Burlington Installs

Centralized-Control

on Nine Miles of Double Track

Train operation by signal indication in either direction on both tracks—Two interlockings removed

The control machine at Rochelle

By W. F. Zane

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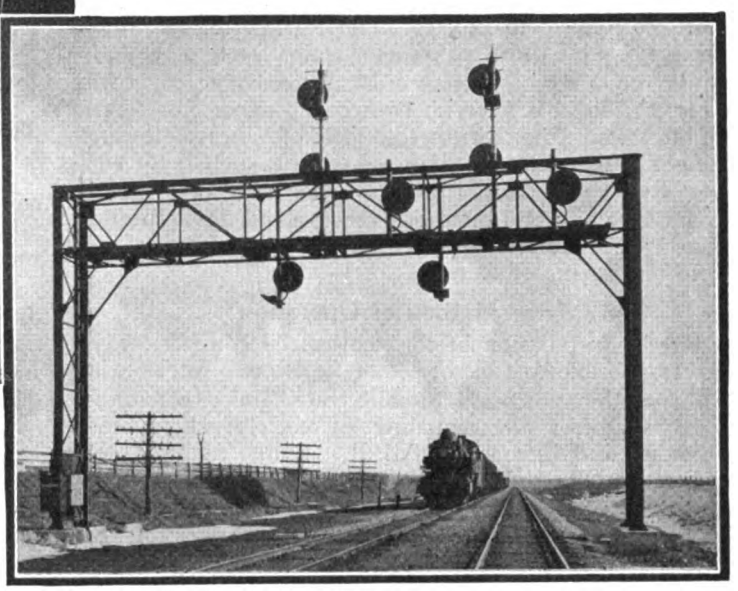
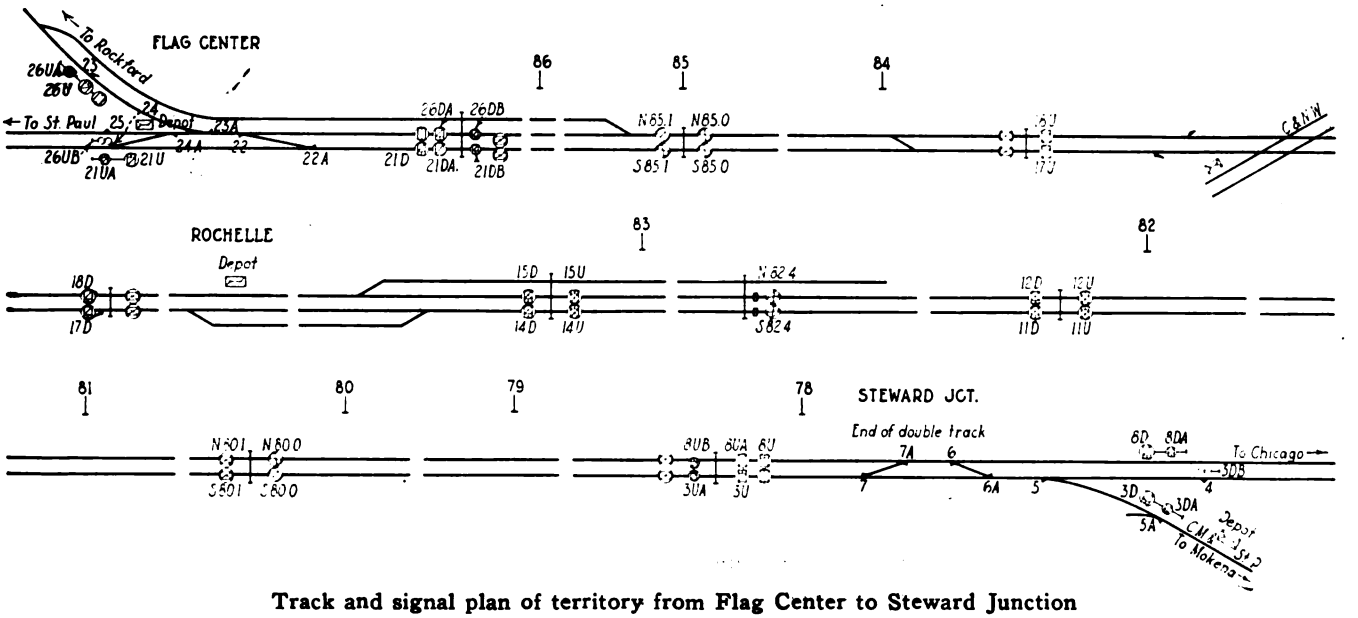


