Maintainer W. C. McDaniel making an inspection of the circuit controllers in power switch machine. Right — Signal construction crew cutting in new position-light signals on the Bristol Line C.T.C.

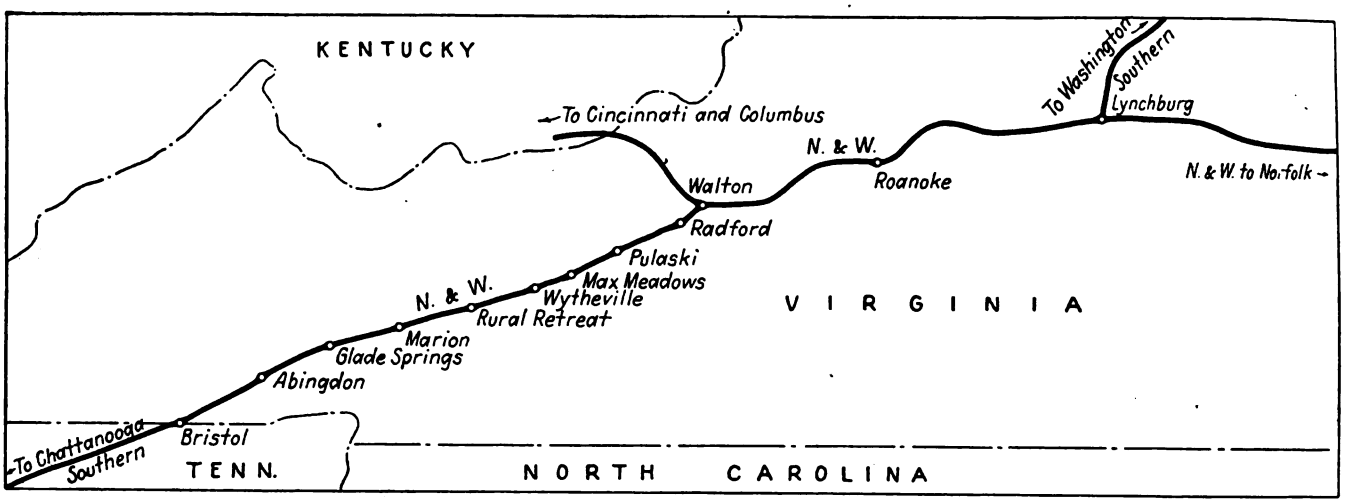
107 Miles of C.T.C. on the N. & W.

Saves train time and increases capacity of busy single-track line handling 10 passenger trains and 14 freight trains daily

As a means of facilitating train movements and securing maximum operating capacity of an existing single-track line, the Norfolk and Western has installed centralized traffic control on 1.2 mi. of double track and 106.7 mi. of single track between Radford, Va., and Bristol, Va. On this territory, known locally as the Bristol line, train movements were formerly authorized by timetable and train orders, automatic signaling being provided as protection, and the siding switches were operated by hand-throw stands. With the C.T.C., the siding switches are operated by power machines, and signals at the sidings, under the control of the dispatcher, display aspects to authorize train movements.

An Old Line Not Readily Changed

This line between Radford and Bristol is a portion of a very old railroad known as the Virginia & Tennessee, built between 1854 and 1856. From Radford the railroad extends in a southwest direction through valleys between the Appalachian and the Cumberland mountain ranges. Although there are no long, steep grades, there are numerous short, rolling grades, as well as some grades ranging up to 1.4 per cent extending for about three miles in certain locations. The curves are numerous with many ranging up to 4 and 5 deg. and several up to 7 deg. Even so, the engineers who located the original line did commendable work, and present-day reconstruction of the line to reduce grades and curvature through this territory would involve expenditures beyond that which could be justified economically. Therefore, as the traffic gradually increased on the Bristol line, the policy followed by the Norfolk and Western has been to leave the line and grade practically in the location originally constructed, but to apply all modern improvements to facilitate train movements and increase the track capacity.



