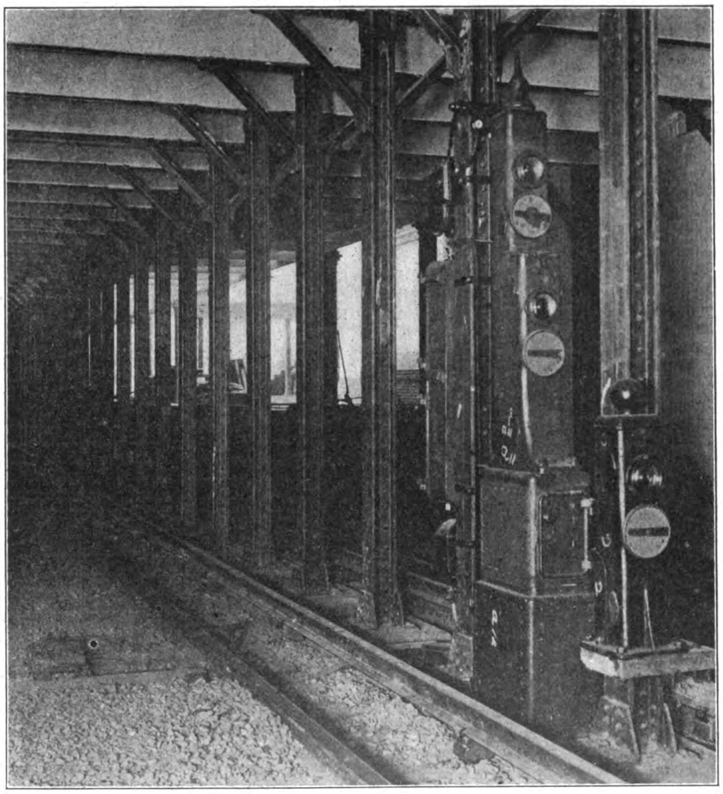
tives are included in the property acquired, besides rails enough for 250 to 300 miles of construction tracks; many steam shovels and dredges also are included. While generally the wooden portions of machines have been destroyed by the climate it is surprising how little the metal parts have corroded.

The first work of the present commission, which will occupy two years, is to determine upon the most practicable plan to adopt. Plans are to be considered for high level canals having six, four, or two locks, or for a sea level canal having one lock at the Pacific ocean end. The estimates for a canal having six locks have been placed at eight years for completion, and at a total cost, including the 50 millions already paid, of 200 million dollars. Recent borings have resulted in establishing the fact that it will be more feasible to build a sea level canal than was at first considered possible; and while Mr. Wallace is not ready to make any definite recommendation to the commission at this time he feels that it is reasonable to consider that a sea level canal with one lock can be built by spending 50 millions more money, and 50 per cent. more time than would be required for the high level, six-lock canal. By this plan 36 million dollars of the estimate of the former commission for locks would be released and be available for extra excavation and river diversion work, including a seven-mile tunnel for flood waters. He is satisfied that the high level plan can be carried out within the estimate of the Isthmian Commission both as to time and money. There is a difference of 10 ft. between the mean tide levels on the two sides of the isthmus, and while the fluctuation of tide is less than two feet on one side, it is ten times as great on the other side, hence the need of one lock for a sea level canal.

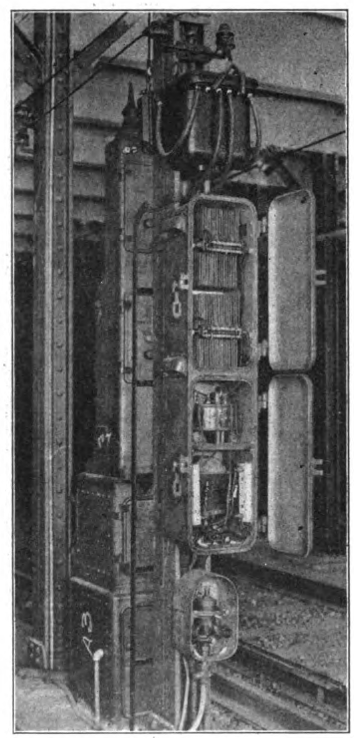
Mr. Wallace referred to the work now being carried on at Panama and Colon, including the building of water works, sewers and paving, all intended to make the sanitary conditions of the isthmus excellent. This work involves the expenditure of over half a million dollars. During the past three months he found the maximum temperature to be 86 deg. Fahr., and the nights cool. In concluding his address he paid a high tribute to Governor Davis, under whose administration conditions on the canal zone have been admirable. He denied that there had been any friction between Gov. Davis and himself, and incidentally stated that if there had been as many newspaper reporters on the isthmus as there are ties on the Panama railroad more misinformation could not have been published about conditions there than has been given to the reading public.

