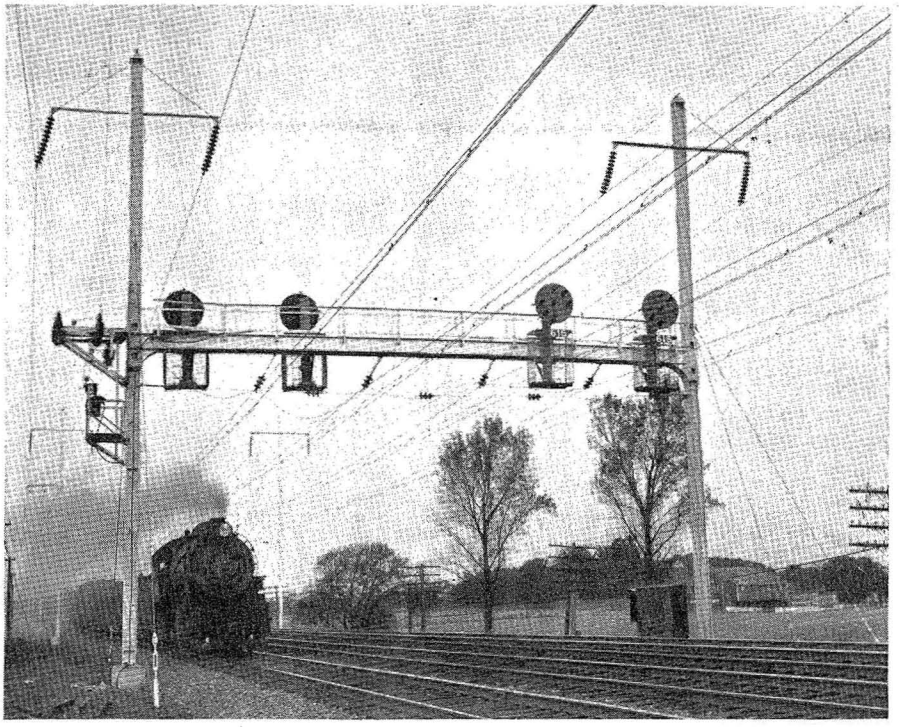


Large scale project, involving 315 miles of railroad line, is being rapidly pushed to completion—Signal, telephone and telegraph construction efficiently handled by 2300 men

Pennsylvania Electrification Signaling

THE Pennsylvania is rapidly pushing to completion the latest project in its electrification program. The signal, telephone, and telegraph construction, which has required a peak crew of 2,300 men, is co-incident with the electrification of 315 miles of railroad line, involving 773 miles of track. The program now under way supplements and extends into new territory the electrification completed in 1935 between New York, Philadelphia, Pa., Baltimore, Md., and Washington, D. C. (For information on the previous installations see *Railway Signaling*, page 245, May 1935, and page 213, June, 1931.)

In addition to the main line from Paoli, Pa., to Harrisburg, the current project includes the heavy freight route between South Amboy, N.J., and Monmouth Junction; the low-grade freight line from Morrisville, Pa., to Thorndale, Parkesburg to and including Enola yard at Enola; freight lines along the Susquehanna river between Cresswell and Perryville, Md.; and the Columbia Branch between Dillerville and Royalton. Embraced in the project also is the electrification of the freight yards at Pavonia, N.J., and South Philadelphia, as well as additions to present electrification in the New Jersey yards at Harsimus Cove, Meadows, Waverly, Linden, South Amboy, and Trenton; Frankford Junction and 52nd Street, Philadelphia; and Thurlow, Pa., near Chester. Regular passenger service was inaugurated on the main-line Paoli-Harrisburg sector on January 15, 1938.

Features of new signal work include extended sections of universal code track circuits for wayside and cab signals, respacing of signals for high speed, extensive revision of 24 interlockings, 2 interlockings changed to C.T.C. installations, new signal power substations and transmission line, and the conversion of open-wire line to cable in the entire territory.

