slot Arm.

This is on account of the grade crossing for the New Rochelle express and the White Plains local trains, also locals from New Rochelle crossing with expresses from White Plains. Train movements at this place require to be made with the utmost despatch. This is on account of the express station at East Third street, Mount Vernon, being selected as the starting point of the time table, see Fig. 4, which has been so arranged that passengers may transfer between express and local trains in both directions without delay. It is further planned that a White Plains local shall arrive with a New Rochelle express and a New Rochelle local with a White Plains express. The operating margin in the former case is shown in the curve, Fig. 6. Assuming that the express and local trains leave at the same time, the trains move together until the local slows up for the stop at Columbus avenue station. In this time the express for New Rochelle must gain sufficiently to clear the interlocking and enable the route to be made for the local to White Plains before the latter arrives at the interlocking signal on bridge 115. In the figure an eight-car express and a five-car local train are shown in their relative positions at the speed allowable. This curve shows that there will be a margin of 11.5 seconds in which the interlocking signal may be cleared before the local train reaches it.

APPARATUS.

The New York, Westchester & Boston connects with the New Haven system at two points, and some of the schedule trains will be operated through from Harlem River on the New Haven road. As a consequence the same system of electrifica-

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tion is used on both roads; that is, 11,000 volts, 25 cycles, single-phase for the propulsion of trains. The propulsion current is distributed from an overhead wire and collected by a pantagraph on top of the cars. This overhead wire is supported by a catenary construction, which in turn is supported by catenary bridges spaced approximately 300 ft. apart. The feeder wires and the signal mains are carried on crossarms placed on extensions of these bridge legs. What is known as the double catenary construction is used except on the New Rochelle extension.

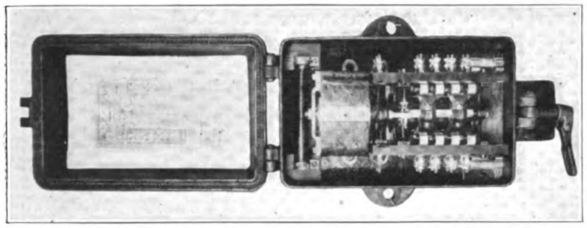

Fig. 9. A Switch Circuit Controller.

tension. This consists of a main catenary wire passing over the bridge truss and supporting a four-inch "I" beam, 75 ft. from the bridge on either side. A second catenary wire is supported from insulators attached to these "I" beams; these supports are, therefore, 150 ft. apart.

From this wire, adjustable extension arms support the copper conductor and the steel contact wire. On tangents, these wires fall in the same vertical plane over the center of the track. On curves, however, the main catenary wire is offset on the bridge truss towards the outside of the curve so as to bring the insulators on the "I" beams over the center of the pantagraph; the extension arms supporting the contact wire also being fanned out for this purpose. On the New Rochelle branch, where the single catenary construction is used, the supports occur only at bridges, and a greater fanning out is necessary. On a number of curves, pull-off poles are required between bridges to bring the catenary into position.

THE SIGNALS.

For the same reason that the electrification is similar, the type of signal is also similar to that used on the New Haven road—that is, two-position signals with center-pivoted blades, having a 60-degree movement from the horizontal. Most of the signals are suspended from catenary bridges, and are arranged so that the top blade comes in a horizontal plane below the main catenary structure, affording an unobstructed view from trains. And the center pivoted blades afford the greatest possible clearance from the high tension wires.

All high signals are operated by the well known Union Style "B" mechanism adapted for alternating current operation. This mechanism will operate the blade through a complete movement in four seconds. The clutch on the slot arm operates a circuit controller by means of which local energy is applied to the motor. A counterweight holds this circuit breaker open when the clutch is de-energized. The interlocking signals differ from the block signals only by the addition of the indication circuit controller.

Dwarf signals are of the solenoid type operated by direct current at 110 volts and controlled by a local A. C. relay. In the subway light signals are used, giving indications corresponding to the night indications of the block signals. All signals are electrically lighted.

INTERLOCKING APPARATUS.

The interlocking plants are operated by the Union Type "F" electric interlocking system. The interlocking machines are similar in design and principle to the electro-pneumatic machines and are fitted with vertical combination springs designed with the clearances necessary for 110-volt circuits. Switch levers are fitted with an electric detector lock in addition to the indication lock, which simplifies the controlling circuits. The switch movements are of the revolving drum type in which a horizontal drum operates the necessary cranks. The motor is connected through a planetary reduction gear and a mechanical friction clutch, to the movement. Movable-point frogs are operated by two drums connected by a shaft, and the slips are operated by a switch and lock movement connected to the locking rod of the frog movement. The motor and the reduction gears are enclosed in a waterproof case, and the entire movement is protected by an iron cover.