Signals in the Subway.*

The installation of the block and interlocking signals in the New York subway involves at once the use of old and well-tried methods and appliances and also the application of some entirely new principles; and the provision of mechanical and electrical safeguards is more complete than anything that has been done before. The problem has been solved by a careful consideration of the local conditions and the location and connections of the signals are such as to give the greatest capacity to the line and the utmost flexibility in operation.



Block Signal and Dwarf Signal with Automatic Stop.



Rear of Signal Showing Auxiliary Apparatus.

Between City Hall station and 96th street, a distance of 6½ miles, there are four tracks, the two middle tracks being intended for express trains. On these tracks the running conditions are quite similar to those on steam railroads and throughout their length they have automatic block signals controlled by track circuit. From 96th street to 145th street on the West Side division there are three tracks. Two of these are for local trains and the middle track is for express trains which will be run only in one direction at a time, running down in the morning and up at night. This express track is also to be worked by block signals. Above 145th street, where there are but two tracks, both tracks are block-signaled. The tracks for local trains between 145th street and City Hall have block signals only at the stations and on curves where the motorman's view ahead is obstructed. Conditions on these tracks are similar to those on the elevated roads where a complete block system has never been thought advisable or necessary owing to the frequency of the stops and comparatively low speed. Including the sections of local tracks at curves and stations, there are 24½ miles of track equipped with automatic signals.

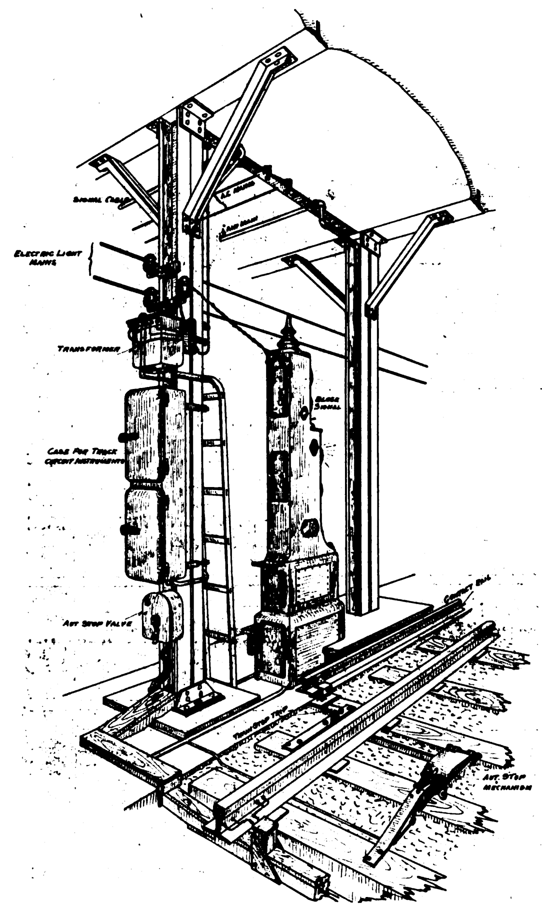
All of the block signals as well as the interlocking signals are a modified form of the Westinghouse electro-pneumatic system adapted to the restrictions of clearance and lighting conditions in the tunnels. The distinguishing feature of the installation is the use of an alternating-current track-circuit for operating the relays controlling the electro-pneumatic valves on the signal posts. An electric track circuit for signals as used on the ordinary steam road is a comparatively simple problem compared to the one encountered here, in which the rails act as return feeders for a 500-volt direct current with amperage sufficient to propel a train requiring at times as high as 2,000 h.p. On the elevated and the subway lines of the Boston Elevated Railroad a direct current of low

*It is announced that the Subway will be opened for business from the present southern terminus (City Hall) to 145th St., on Oct. 27.

voltage is used, and with good results, but there the traffic is not so enormously heavy and the chances of derangement of the delicate mechanism of the signal relays by a sudden rush of current or drop of voltage in the return rail are not serious. Preliminary experiments made on the North Shore Railroad in California by the Union Switch & Signal Co., which installed all the signals, showed that an alternating current track circuit could be successfully used with a high-voltage direct-current return power circuit provided the return power circuit was carried through only one rail with the other rail insulated at the ends of the blocks and all of the automatic signals in the Subway were designed on that principle.