Map showing the general location of the C.T.C. territory between Radford and Bristol

The track is constructed and maintained to withstand heavy traffic at maximum train speeds permitted by the curvature. All trains are operated by steam locomotives which are designed not only to take the curves at safe speeds, but also they have the power to take the trains around the curves, up the grades and down the grades at a uniformly constant speed.

Heavy Traffic Moved

The broad valleys through which this Bristol line extends include prosperous farming communities, and numerous large industries are located at Radford, Pulaski, Marion, Abingdon and Bristol. Thus the territory is thickly populated to require local passenger-train service, as well as local freight service. A map of the Norfolk and Western shows how this Bristol line and other portions of the N. & W. form a part of a route, in cooperation with the Southern Railway and other railroads, between eastern cities and Knoxville, Chattanooga, Memphis, Birmingham and New Orleans. A local passenger train, a mail and express train and three through passenger trains are operated each way daily. A local freight is operated each way daily except Sunday. Several time freights are operated as required. On the average, there are 10 passenger trains and about 14 freight trains daily over this territory, plus some intermediate shifting and shuttle service. Except for the local passenger and local freight trains, all the trains are operated in connection with other railroads in through schedule service, and, therefore, trains must be run on time.

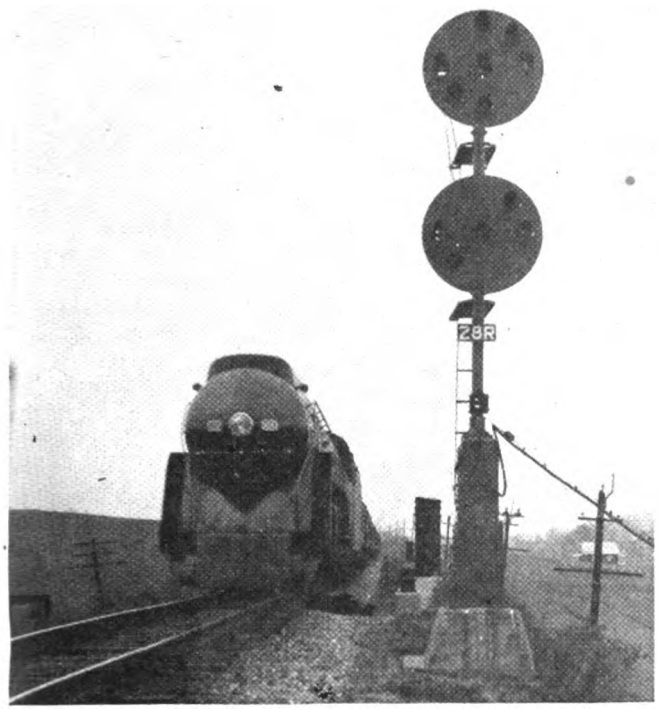
In consideration of the fact that the grades and curvature could not be improved readily to permit faster train speeds, the Norfolk and Western decided to install complete centralized traffic control, as the best means of handling approximately 24 trains daily and maintaining uniformly fast schedules.

Station	Car Capacity of Siding
Radford	Yard
2.9 mi.	
Melborn	141
3.2 mi.	
Wysor	130
1.4 mi.	
Wurno	85
2.4 mi.	
Pulaski	81
2.4 mi.	
Granite	80
2.7 mi.	
Clark	137
5.6 mi.	
Max Meadows	103
3.5 mi.	
Kent	73
2.7 mi.	
Wytheville	123
4.3 mi.	
Grubb	68
2.1 mi.	
Crockett	131
3.1 mi.	
Rural Retreat	137
2.5 mi.	
Grosclose	48
3.7 mi.	
Atkins	134
4.2 mi.	
Marion	126
5.0 mi.	
McMullin	72
2.4 mi.	
Seven Mile Ford	126
1.9 mi.	
Chilhowie	68
4.4 mi.	
Glade Spring	114
3.0 mi.	
Meadow View	135
3.6 mi.	
Hayter	129
2.8 mi.	
Abingdon	51
4.6 mi.	
Wyndale	132
6.5 mi.	
Bristol	Yard