Train approaching home signal bridge at Flag Center

IN pursuance of a policy of increasing efficiency economically, and at the same time promoting safety of operation, the Chicago, Burlington & Quincy has installed a centralized-control system on a nine-mile section of double track between Flag Center, Ill., and Steward Junction, on its main line between Chicago and St. Paul, Minn. The control machine is located at Rochelle, Ill., three miles from Steward Junction, the west end of the territory.

Previous to the present installation, this territory was operated under a double-track automatic block system, employing semaphore signals of the lower-quadrant,



Track and signal plan of territory from Flag Center to Steward Junction

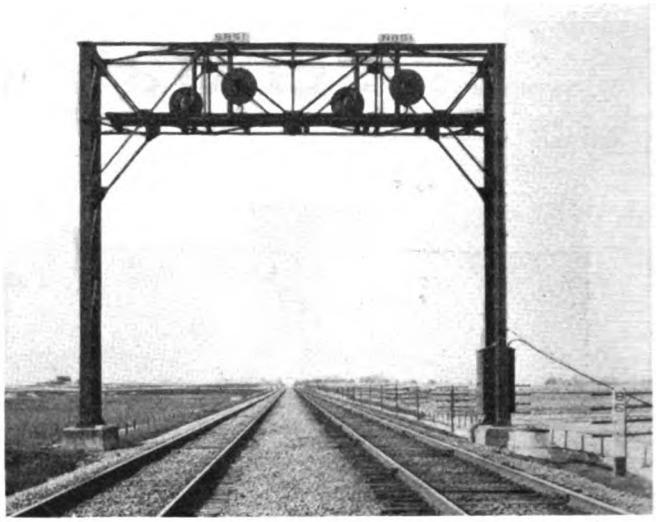
two-position type. At Steward Junction, a mechanical interlocking plant handled the end of double track as well as a junction with the Chicago, Milwaukee, St. Paul & Pacific, which plant required an operator for each trick. At Flag Center a similar plant with the same number of operators controlled the end of double track, and also handled the junction switches for the Burlington's branch to Rockford, Ill. The Milwaukee operates branch-line service over Burlington rails from Steward Junction to Flag Center, and thence over the Rockford line to Davis Junction where its own rails are reached.

Track construction is of 90 and 110-lb. rail with washed gravel ballast. The ruling grade is 0.49 per cent westbound and 0.42 per cent eastbound, with a maximum curvature of 2 deg., all curves being comparatively short.

The traffic includes 35 scheduled trains daily besides extra freight trains, the number of which fluctuates with the movement of coal. The Burlington operates 6 through and 5 local passenger trains each way daily, while the Milwaukee has a local passenger each way daily, the local service on both roads being gas-electric motor cars. The Burlington also operates 3 through freight trains and the Milwaukee one such train each way daily. Also the Burlington has one local freight each way daily and another every second day. In addition a considerable number of extra coal trains are operated during certain seasons.

New Method of Operation

By the installation of the centralized control system, it was possible to control remotely the two interlocking plants at the ends of the double track, and eliminate the six operators. The signaling of each track in each direction and the use of A.P.B. circuits, made it possible to handle trains on either track in parallel movement, thus relieving directional congestion as well as enabling a fast train to be run around a slower one and keep both moving. This complete flexibility of operation is obtained without the use of train orders, all train movements being made on signal indication only. The tangible economies accomplished by the new centralized control installation are shown in the accompanying tables which give a comparison between the old arrangement and the new.