Current for the signal track circuits is supplied through 500 volt a.c. feed wires from the sub-stations, which run through the tunnel from end to end. Each signal post at the entrance of a block section carries a step-down transformer with two secondary coils, one of which delivers an alternating current of 10 volts for the track circuit and the other delivers an alternating current of 50 volts for the signal lamps. The low voltage secondary coils are connected across the rails at one end of a block section and the track relay is connected across at the other end of the block, with a choke coil interposed to keep out the direct current. The action of the relays is similar in every way to those used with continuous current circuits.

On account of the limited clearances in the tunnel and the conditions of night which prevail, the signals indicate by color and not by position. The appearance of the signal and its auxiliary apparatus is shown in the accompanying illustrations. The mechanism controlling the indications of the signal is enclosed in a cast-iron box about 9 ft. 9 in. high, and 10 in. square, mounted on a concrete base between the tracks. In the bottom of the box are the air cylinders and the electro-pneumatic valves which control the admission of air to them. The distant signal is below the home signal, in accordance with standard practice. For each of the two signals, the home and the distant, a bull's-eye lens of white glass is mounted in the front of the case and behind it are two 4-c.p. incandescent lamps connected in parallel and both lighted so that the light will be maintained even if one is out of order. The color indication is given by colored glasses mounted in slides or frames which are counterweighted and are pushed up between the lamp and the lens by rods from the air cylinders below. The color indications in the signals are: red for stop, green for proceed, and yellow for caution. Immediately below the lenses are white circular discs with small black semaphore arms on their faces which remain horizontal if the signal is at danger or caution and stand at an angle of 60 deg. when the signal is cleared. This gives the motorman a visual signal indication if the lamps are not burning and is a check on his color sense. The case has doors, front and back, for the ready inspection and repair of the mechanism inside.



Automatic Block Signal and Train Stop in the Subway.

Back of each signal box and mounted on the columns supporting the roof of the tunnel is the auxiliary apparatus, which is enclosed in separate boxes. The alternating current mains are carried along on the columns near the roof and these are tapped by the connections to the transformer before mentioned, which is mounted near the top of the column. Immediately below this is the box containing the "grid" resistance for preventing the short-circuiting of the alternating current relay which is enclosed in a separate box, with the choke coil. At the bottom of the post is the valve for the automatic stop. Current for operating the electro-pneumatic valves in the signals and interlocking plants is furnished from 16 sets of storage batteries situated at certain interlocking towers in the subway which are charged by small d.c. motor generators. These batteries are arranged in pairs so that one is being charged while the other is being discharged and they furnish current at 16 volts.

The dwarf signals used at interlocking plants in the tunnel are substantially the same in their construction as the block signals except that they show only one indication on each post. The posts are 3 ft. 4½ in. high and are capped with a sphere instead of a pointed cone as are the block signals. Red and green, for stop and proceed, are the only two colors shown. These signals, like those for fast movements, have an indicator dial. Where the movement of trains is always in one direction, the dwarf signals are replaced by dummy signals of similar external appearance, but showing a fixed purple light and having the disk below the lens painted purple also.

The length of the blocks and the location of every block signal on the entire line was carefully worked out from data relating to the grades and alinement of each section. Before locating the signals an exhaustive series of brake tests was carried out by the Westinghouse Air-Brake Company, under the direction of the consulting engineer of the Interborough, to determine the distance required for stopping a train with emergency applications of the air-brake at all speeds up to 50 miles an hour. These were plotted in the form of a speed-distance chart with a curve for level track and adjusted curves for trains on 1 per cent. and 2 per cent. ascending and descending grades. From this chart the theoretical minimum distances between signals for the maximum possible speed on any gradient could be easily found, thus establishing the proper length of each overlap separately. This method was a radical departure from standard railroad practice, but one which was deemed absolutely necessary in this case. With these conditions and data to work from it was not difficult to fix the position of signals in respect to stations, curves and junctions. Suppose the stopping distance for a train running at 30 miles an hour was 400 ft. Adding 50 per cent. for safety, the minimum length of block would be 600 ft. and the length of overlap would be 1,200 ft. The minimum distance between signals is, as a matter of fact, about 820 ft. on the express tracks. The lengths of blocks have been so fixed that the maximum working capacity of the express tracks is a train every two minutes and on the local tracks a train every minute.