Two Sidings Retired and Thirteen Were Lengthened

Not counting yard territories at Radford, Pulaski and Bristol, there were previously 25 sidings which were used regularly for meeting and passing trains. Within recent years, ten of these sidings had been lengthened to capacities ranging from 103 cars to 132 cars. As part of the 1946 program, 4 more, at Clark, Rural Retreat, Atkins and Meadow View, were lengthened to hold 134 to 137 cars. These 14 long sidings as well as 8 sidings, with capacities ranging from 48 to 85 cars, were equipped with power switches and controlled signals in the C.T.C. system. Thus with 22 sidings equipped with C.T.C., this left 3 of the previous sidings. One of these, at Emory between Meadow View and Glade Spring, was removed except for one switch leading to a spur. The 38-car siding at Wallace was left with hand-throw stands for use as a house track. A second of two sidings at Glade Spring was left with hand-throw stands. The locations and car capacities of the 22 C.T.C. equipped sidings, as well as distances between the last switch of one siding and the first switch of the next, are indicated in a table herewith.

As may be noted, the distances between sidings are not uniform, this being a result of the fact that certain sidings were lengthened where practicable from the standpoint of minimum expense for cuts and fills. On the other hand, by applying power switches and signals to nearly all the sidings, 14 long ones as well as 8 shorter ones, the dispatcher has a very flexible range for making meets and passes on close timing. A more extensive program of rearranging sidings, to reduce the number and to



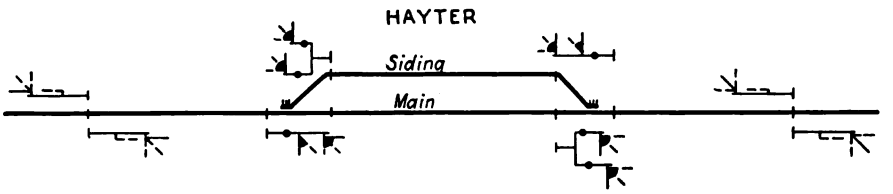
Passenger train near the west end of the siding at Hayter, with signal 28R at right

locate them on an exact time-distance train operation basis, would have been much more expensive than the policy adopted to equip all but three of the original 25 sidings.

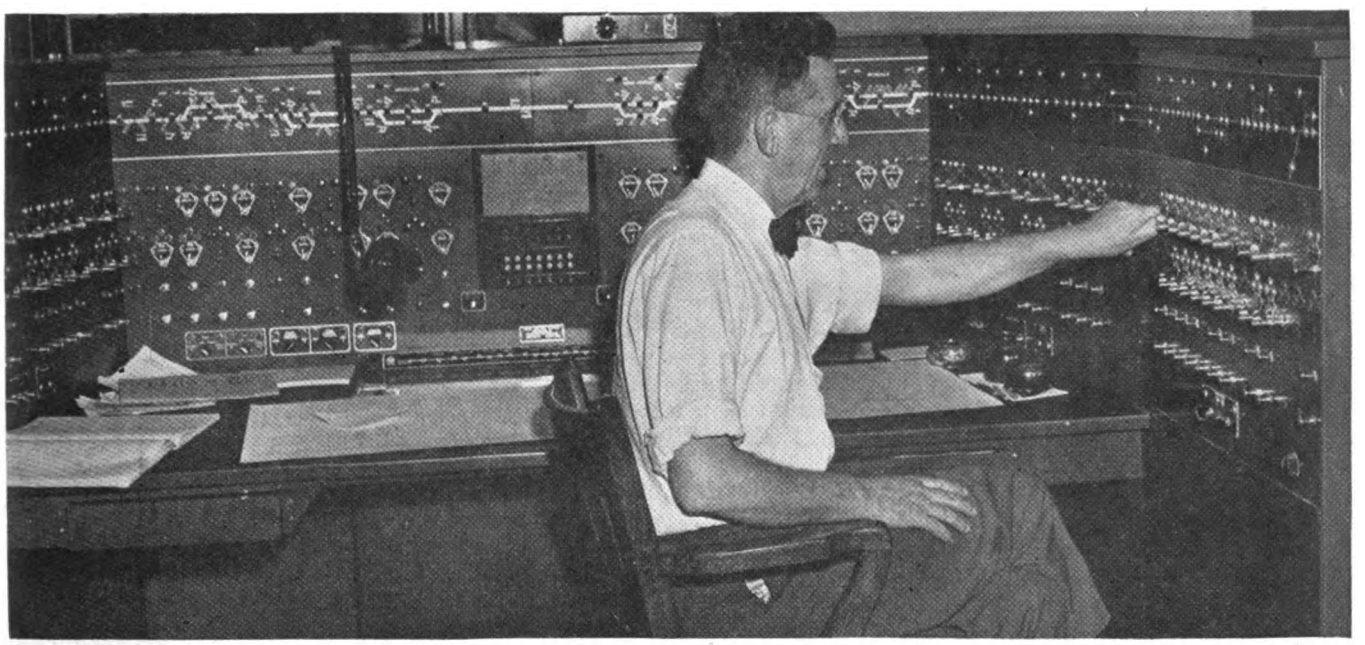
On account of adverse grade conditions, ordinarily the through freight trains do not consist of more than 70 cars, but the extra siding capacity was provided, wherever possible, for several reasons. One reason is to allow track length so that a train can enter a siding at the speed for which the turnout is designed, and, after the rear end is in the clear, still have track length to stop from that speed. Long sidings are also a benefit in permitting trains to meet without either train being required to stop. At nearly all of the power-equipped sidings, the old shorter turnouts were replaced with new No. 15 turnouts which are good for train speeds up to 30 m.p.h. when entering or leaving a siding.

