

SIGNALING ON THE NEW YORK TUNNEL EXTENSION OF THE PENNSYLVANIA.*

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The switch and signal system was made unusually complete. The physical conditions surrounding the station yard are exceptional in the following respects: (a) the yard is practically underground, and the view from trains and of the tower operators is obscured by numerous yard structures and building columns; (b) clearances, both overhead and side, between the trains and structures are very limited, and the space available for the installation of signals and apparatus is restricted; (c) the character and extent of the train movements required the realization of the fullest capacity of all track facilities, necessitating the greatest freedom for simultaneous parallel movements; (d) the complexity of the track plans and the presence of yard service facilities, such as the piping system for steam, air and water, drainage and traction conductors and conduits, required that the signal appliances should be mounted on special foundations and that control wiring should be run in permanent and accessible shape in a conduit system.

On account of these conditions it was found necessary to divide the control of the yard movements between four different power-operated switching cabins. These cabins, each controlling only a part of the yard, required a certain amount of interconnection to insure rapid and complete movements in the yard, a result accomplished partly by electric locking between cabins, partly by light indicators on the track models in the cabins, to show how the tracks between them are occupied and when trains are approaching, and partly by central communication by telephone, etc., with the train director. At the Manhattan Transfer, where the change is made from steam to electric power, two very complete electro-pneumatic interlocking plants are provided, and at the Sunnyside yard four plants are required.

The tunnels involve train movements over heavy grades, at high speed and at the minimum safe interval, a condition which led to the adoption of automatic block signaling with overlaps of the same length as the block sections; in other words, a two-indication block in which a "proceed" indication requires that two sections shall be unoccupied. "Caution" indication must show that at least as much track is unoccupied as the foregoing. The length of the sections is variable, depending on the grade and maximum train speed at the point in question, being made 150 per cent of the length in which a stop can be made by the application of the brakes.

At each block in the tunnels a "track stop" is installed to apply the train brakes automatically should a danger signal be overrun. The closest headway at which trains can be run at normal speed, therefore, is the time required to pass over two block sections, corresponding to about two minutes, and at restricted speed under caution signals, one block, or about one and one-half minutes.

"Lock and block" control has been provided between the station and the Long Island approach of the East River tunnels, so that if necessary any one of the four tunnel tracks can be operated in the reverse direction. The North River tunnels have the same provision, with the addition of automatic signals for following movements. The grades are such that the spacing of signals for reverse movements could not be the same as for movements in the normal direction of traffic, and on account of this there was considerable complication in putting the signals for a certain direction out of commission and those for the opposite direction in, and changing the control of the automatic stops so as to make them effective at the right time.

The Meadow section has been equipped with automatic semaphore block signals without track stops. Complete reverse-movement signaling has been provided for at each block. At

the Hackensack River, midway of the section, the drawbridge has been provided with the usual interlocking bridge and signal appliances and cross-overs between tracks at the east approach to the bridge, so that reverse movements may originate either east or west from this point.

The "Rudd and Rhea" arrangement of signals was adopted for signal arms and lights. Signal indications are given in three positions in the upper right-hand quadrant, automatic blades being pointed for day indications and marked by a staggered light for night indications. Interlocking signals are multiple-arm, using square-ended blades with vertical marker lights. In the station one-speed signaling is used with calling-on arms where required.

Because of the absence of daylight conditions in the tunnels, and in the covered portion of the terminal area the indications are given entirely by lights. The light signal contains no mechanism other than that required for changing the colors of stationary lights in such a manner as to reproduce the same colors, and combinations as called for by changes in the position of a semaphore signal under like conditions in the controlling currents. The signals are cast iron receptacles carrying colored lenses, behind which are located standard 4-c. p. incandescent lamps (two in multiple for each lens); and the mechanism consists of relays housed in separate shelters near the signals, the contacts of which are adapted to shift the current from lamp to lamp and thus change the colors displayed as the relays are energized or de-energized by manipulation of the machine levers, or by the action of track circuits, or by both.

Because of the difficulty of obtaining ample clearances and suitable supports for semaphore signals in the yard, and in order to maintain a uniform type of signal within the station area, special hooded lenses and lamps of high candle-power are used in the "lamp" type of signal in these exposed places, and are found to give effective indications for the possible range of observance. Elsewhere on the line, outside of the terminal and tunnels, this form of signal would not prove satisfactory because of the higher speeds and longer range of observation required. The semaphore is used, therefore, on the open line.

The track circuits are operated on alternating current, using double-rail return with induction bonds on the main line and in the tunnel, and single-rail return in the three yards. The electro-pneumatic interlocking machines have lever lights and illuminated track models, and train describers, telautographs, telephones, telegraphs and train starting system instruments are all provided in the station yard towers. The pneumatic power is obtained from the 31st street service plant, relayed by compressors. The electric power is single-phase, 60-cycle alternating current, distributed at 2,200 volts from a special switchboard in the service plant. Transformers in the towers and at signal locations step this current down to 220 volts for local circuits, to 13 volts for track circuit, and to 55 volts for signal lights and other alternating current apparatus. Motor generator sets in each tower supply 25-volt direct current for operating direct-current relays and electro-pneumatic valves. Storage batteries, charged by motor generator sets, maintain the constancy of this current supply. In Cabin "A" alone there are 900 relays, and the total number in all the cabins is 2,600. The total length of signal wire used in this installation is 1,530 miles.

The following table shows the number of units in each of the interlocking towers:

Sym- bols	Location	Levers				Total
		Switch	Signal	Traffic	Space	
A	Pennsylvania Station Yard.	68	71	2	38	179
B	Pennsylvania Station Yard.	17	13	0	17	47
C	Pennsylvania Station Yard.	19	15	2	11	47
D	Pennsylvania Station Yard.	23	26	2	20	71
F	Sunnyside Yard.....	11	12	6	18	47
H	Sunnyside Yard.....	14	10	2	21	47
N	Manhattan Transfer.....	28	26	6	11	71
Q	Sunnyside Yard.....	22	18	0	31	71
R	Sunnyside Yard.....	15	15	0	28	58
S	Manhattan Transfer.....	25	23	10	25	83
W	Hackensack River Bridge..	2	2	5	2	11

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