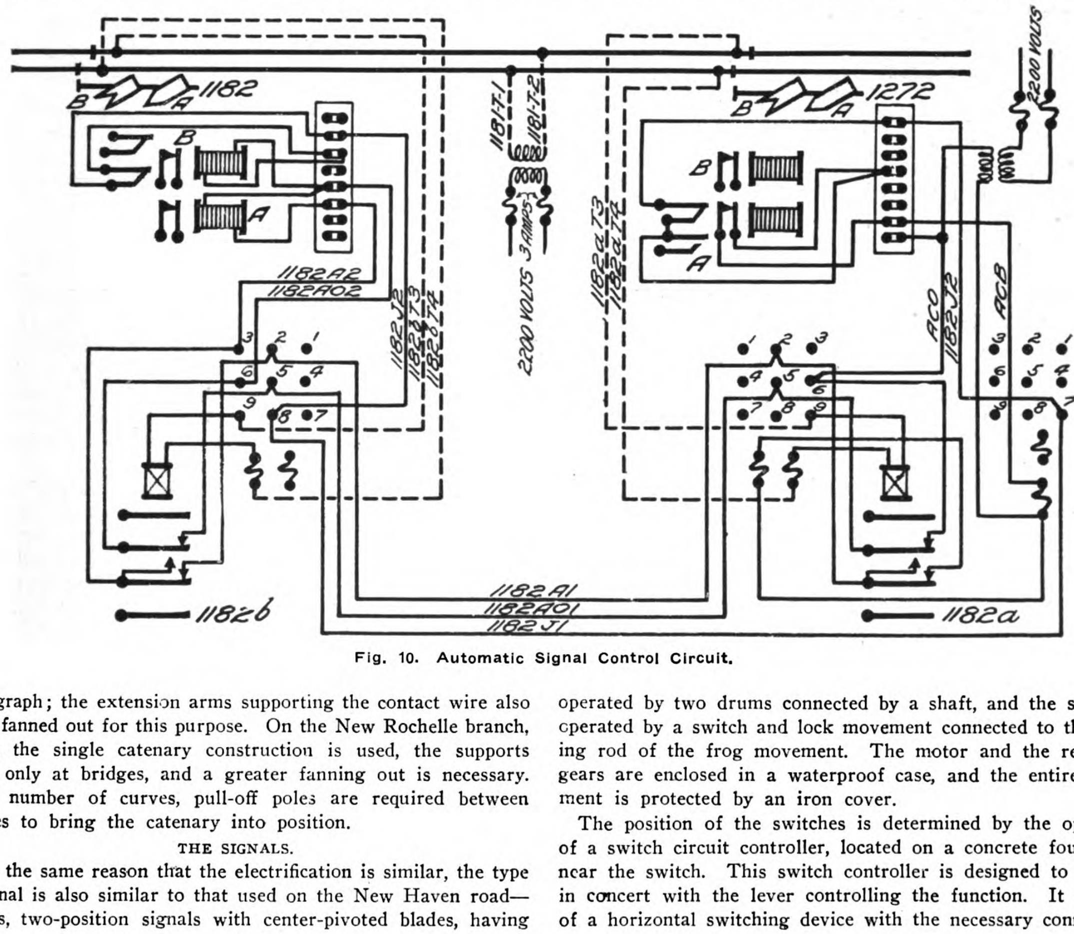

Fig. 10. Automatic Signal Control Circuit.

The position of the switches is determined by the operation of a switch circuit controller, located on a concrete foundation near the switch. This switch controller is designed to operate in concert with the lever controlling the function. It consists of a horizontal switching device with the necessary connections

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to change the direction of the current in the armature of the switch motors and consequently the direction of the switch movement. Both ends of a crossover move simultaneously, the controller having sufficient contacts to control the motors of each movement.

SIGNAL CIRCUITS.

Somewhat of a departure from the usual arrangements in circuits has been adopted in several instances, chiefly with the object of simplification, to avoid the use of special apparatus, and on account of the conditions to be met.

No wires are used that are common to more than one source of energy, contrary to the customary practice in signal work. The principal reason for requiring this condition was to lessen the effect of the inductive influences from the propulsion current by limiting the length of any wire to the length of two battery. These mains avoid the use of large wires to each function and in consequence can be of such a size as to render the drop in voltage almost negligible at less expense than by using separate energy wires. The wires connecting the functions and the levers are No. 16 B. & S. gauge made up into four-wire cable, which was considered the minimum size allowable for mechanical strength.