Completion of the work will enable the Pennsylvania to realize the advantages of continuous electric operation of trains in the entire territory between Harrisburg, Philadelphia, New York, Baltimore, and Washington. Upon completion the Pennsylvania will have 2,677 miles of electrified trackage.

The actual electrification construction work, and a few features of the signal construction, such as track bonding and signal transmission line, is being done by four contractors, each contractor working on specified sections of the railroad, under the direction of the chief electrical engineer.

Organization for Signal Construction

The signal work on this project, as might be judged from the number of men engaged, is quite extensive. In order, therefore, to facilitate the handling of men and material, and to provide for efficient co-ordination of the work, a separate electrification signal, and telephone and telegraph, construction force was established under the direction of a specially assigned

engineer of telegraph and signals, assisted by an office force of skilled technical engineers and designers. This group was charged with the responsibility for the engineering, design, and proper co-ordination of the various phases of the work. All layouts, circuit plans, and other engineering plans were prepared in this office, under the direction of the engineer of telegraph and signals.

The field work was placed under the direct supervision of supervisors, assistant supervisors and foremen who had considerable experience on the previous electrification projects. In order to allow for concentration of effort by the various supervisors, each was assigned a particular area or section of the railroad. These sections were as follows (please refer to the accompanying layout): Morrisville to Downingtown on the freight line and Paoli to Downingtown on the main line; Downingtown to Thorndale on the freight line and Downingtown to Dillerville on the main line; Dillerville to Harrisburg, including the Harrisburg Terminal; Parkesburg to Shocks Mills and Dillerville to Royalton on the Columbia branch; Shocks Mills to Enola; and Cresswell to Perryville on the C. & P. D. branch.

The section between Monmouth Junction and South Amboy is being handled directly from the office of the engineer of telegraph and signals. Each assistant supervisor's territory was further subdivided and signal foremen and telephone and telegraph foremen were assigned to certain of the smaller sections, being shifted from section to section as the work was completed. The workmen are being assigned to different foremen and to different types of work, as necessity demands, the crews consisting of small crews of 3 or 4 men on specialized work to as many as 15 or 20 on the rough work, which requires less supervision.

Signal material was assembled at storehouses established at Harrisburg, Lancaster, Lemoyne, Middletown, Columbia, Marsh, South Amboy, and 30th Street, Philadelphia. In order to provide information periodically as to the progress of the work, a weekly form of progress report was established. (A detailed description of this type of progress chart will be found on page 371 of the July issue of *Railway Signaling.*) As various sections are completed, they are inspected by a group composed of both electrification and regional signal inspectors and engineers, after which the sections are placed in service and turned over to the division forces for operation and maintenance.