Previously this territory was equipped with automatic block signaling including semaphore signals. As a part of the changeover, these semaphores were removed, all the signals in the new C.T.C. system being of the position-light type. An item of interest is that the Norfolk and Western does not use dwarf signals in C.T.C. territories. At the end of a siding, the main-track station-leaving signal and the leave-siding signals are both mounted on the platform of a bracket mast, located to the right of the siding as shown in a picture herewith. These signals are the same type and size, the only difference is that the leave-siding signal is mounted 6 ft. lower than the main-track signal.

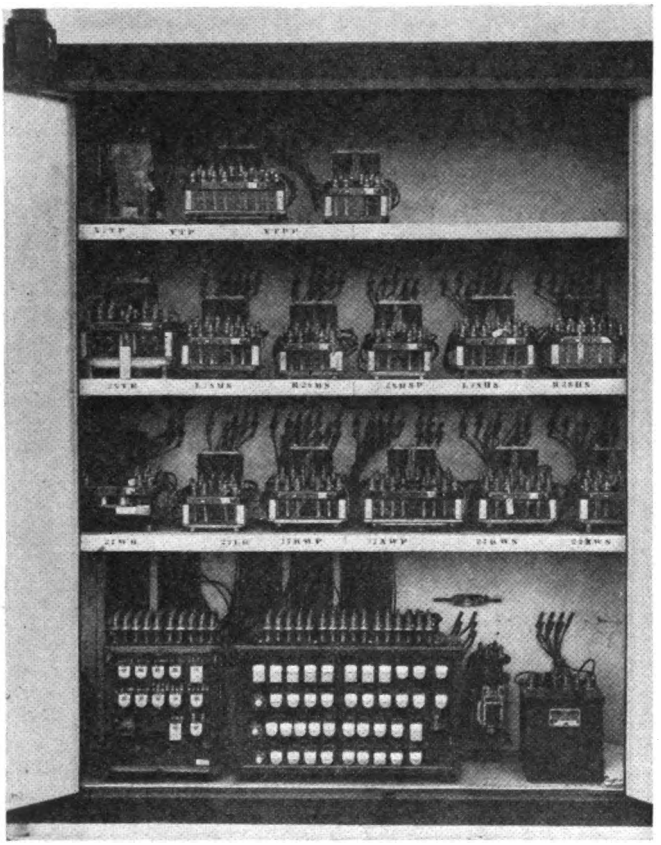
Each siding is equipped with track circuits which enter into the control of the signals and also serve to control lamps on the control machine to indicate occupancy of the sidings. The controls are arranged so that the signal for entering a siding cannot be cleared if the siding is occupied. Thus if such a signal displays a Medium-Clear aspect, the engineman has confidence to pull into the siding at the speed for which the turnout is designed, i.e., 30 m.p.h. for a No. 15 turnout. In order to direct trains to approach at this speed when entering a siding, a second operative signal head was installed on each signal in approach to a power switch in the fac-