The principal features of this type of interlocking are brought out in connection with the interlocking switch circuits. Only four wires are necessary between the lever and the switch. Two of these operate the switch controller, the position of which is determined by an armature free to make a 90-degree movement in a fixed field which responds to the direction of current in the controlling wires as determined by the position of the lever. It is provided with a toggle arrangement to prevent it

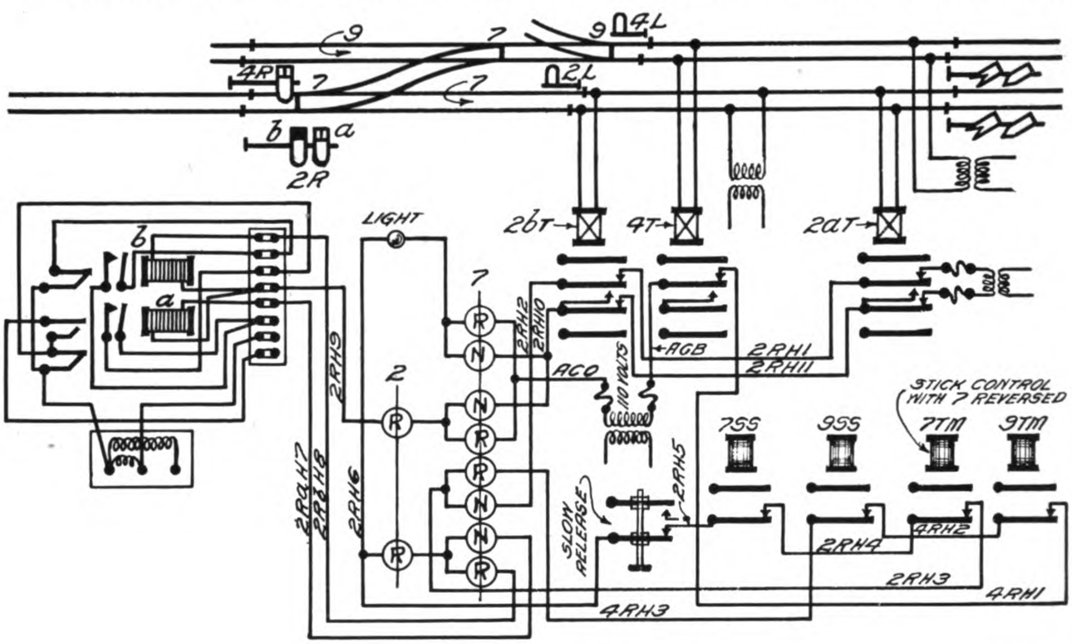

Fig. 11. Interlocking Signal Control Circuit.

blocks. The inductive influence on long wires is liable to be dangerous to handle and might have an injurious influence on the proper working of some of the apparatus. This increases the number of wires necessary for the block signals on the four-track section by 25 per cent and on the double-track section by 17 per cent. It, however, enables both sides of the circuit to be controlled by the relays, providing double security in this connection, and isolates trouble so that it cannot affect more than one source of energy, thus simplifying maintenance.

The circuits for an automatic signal are shown in Fig. 10. The slots which hold the blade clear are operated directly on the line circuit, which eliminates all relays except those used on the track circuits. The entire system is operated on 110 volts, A. C. The signal lamps, however, are two candle-power, 2.5 watt, tungsten; and in order to obtain the highest efficiency from these small lamps they are operated at 12 volts, obtained from a small transformer on the 110-volt circuit. Two lamps are connected in multiple circuit.

Circuits for the control of an interlocking signal are shown in Fig. 11. Each wire from the slot is controlled by the signal lever and then by the controlling instruments. The solenoid magnet of the dwarf signals is controlled by a local A. C. relay which takes the place of the slot magnet in the high signals and avoids controlling the heavy current to operate the signals through the spring combination. The D. C. energy for operating the interlocking functions is distributed throughout the interlocking by a set of bus mains connected to the storage from changing its position should the current in the controlling circuit, which is constantly energized, fail. The other two wires are for controlling the normal and reverse indication lock on the lever. It can thus be seen that the wires are used exclusively for one purpose and not changed over for different functions at different parts of the movement, which reduces the circuits to the simplest possible arrangement, thus insuring reliability and greatly facilitating maintenance.

A safety relay is used in connection with the switch indication which controls the signal circuits. This relay can only be energized when the position of the switch and the lever correspond. If the switch points open or change position wrongly, a clear signal cannot be obtained. The signals are also controlled by the track circuits to give the necessary fouling and semi-automatic protection.

The locking circuit on the switch levers is separated from the indication lock. The light indications on the switch and signal levers and on the track model are 110 volts, two candle-power, operated in multiple circuit with the relays.

No. 3 OF THE 1912 JOURNAL of the Signal Association has been issued by the secretary, C. C. Rosenberg. The book contains the discussions on the reports presented at the New York meeting on June 12-13. Twenty-seven new members of the association were elected and enrolled as of June 11. The high number is now 1828, and is held by F. C. Englehardt, of the West Jersey & Seashore.

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