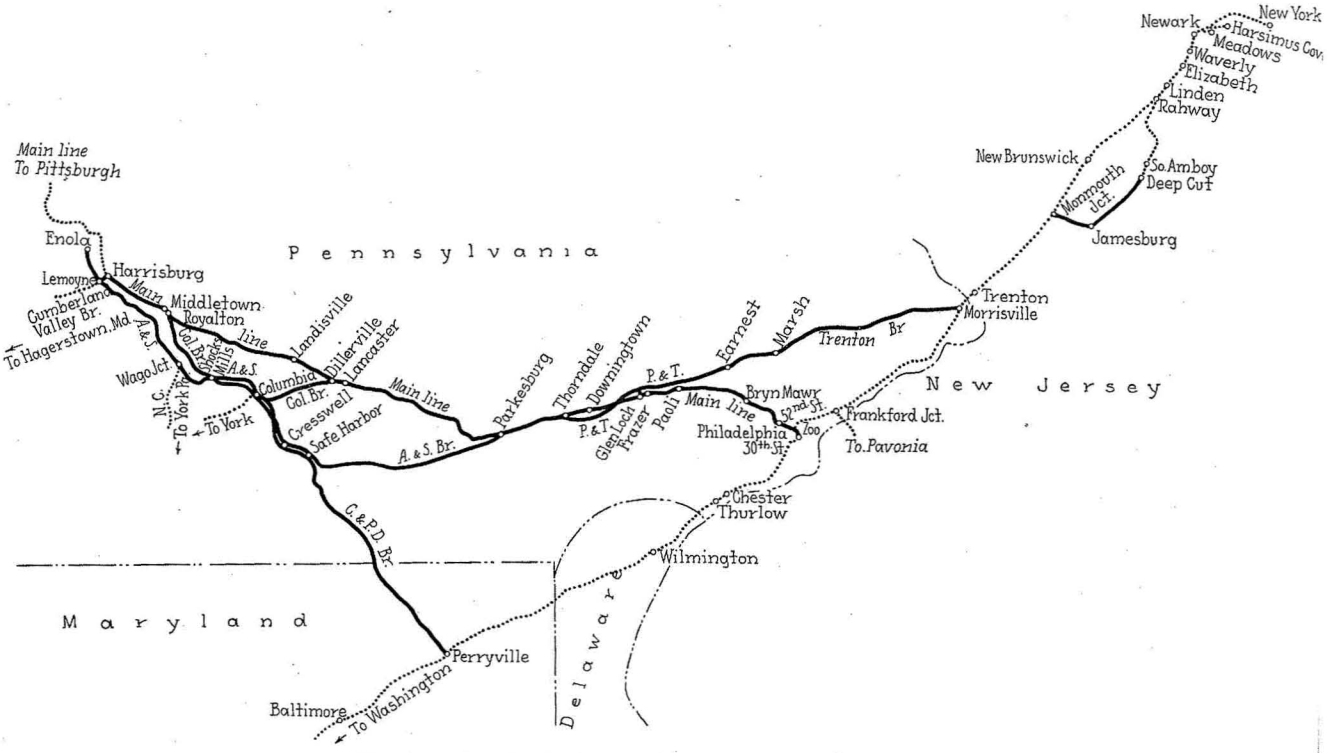
Former Signaling and Operation

Prior to the electrification, approximately 90 per cent of the signals were of the position-light type, the remainder being Style T-2 semaphores. The main line from Paoli to Dillerville and Royalton to Harrisburg was equipped with 60 cycle, polarized a.-c. track circuits, with Model 15 or TV-30 track relays, and Dillerville to Royalton with d.-c. track circuits. The major portion of the signaling system was two-block territory, with some three-block territory. The Columbia branch was signaled and operated under manual-block rules. The A. & S., Trenton and P. & T. branches were completely signaled with d.-c. track circuits, with storage cells on a.-c. floating charge from a 440-volt, 60-cycle line; and the C. & P. D. branch was operated under manual-block rules, with the exception of a short section of automatic signals on a small double-track portion in the middle. Operation of the greater portion of the C. & P. D. branch is to remain as it was formerly.