To prevent the occurrence of collisions as a result of disobeying the signal indications, an automatic train stop has been put in under an agreement made by the contractor with the Kinsman Block System Company, of New York. This consists essentially of a rod or shaft extending across under the rails opposite the signal post and carrying on the end nearest the third rail an arm or trip. Between the rails is a cast iron box containing an air cylinder, an electro-pneumatic controlling valve and a counterweight on the end of another arm attached to the shaft. If the signal is set at "stop" the air in the cylinder is cut off by a circuit-breaker connected with the signal blade, and the counterweight drops, throwing the stop arm to an upright position above the level of the rail. All of the cars to be run in the subway are fitted with an arm, carried on the truck, which is connected to a valve in the air-brake train pipe; and if the train runs past a signal set at stop the stop-arm, which has assumed an upright position, engages with the trip or arm carried on the truck and opens the train pipe, thereby setting the brakes on all the cars in the train and bringing it to a stop before it enters the second block ahead, in which is the obstruction by which the signal has been set to stop. In order not to delay trains unreasonably in case of derangement of the automatic stop, the trainmen are supplied with a socket key with which to turn the air valve controlling the movement of the stop-arm so as to lower it while the train is passing. The trainman must hold the valve open with the key until after the train has passed, after which the device will resume its stop position.

The accompanying diagrams show the track circuits and the operation of the automatic train stop on a typical section of one of the express tracks. The rail Y acts as a return feed main of the power circuit and is not insulated at the ends of the block sections. The rail X is insulated at the end of each block section just beyond the signal post. The current for the track circuit is supplied through the secondary coil of the transformer which is mounted at the end of each block. Current flows at all times through the rail X, through the signal relay at the beginning of the block and back through the rail Y to the transformer. The relays have two armatures, M and N, which are normally held up. If now a train enters the block ahead of signal 1 (lower diagram), the relay at 1 is de-energized and both armatures drop. When the circuit at N is broken, the electro-magnet of the pneumatic valve controlling the home signal at 1 is de-energized and this cuts off the supply of compressed air which allows the signal to move to the stop position by gravity. The movement of the home signal blade at 1 opens a circuit breaker in the circuit controlling the distant signal at 2. This throws the distant signal at 2 to caution. At the same time that the circuit is broken at N, the circuit in the armature at M is broken and this keeps the home signal at 2 at stop. The home signal at 2 being at stop, the circuit breaker at 2 which is connected through the distant signal at 3 is held open and the distant signal at 3 is held in the caution position. The automatic train stop is connected through the armature M, and when the circuit in this armature at signal 1 is broken, the train stop at 2 is thrown up. Immediately, therefore, after a train has passed signal 1, the home at 1 comes to stop and the home and distant at 2, already at stop and caution, are continued in that position. The automatic train stop at 2 is thrown up and the distant signal at 3, already at caution, is kept so. When the train has passed out of the block beyond signal 1, the relay at 1 picks up both the armatures M and N, closing the circuit for the home signal at 2 and for the train stop at 2. These then resume the clear position and the movement of the home signal at 2 closes the circuit breaker connected with the distant at 3, throwing it also to clear. A train in any block is thus protected by a distant signal two blocks in the rear and by the home and distant signal, together with the automatic stop, one block in the rear.

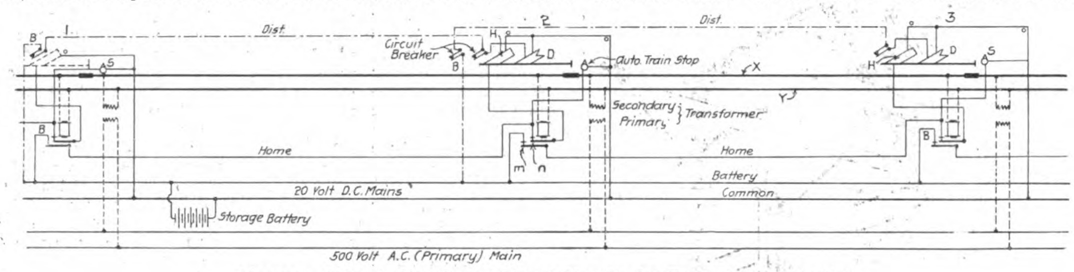


Diagram of Track Circuit and Signal Circuits for Typical Block Section.