Track and signal plan of Hayter, which is a typical layout



Train Dispatcher L. A. Dunham operating the machine in Roanoke which controls the 107 mi. of C.T.C. between Radford and Bristol



At field station the relays and the line coding equipment are in sheet-metal cases

switching moves in the yard limits at Radford, Pulaski and Bristol, the switches and signals in the limits of these yards are controlled by separate small machines in the yard offices at these respective towns. The switches and signals outside these three yard limits, on the entire territory between Radford and Bristol, are controlled by one machine in the division dispatcher's office at Roanoke, Va., which is 43 mi. east of Radford. This machine is made up of one 5-ft. center panel and two 2.5-ft. wing panels at each end, thus totaling 15 ft.

The C.T.C. code line circuit between Roanoke and the far end of the C.T.C. territory at Bristol, 151 mi., is on two No. 8 Copperweld line wires with Formex covering which gives weatherproof protection as well as electrical insulation. On account of the insulation being so thin it does not increase the diameter of the wire materially, therefore, the weight of frozen sleet on a wire will be less than on a wire with thick braided covering.

By means of carrier current equipment the controls and return of indications are handled as three separate ter-

ing direction. Such a distant signal displays the Approach-Medium aspect when the entering signal displays the Medium-Clear aspect.

On intermediate automatic signals located on ascending grades of more than 0.95 per cent, the most restrictive aspect is a horizontal row of lights in the top unit and a row of lights at 45 deg. in the lower right-hand quadrant. This is a grade signal aspect which authorizes trains to pass this signal without stopping, and proceed at restricted speed, prepared to stop short of train or obstruction.

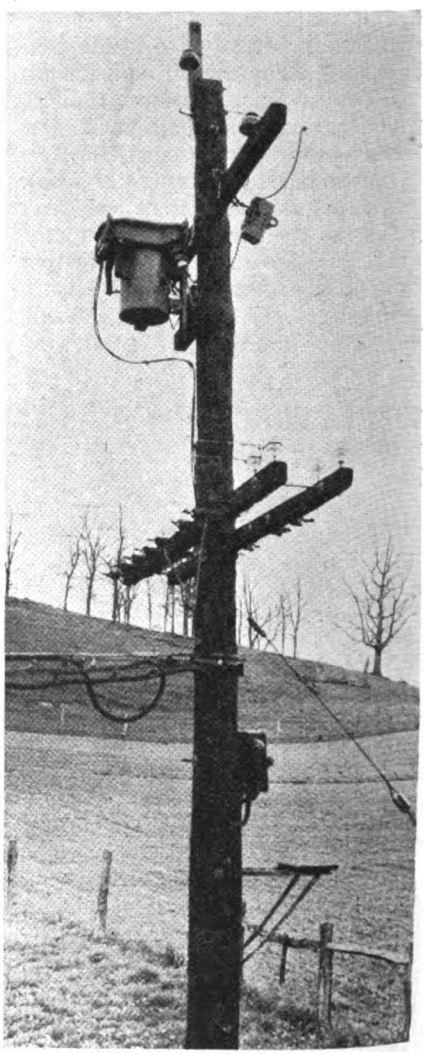
The switch at the west end of the short siding west of Glade Spring is not equipped with a power machine because ordinarily this siding will not be needed for use by through trains. In some instances it may be desirable to stop eastbound trains, such as the local freight, to direct them to enter this siding. For this reason a "Take-Siding" indicator was installed on eastward signal No. 38R located just west of this switch. This indicator consists of a large lamp body with a ground-glass cover glass 10 in. in diameter. Normally this lamp is dark. When a train is to stop and enter this hand-throw siding switch, the dispatcher sends out a control which causes the lamp to be lighted, thereby displaying the letter "S". At the same time the horizontal row of lamps is lighted in the position-light signal head above, and the signal next in approach displays the Approach aspect.