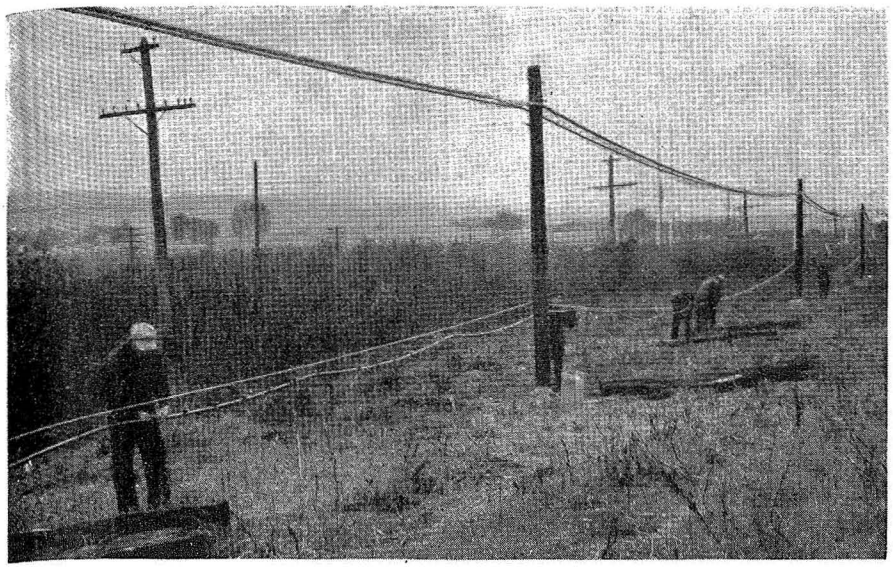
The New Signaling

The engineering and design work was started in December, 1936, while the field work was initiated in March, 1937. The signal construction work on various sections, of course, is scheduled for completion as co-incident as possible with the completion of electrification construction. All of the work is being pushed rapidly to its final stages in order to realize the economies of electric operation.

Upon completion of the electrification, all signals will be of the position-light type. On the main line signals will be spaced at an average of two miles in automatic territory. With very few exceptions, all signals are being shifted to give longer blocks and higher speeds. In the two-track territory from Columbia to Shocks Mills on the low-grade freight li



Territory involved—Heavy lines indicate present program



Strapping the signal cable to the messenger

the normally westward track is to be signaled for operation in both directions. Universal code track circuits for wayside and cab signals are provided on the main line from Paoli to Harrisburg, and on the low-grade freight line from Morrisville to Enola Yard. With universal code, the track circuits are coded continuously, the track circuit current on the Pennsylvania being 100-cycle current interrupted to give a code frequency of 180 per minute to control a "Clear" aspect, interrupted 75 times per minute to control an "Approach" aspect, and, where necessary, interrupted 120 times per minute to control the "Approach-restricting" aspect. Both the aspects of the wayside signals and those of the cab signals are controlled by the various frequency interruptions of the 100-cycle track circuit current. For this reason, line wires are eliminated, except in special cases such as near interlockings for lock and approach circuits, and at highway crossings.

Extensive revisions are being made at 24 interlockings and 2 new C.T.C. installations are being made. As in previous electrifications, a new 100-cycle signal power line, supported on the catenary poles is being installed, together with necessary motor-generator sets, transformers, and sectionalizing switches.

Signals

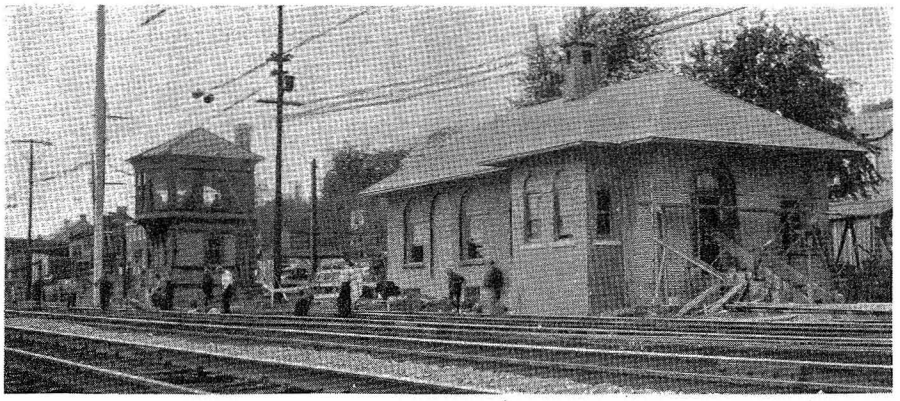
Prior to the electrification, almost twice as many position-light signals were in service as were called for in the final plans. For this reason, the position-light signals at approximately every other location in a particular territory are being removed, sent to the Wilmington shops for reconditioning, and installed at the final locations. The two-mile spacing on the main line was divided up into cut-sections, the length of the track circuits being determined by ballast conditions and other limitations imposed by the cross-bonding and structure grounding necessitated by the propulsion current system.