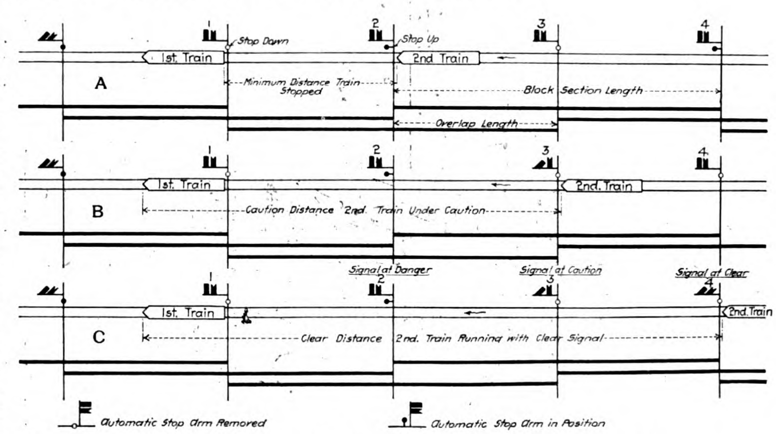


Diagram of Double Overlap Arrangement in the Subway.

The interlocking equipment is the well-known Westinghouse electro-pneumatic system with some slight modifications in the design and arrangement of the parts in the machines and switches on account of the very limited space in the tunnels. The cabin shown in one of the illustrations is only 30 in. wide and the machine has been rearranged so as to reduce the width, chiefly by changing the position of the bed-plate from a horizontal to a vertical position and changing the other parts to suit. The switches are all operated with motion plates instead of the usual bell-cranks. There are 23 interlocking machines with a total of 383 levers, situated as shown in the following table:

	No. machines.	No. levers.
City Hall	3	32
14th St.	2	16
18th St.	1	4
Spring St.	2	10
42d St.	2	15
72d St.	2	15
96th St.	2	19
100th St.	1	6
103d St.	1	6
110th St.	2	12
116th St.	2	12
Manhattan Viaduct ...	1	12
137th St.	2	17
145th St.	2	19
Dyckman St.	2	26
135th St.	2	6
Lenox Junction	1	7
145th St.	1	9
Lenox Yard	1	35
Westchester Ave	1	13
St. Ann's Ave.	1	24
Freeman St.	1	12
176th St.	1	56

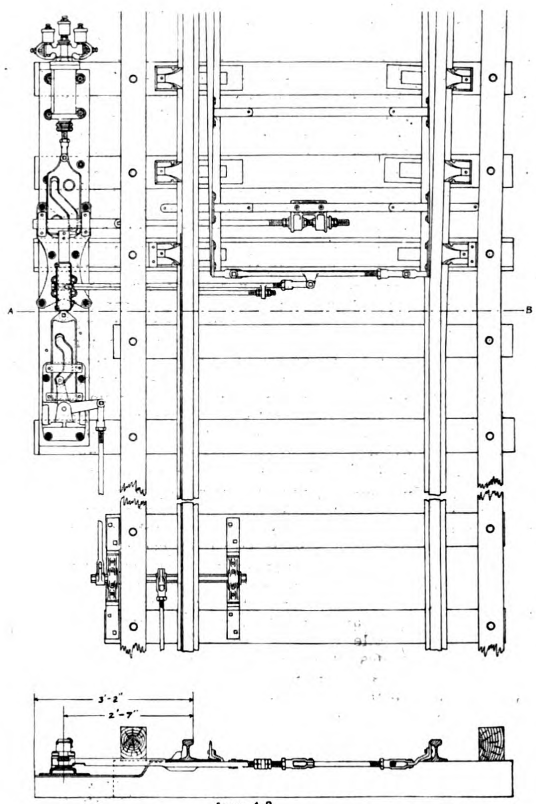
The small machines controlling single crossovers are mounted in neat boxes on the station platforms and will not have a regular attendant. They are so arranged that they can be set and locked for clear main tracks in both directions. There are a total of 227 interlocked switches, 224 automatic train stops, 354 home signals, 187 distant signals, and 150 dwarf signals.