Each of the power switches is operated by a Type A-21 dual-control electro-pneumatic switch machine. When the selector lever is operated, the air supply to the machine is cut off, the valve control circuits are opened, and a code is sent to the control office. Duplicate air compressors, each rated at 3.5 cu. ft. per min., are located at each siding switch to furnish pressure to operate the switch machine. Each compressor is driven by a 220-volt a.c. motor, rated at ¾ h.p. The compressors are controlled automatically; one being set to cut in at 55 lb. and cut out at 70 lb., while the other one cuts in at 45 lb. and out at 60 lb.

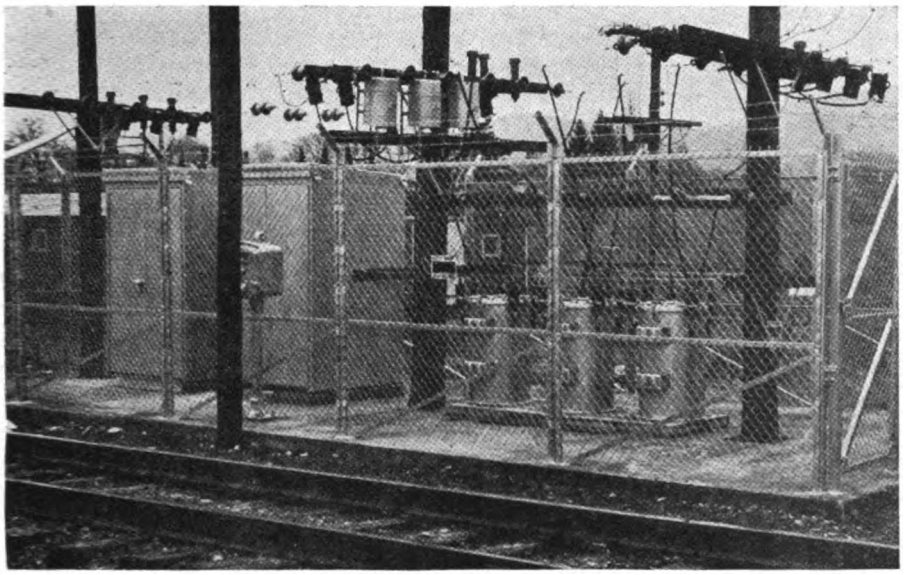
Insulated gage plates 1 in. by 8 in. are used under the first two ties under each switch, and these plates extend and are attached to the switch machine, thereby preventing lost motion. Morden adjustable rail braces are used on a minimum of four ties.

At various locations, house tracks and spurs are connected to the main track with hand-throw stands. At these locations the previous stands were replaced with T-21 hand-throw switch-and-lock movements including an SL21 electric lock which locks the hand-throw lever in the normal position. At each of these locations a Hayes derail, located at the clearance point on the turnout, is pipe-connected to and operated by the T-21 stand. A telephone for communication with the dispatcher is located near each of these hand-throw switches.