Field forces were provided with straight-line plans showing the signal, cut-section, and transformer catenary pole locations. Typical wiring circuits were supplied for use at straight automatic locations. At interlocking distant signals and signals in the limits of highway crossing protection controls, individual plans applicable only to each respective location, were designed. Signals are in general installed on catenary poles and beam-type signal bridges, which also serve as catenary and transmission line supports.

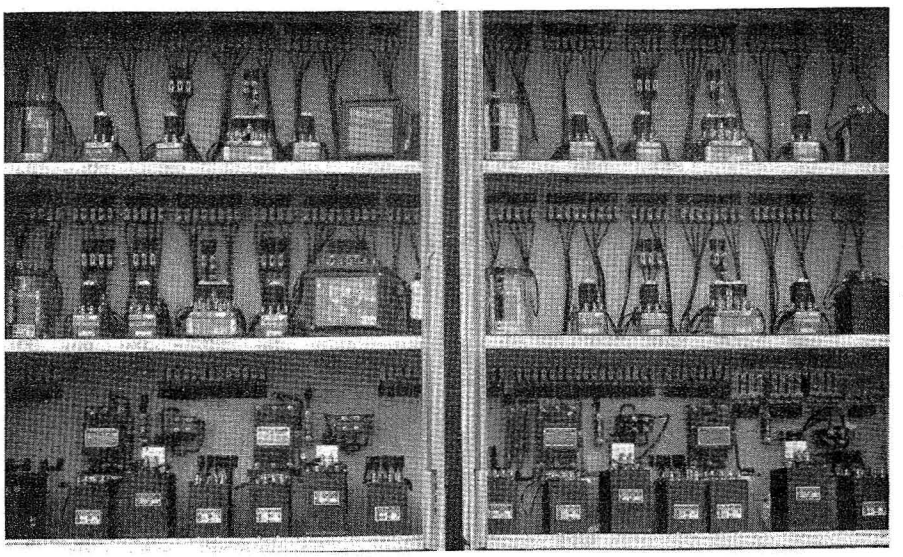
Track Circuit Requirements

It was stated above that the number of cut-sections in a two-mile block depended on the length of circuit which could be operated satisfactorily under the existing ballast leakage conditions and other limitations. The requirements met in an installation of this kind are that cross-bonding be installed at sufficiently close intervals adequately to take care of the propulsion return current. The wide spacing of cross-bonds is limited by the amount of propulsion return current to be taken care of, while the close spacing is limited by the length of track circuits employed between two successive cross-bonds. The length of track as a rule is limited by the ballast leakage except in special cases where traction return current requires exceptionally close cross-bonding in which case the track circuit length is limited by the close spacing of cross-bonds. The maximum length of track circuit where cinder ballast is used is approximately 5,000 ft. With stone ballast, the maximum length of track circuit is approximately 6,000 ft.

A total of 24 interlocking layouts are being revised, and 2 new C.T.C. installations are being made. Of the 24 interlockings, 2 at Harrisburg and 1 at Lancaster were comparatively large jobs. At the east end of Harrisburg station a new interlocking station, "State," was built containing a new 127 lever electro-pneumatic interlocking machine. This interlocking station takes the place of three separate plants; "V," a 23-lever, 25-cycle, electric plant; "DO," a 24-lever, mechanical plant; and "FH," a small, hand-operated layout. At the west end of the station at Harrisburg, "Harris" interlocking was revised to take care of necessary track changes. Traffic locking is provided for the tracks between "Harris" and "State." Extensive track changes were also made at Lancaster, involving a 69-lever machine. Connestoga and Dillerville formerly were remotely controlled from Lancaster. In the new layout, Connestoga, Dillerville, and Lancaster are all operated as one interlocking. At Parkesburg, a new brick interlocking station was built east of the old location, housing a 36 lever "EP" machine. A 44-lever



New brick tower under construction at Parkesburg



Interior of a typical large sheet-steel instrument case

mechanical plant at Coatesville was abandoned. All building work was done by the contractors.