The compressed air for operating all of the block and interlocking signals is supplied from motor-driven compressors located in six sub-stations, one each at City Hall, 18th street, 54th street, 96th street, 143d street, and at Dyckman street and at 133d street on the Bronx division, being approximately two miles apart. Current for operating the motors is supplied from the main feed wires running from the central power plant at 59th street and Eleventh avenue. Three of the sets are sufficient to supply power for all the signals and the other three can be held in reserve for emergencies. The motor is a Westinghouse direct current machine taking 60 amperes at 600 volts and driving an Ingersoll-Sergeant, straight tandem compound, single-acting compressor through a Morse silent chain. The compressor has cylinders 19¼ in. and 12¼ in. x 12-in. stroke, and has a capacity of 239 cu. ft. of free air per minute when running at 120 r.p.m. The compressed air is transmitted from the sub-stations through 3½-in. mains which give sufficient storage capacity to the installation. An automatic rheostat and pressure regulator keeps the pressure between 80 lbs. and 90 lbs.

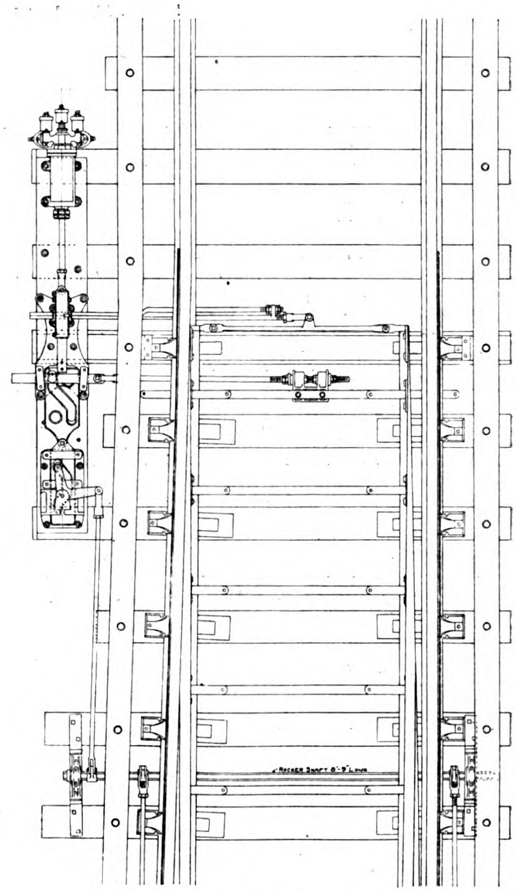
In connection with the signal system, there are a number of other safety devices of much interest. One of these is the emergency box, patented by Mr. Gibbs, which is located in each station, and into which all of the signal circuits adjacent to the station are led. In case of a sudden emergency, an employee or other person on the station platform can push the button in this box and immediately the signals for all tracks adjacent to the station are set to danger.

To prevent short circuits through the cars and motors when passing from one section of the third-rail to another, due to difference in voltage or grounding of one section, a balance coil relay controlling a dwarf signal in front of the break in the third-rail is introduced. When a decided difference in voltage exists between the two sections of third-rail, the signal stands at danger and continues to stand in that position until the voltage is equalized. Where the section break occurs near interlocking points, a modified arrangement is used. In this case small voltmeters are mounted over the machine. The operator can tell at a glance if the difference in pressure is great enough to be destructive, and can set the signals accordingly.

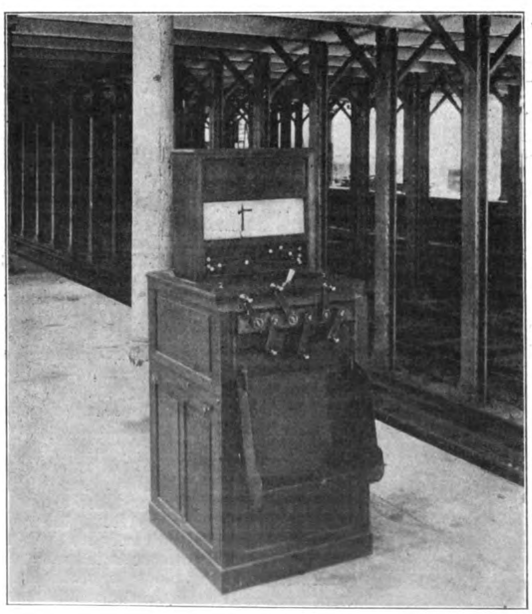
Not connected in any way, but, nevertheless, a very important adjunct to the signal system, is the installation of fire and emergency alarm signals throughout the tunnels. At every manhole on the West Side division are located a fire-alarm box and general emergency alarm box, which are connected with