In order to arrange for numerous



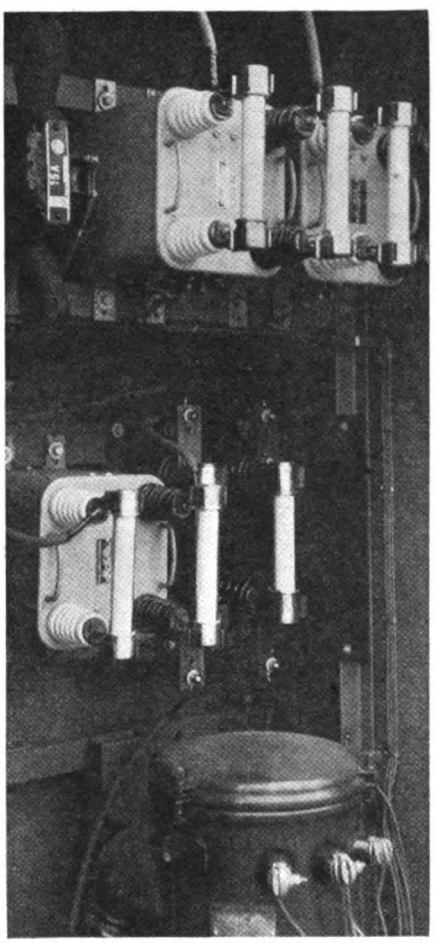
High tension transformer location



Automatic substation at Wytheville

ritories: (1) west end of Radford to Wytheville excluding Pulaski yard limits; (2) Wytheville to Marion; and (3) Marion to east end of Bristol yard limits. All carrier apparatus is in duplicate, both in the Roanoke office and at the respective field locations. If the equipment normally in service fails, the dispatcher can send controls to cut in the spare apparatus. At Radford, there are repeaters for the carrier. These repeaters are normally not in service, being held out by a 16-volt d.c. energy on the line controlled from the dispatcher's machine. If damp weather or other circumstances cause line losses, the dispatcher can cut off the 16-volt d.c. energy, and thereby cut in the repeaters. Also, of course, if a break occurs in the C.T.C. code line between Roanoke and Radford, the d.c. would be cut off, and thereby cut in the repeaters as an aid in overcoming losses due to the line break.

In addition to the C.T.C. codes, this two-wire circuit between Roanoke and Bristol also handles telephone communication at voice frequency by means of which the maintainers, using portable sets, can communicate with the dispatcher. Also these telephones are helpful for use between two locations in the field when chasing trouble or making tests.



Rear view of automatic substation control unit

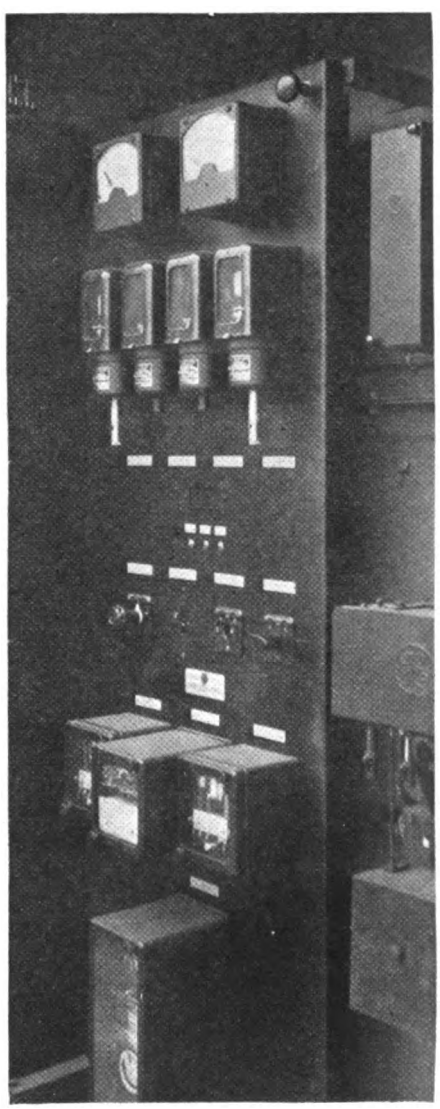
Track Circuits and Local Signal Controls

The previous automatic block signaling was straight a.c., including a.c. track circuits with Model 15 vane relays. These a.c. track circuits were retained. As a means of preventing lightning damage to the condensers in these track relays, Thyrite arresters are connected across the track connections. The 110-volt a.c. local signal control circuits in the former signaling were included in the C.T.C.