An illuminated model board, constructed of sheet metal, is provided at each interlocking. The track diagrams are painted on the face of the model boards, and lights are provided to indicate signals displayed, track circuit occupancy, and trolley de-energization. The latter lights are controlled by the switches operating the catenary sectionalizing switches. Revisions in the locking at the various interlockings, in accordance with changed track layouts, are being handled by special "locking" men. Sometimes several steps were involved in arriving at the final track layout, so that several locking changes were necessary at these locations.

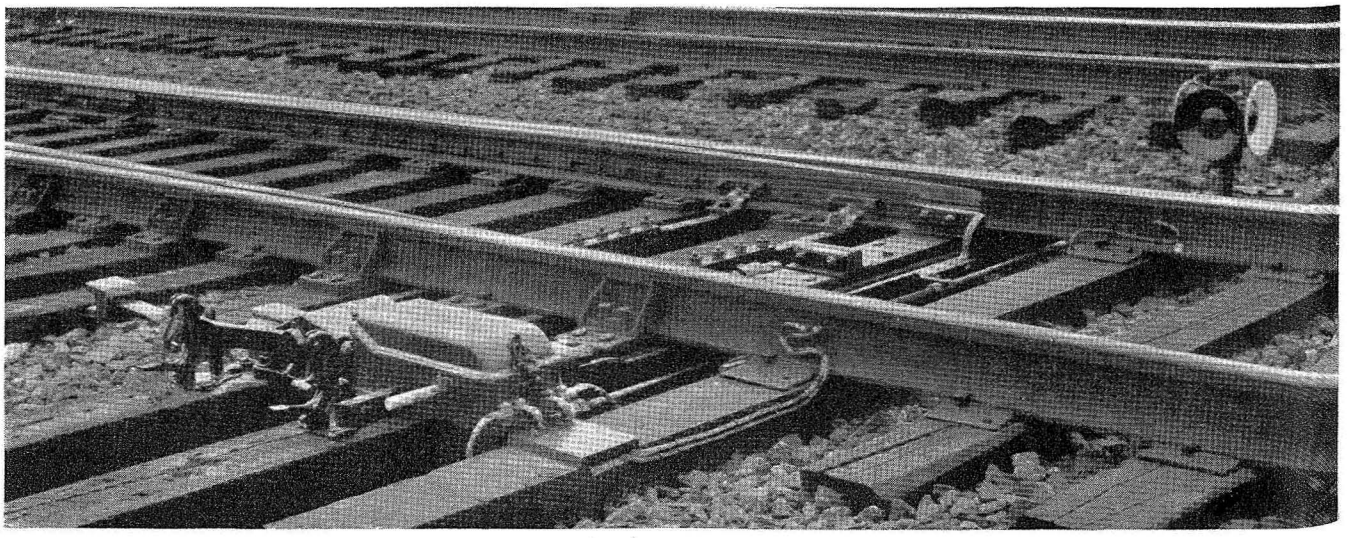
At new switch installations in interlockings in high-speed territory A-5 switch machines with point-detectors are provided. The size of rail varies from 130 to 152-lb., with the major portion either 131 or 152-lb. Most of the new switches have 152-lb. rail, with 45-ft. switch points. Style CP valves are used in all cases. Small duplicate 3¼-cu. ft. per unit capacity, air compressors are being provided for small electro-pneumatic plants. Normal operating pressure is 70 lb. per sq. in., the first compressor cutting in at 65 lb., and the second at a point determined by the load.

Dragging equipment detectors are used approaching interlockings, protecting each track in the normal running direction. In two-block territory the detectors are placed the length of the longest train, plus approximately 1,500 ft. from the distant signal. In three-block territory the detectors are located braking distance from the home signal, plus approximately 7,300 ft.