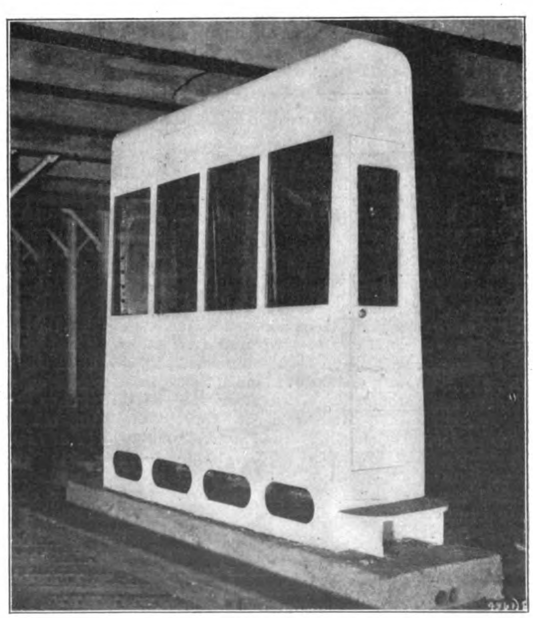
Split Switch with One Detector Bar.



Split Switch with Two Detector Bars.



Interlocking Machine at Eighteenth Street Station.



Interlocking Cabin at City Hall Station.

recording gongs in every station and also in the train despatcher's office, general superintendent's office and all of the sub-stations and power houses. In case of fire in the tunnel, the station men are instructed to pull the city fire alarm located in the passenger station which is nearest the scene of trouble, every station having one of these. The men in the electrical sub-stations, on receipt of either a fire or an emergency alarm, immediately shut off the power from the third-rail in that station so that there will be no danger to passengers walking through the tunnel. This entire alarm equipment has been furnished by the Gamewell Company.

All of the general features of the installation of the safety devices and signals on the line were worked out under the direction of Mr. George Gibbs, Consulting Engineer for the Interborough. Mr. J. M. Waldron, Signal Engineer for the road, supervised the installation. The Union Switch & Signal Company made and installed all of the apparatus under the direction of its chief engineer, Mr. J. P. Coleman, and Mr. Sidney Johnson, who had entire charge of the actual work of construction. Mr. H. M. Sperry, general agent at New York for the Union Switch & Signal Co., suggested the arrangement of the double overlaps, which is one of the most novel and important features of the installation.

All-Electric Interlocking at Oakdale, Tenn.

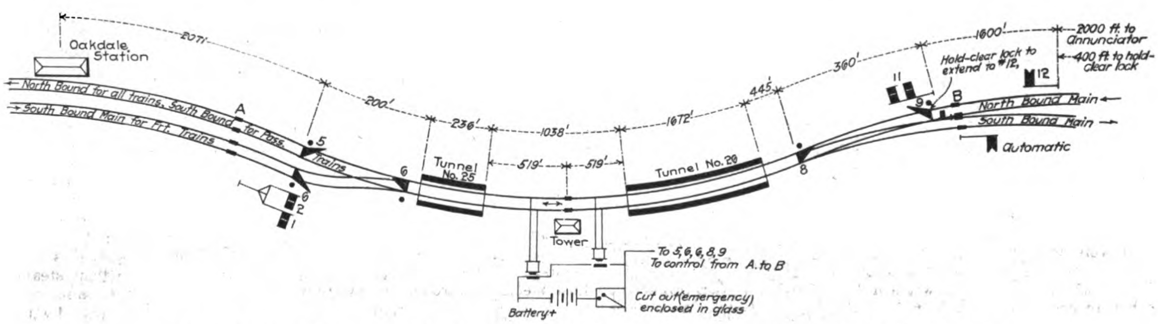
The Cincinnati, New Orleans & Texas Pacific has installed power interlocking at tunnels 25 and 26 near Oakdale, Tenn., in which one of the switches is 2,636 ft. from the cabin and one derailing switch 2,996 ft. From the north derails to the south is 3,951 ft. The apparatus is the Taylor all-electric, of the General Railway Signal Company, of Buffalo and Rochester.