When installing the C.T.C., the Approach-Medium aspect was added on all the intermediate signals in approach to sidings. By using a.c. or d.c. from a rectifier, in combination with a 4 M.F. capacitor, the control of the Approach-Medium aspect and the track-occupancy indication are handled over one wire and common.

The 4,400-volt, three-phase, 60-cycle power line, previously in service, was continued in use. New surge-proof line transformers, 4,400/120 volt, rated at 3 kv.a., were installed at each end of the siding, and ¼ kv.a. at intermediate signals. In order to insure continuity of the a.c. supply to the C.T.C. system, new connections were made with additional sources of commercial power supply, and automatic substations, to switch to another feed if one fails, were installed at Radford, Wytheville, Marion and Bristol. The only batteries on this installation are those used to feed the line coding equipment. For this purpose a set of 8 cells of 40-a.h. storage battery is used at each field station. Additional batteries are required at the carrier locations.

The pole line was rebuilt as required, using 30-ft. Class 3 creosoted pine poles spaced 130 ft. The 4,400-volt circuit is on No. 4 bare copper wire. The ground wire, which is on the top bracket, is three strands of No. 10 Copperweld. The line control



Automatic substation control panel

circuits previously in service are on No. 10 Copperweld with braided covering. The new line control circuits are on No. 10 Copperweld.

As a means for reducing losses to the carrier circuit, the cable drops for the C.T.C. code line circuit are in No. 14 wire which has a new type of insulation known as Polyethylene.

Slide-Detector Fences

At locations in this C.T.C. territory where the track is close to rock bluffs, the Norfolk and Western has installed detector fences, as shown in the accompanying pictures. The posts are old rails, set in the ground, and extending as high as may seem necessary, depending on local conditions. Ordinary hog wire fencing extends from each end of the fence to a location near the center, the ends of the fencing being tied around sections of 1½-in. pipe. At the intermediate posts the wire is held loosely in loops. At the far ends, these pipes are held by adjustment bolts. At the center, the pipes are under tension by coil springs to hold the fence taut. From the pipe for each fence section a small wire cable extends to a trigger mechanism. At the center location there is a circuit controller, normally held in the closed position by a trigger, which is tripped when a rock strikes any section of the fence. As shown in the picture, a special fence panel section is located at an angle on top the high posts under the overhanging bluff. This is to detect rocks which may fall from the bluff above.

When the controller operates, the circuits are opened to set the signals at their most restrictive aspects. When a train arrives and stops at the signal, a member of the crew walks to the slide location to determine the damage, and to telephone to the dispatcher. The maintainer must be called to restore the controller to its normal position.

Left—The circuit breaker on center post of the rock-slide fence shown in other picture

Right — Rock-slide fence at Kent includes an overhead panel and ordinary vertical sections

Benefits of the C.T.C.

The benefits accomplished by the centralized traffic control have been to increase the capacity of this single-track line and to expedite train movements by reducing delays on sidings. As a general rule, the through passenger trains were given preference before and, therefore, there was not much chance for improvement other than advancing meets in case opposing trains are late. With C.T.C., the greatest improvement is in the operation of freight trains, because the dispatcher can direct them by signals to keep moving for close meets rather than waiting on sidings. The dispatcher reports that approximately 50 per cent of the meets are so well timed that neither train stops.

With the C.T.C., the passenger train received late can make up time in the C.T.C. territory. On the average the through freights make the 108 mi. run either way between Radford and Bristol in about 3 hr., which is much better than previously, under timetables and train orders. The C.T.C. is especially beneficial when anything goes wrong. For example, under train orders, if a train pulled a drawbar in a section where there was no operator on duty for 20 mi. each way, the road would be tied up for hours before trains could be moved normally again. Now, with C.T.C., as soon as a crew telephones that they have a drawbar down, the dispatcher can hold the trains back as required. Then as soon as the drawbar is taken care of, all trains can be directed to get under way promptly.

This centralized traffic control was planned and installed by Norfolk and Western forces under the direction of J. A. Beoddy, superintendent of telegraph and signals, the major items of equipment being furnished by the Union Switch & Signal Company.