While continuously-coded track circuits, controlling both wayside and cab signals, are used in automatic territory, the cab-indication code is super-imposed on the track circuits in interlockings, initiated by track occupancy. Coding initiated by track occupancy, rather than continuously-coded interlocking track circuits, is used as a safety feature to prevent a proceed aspect of any nature being given in the cab of an engine if the home signal is passed in the stop position. The code control relays used to initiate action of the coders are controlled over the interlocking track sections and over the proper signal control relays. The two C.T.C. projects are located at Thorndale and Columbia. Both installations are two-wire, time-code systems, except for the switches and signals in the immediate vicinity of the control machines, which are direct-wire operated.

Power Supply

The railroad distribution line is 132,000-volts, 25-cycle, single-phase, while the propulsion current is 11,000-volt, 25-cycle, single-phase. The signal power line is 6,600-volts, 100-cycle, and consists of two No. 0 wires on crossarms attached to the catenary columns. Power from the 11,000-volt bus is transformed down at various locations to 2,200 volts, 25 cycle, and operates the motor of a motor-generator set, generating power at 440 volts, 100 cycle. The output of the generator is then stepped up and transmitted at 6,600 volts, 100 cycle. Motor-generator sets to supply power to the territory involved are located at South Amboy, Morrisville, Earnest, Frazer, Parkesburg, Landisville, Harrisburg, Enola, Perryville, Safe Harbor, and Bryn Mawr. Two motor-generator sets were required at Harrisburg because of the exceptionally heavy load in the Harrisburg terminal. In case of trouble on the line, automatic switching, located at points approximately 10 miles apart, cuts out the troubled section. The 6,600-volt line was erected by the contractors,



Completed installation of T-10 switch movement

including the pole attachments and transformer platforms. The transformers and sectionalizing switches and 440-volt Harrisburg terminal line were installed by the signal department forces. Various size transformers, of the oil-cooled type, were used, ranging from ¾ k.v. to 7½ k.v.

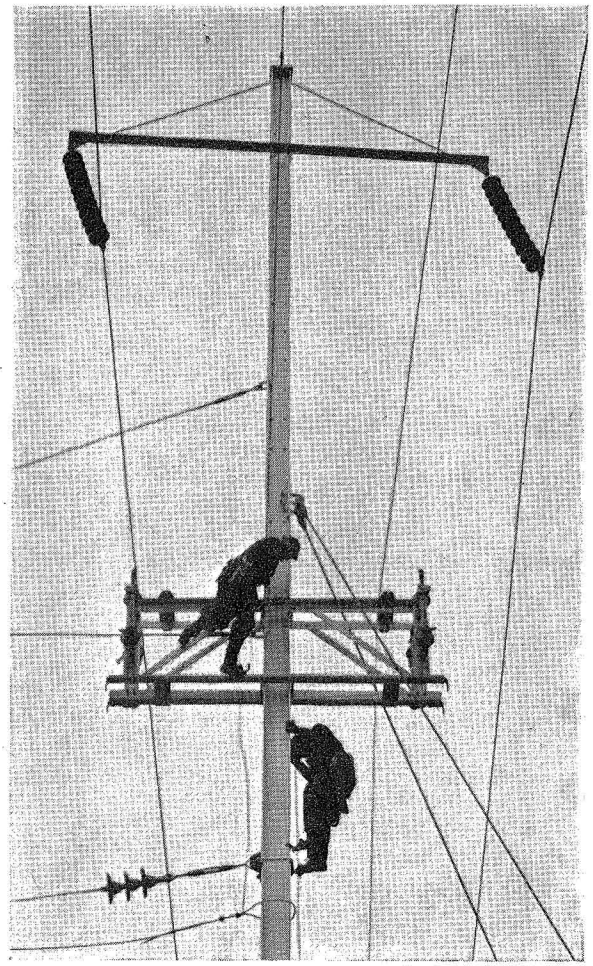
The instrument cases are of the sheet-steel type, and are of four sizes, 9 ft. 11 in., 4 ft. 8 in., 3 ft. 6 in., and 28 in. by 15 in. The cases are mounted on concrete foundations, poured by the contractors' concrete trains. The forms are placed by the signal department forces, removed, and used over again. The cases have asbestos backboards and bakelite group terminals. The relays are shelf-mounted on rubber matting, without shock absorbers. Cables are brought into the cases through fibre ducts into a wireway in the rear. Platforms are provided both in the front and in the rear of the cases. The cases are wired at the Wilmington shops. In addition to preparing the layouts and circuits diagrams, case wiring diagrams were prepared in the office of the engineer of telegraph and signals, and are used in wiring the case at the Wilmington shops. The instrument cases are sent from the Wilmington shops to the various headquarters by carload lots and then unloaded at the final location by work train derricks. The instruments are not placed in the cases until the cases are on the foundations.