A plan of the tracks embraced in this plant is given herewith. It will be observed that all of the switches and signals are out of sight of the signalman. The switches are locked automatically by track circuit locks controlled by the presence of a train at any point between A and B, and we are informed by Mr. Short, Superintendent of Signals, that trains are run through the single track section without either time-table or train orders, movements being governed entirely by the signalman by means of the semaphores. The arrangement of the relays for actuating the locks is shown in the drawing. Either track circuit, when shunted, locks the levers of derails 5, 6 and 9, and of switches 6 and 8

Signals 1, 2, 11 and 12 are slotted so as to afford immediate rear end protection. There is an electric lock on derail No. 9, which is closed by a northbound train when it reaches a point 2,000 ft. in the rear of home signal No. 12, and an automatic annunciator in the cabin is rung from a point 1,600 ft. farther south. Trains from the north are announced by the agent at Oakdale station by an electric bell. The tower is connected by telephone and bells both with this and with the first station south, and the towermen are not operators, both being cripples, having been hurt in the service of the road.

The machine is a 12-lever frame, with ten working levers; and the power is derived from a 1 K.W. generator, operated by a 2 H.P. Fairbanks-Morse gasoline engine which stands in the first story of the tower. The storage battery is 52 cells, Willard 30-ampere-hour lead accumulator. The switch and signal motors are the standard Taylor motors. There are no distant signals for southbound movements as all trains stop at Oakdale station.

The cost of this plant was about $5,500, which, we suppose, does not include the cost of the tower. While this is a low figure for apparatus performing such important functions over so large a territory, the saving in running expenses is, obviously, a still larger item, as, without perfect control of the switches at the ends of the single track section, it would be necessary to employ a night and a day attendant at each end.



Taylor Interlocking at Oakdale, Tennessee; Cincinnati, New Orleans & Texas Pacific Railway.

The Application of Electricity to Steam Railroads.*

BY BION J. ARNOLD.

The last ten years has been a period of great activity and development in the field of interurban electric railways, which has brought into extensive use the alternating current, rotary converter sub-station system of operating direct current roads. With the introduction of the suburban railway, came an increased volume of passenger travel, induced by the increased facilities which may well be noted as an example by the steam roads of what may be expected in increased revenue when frequent and pleasant service is available to the public. Those engaged in electrical industries have thus far been absorbed in fields which seem to have been naturally theirs, and their success has been such that they now aspire to enter the field occupied by the steam locomotive as a legitimate field of competition. The question is, whether this field is one in which the advantages of electricity will be sufficient to overcome the obstacles which seem almost insurmountable.

Those who have given the subject little thought or who are unable to analyze it carefully on account of the lack of the technical knowledge necessary to appreciate the difficulties to be overcome, are most apt to predict the early supremacy of the electrically driven train over the steam locomotive.

That the obstacles encountered in the development of interurban railroads have been apparently formidable yet quickly overcome is not necessarily proof or even good evidence that the legitimate field of the steam locomotive can be entered and successfully achieved. Those most familiar with the subject are now prepared to admit that our great steam railroad terminals, where many switching locomotives are shunting back and forth continuously, and those portions of the steam roads entering our great cities, where suburban trains are numerous, frequent, and comparatively light, can be more economically operated by electricity than by steam. This is evident for the reason that it simply means duplicating, on a large scale, the systems which have proven successful on street railways, operating, as they do, numerous units running at frequent intervals. Proof that this field is recognized as a legitimate one for electricity is furnished in the examples of steam railroad terminals that are now being equipped electrically, such as the lines of the New York Central and Pennsylvania in the vicinity of New York, involving an expenditure of about $70,000,000, where not only suburban service will be operated electrically, but where in the case of the New York Central, the main line trains will be brought into the city from points 30 to 40 miles distant. While these are good examples of electrical operation on steam railroads, and instances of faith on the part of the railroad managers in the ability of electricity to successfully meet the conditions of steam railroad work, where the trains are sufficiently frequent, they are by no means conclusive evidence that electrically propelled trains can be made to successfully meet the conditions of trunk line passenger and freight service which is the field now so successfully held by the steam locomotive.

The best conditions for electrical success are a great number of units moving at a practically uniform schedule, at equal intervals, within a limited distance. The steam locomotive is the most economical where there are few but heavy units moving at uneven speeds over long distances at unequal intervals and at high maximum speeds. The amount of energy transmitted to any great distance and used by electric cars on the roads that have been built up to the present time is small when compared with the amount of energy that it takes to propel a steam railroad train weighing 500 or 600 tons at the speeds ordinarily made by such trains. When investment is taken into consideration, power cannot be produced in a steam central station, under conditions that exist to-day, and transmitted any great distance to a single electrically propelled train,

*Extracts from the President's Address before the International Electrical Congress, St. Louis, Sept. 14.