Cable and Wiring

Although a total of approximately 12,000 poles were set to provide a new pole line on all lines except on a portion of the C. & P. D., where the pole line was taken care of during the Wilmington-Washington electrification, the use of universal code track circuits required that aerial signal cable be used only in the vicinity of interlockings to take care of circuits associated with the interlocking such as approach and back-lock circuits, and at highway crossing installations. At such locations the aerial braid signal cable was run on the same pole line with the telephone and telegraph cables, and the neutralizing wire, being supported by woven, impregnated straps attached to a ⅜-in. messenger, which is attached to the pole with through-bolt messenger suspension clamps. In the body of the pole line, the cable is at a height of approximately 20 ft. The aerial signal cable consists of various numbers of No. 14 conductors, varying from 5- to 37-conductor, as required. The poles were distributed in groups according to areas, and the hardware attached while the poles were on the ground. A great majority of the holes were dug and the poles set by boring machines equipped with a boom. Where the machine could not get in, the holes were dug and the poles set by hand. With four men on the machine, including a chauffeur, an operator and two helpers, as many as 60 holes were dug and 60 poles set in a day. The boring machines were also used for drilling the guy holes. The greater portion of the signal cable was pulled in by tractor, the messenger wire first being attached to the pole about 3 ft. from the ground. After the cable was lined out on the ground, the straps were attached and the cable raised to the messenger, the messenger subsequently being raised to the proper height on the poles. The aerial line circuits are protected by lightning arresters with separate driven grounds.

The underground runs are in parkway cable with No. 14 conductors for signal and switch circuits and No. 6 conductors for track leads. This cable varied from single-conductor to as high as 91-conductor cable at interlockings. Most of the short runs of parkway were placed in a trench 30 in. deep. For long runs, a ditch digger was used to dig the trenches. Where a great many parkway wires were needed, two cables of smaller size were used. This allowed the cable to be ordered in longer continuous lengths and eliminated splices in many cases. The drops from the transformers to the cases are composed of twin No. 6 parkway. Leads from the signal cases to the signals on the bridges are in parkway, run underground from the case to the bridge, where it is placed in the web of the upright. No. 16 flexible wire was used for relay leads. These leads were purchased with the eyelets attached.

The signal department forces placed the impedance bonds in the track circuits, the contractors applying the regular power rail bonds. These bonds have ⅜-in. pin terminals, and have two 17-strand cables, the inner 7 wires being of copper, and the outer layer being composed of 3 copper and 7 steel wires. The impedance bonds were distributed by work train. Two No. 0 leads, with pin type terminals, extend from each impedance bond lug to the rail. The track leads for track circuits consist of a 4-conductor, No. 6 parkway cable from the instrument case to a junction box. Here the rail leads fan out, three single-conductor, non-metallic parkway cables going to bootleg outlets for three rail connections and the other connection being made at the junction box.



The transformers and sectionalizing switches on the 6600-volt line were installed by the signal department forces