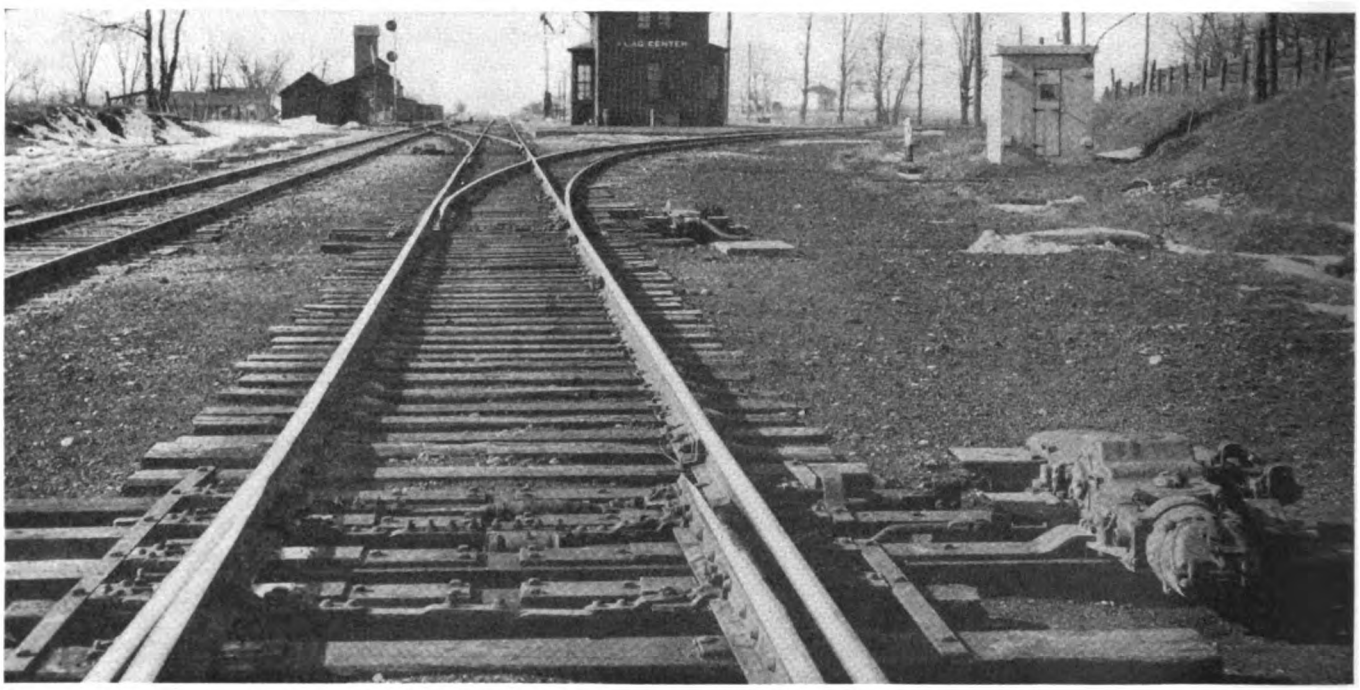


The intermediate automatic block signals are arranged for either-direction operation on both tracks

The cost of the project was $65,815, so that the saving derived represents a 12.7 per cent return on the investment. In addition, there is the intangible saving of increased ease of movement, which should be evident during periods of increased traffic.

Operation of the System

The central machine, located in the office at Rochelle, governs the starting signals out of Rochelle on all the main tracks, the signals on all main tracks protecting the station limits and the interlocking plants referred to. This machine has 6 switch, 2 derail, 10 signal levers and 10 spare spaces. The indication on the machine panel consists of a track diagram with complete track occu-



The power switch machines are equipped for dual-control

pancy and approach annunciator lights, normal and reverse derail and switch lights, directional arrow signal lights and a single-stroke bell to call attention to the approach of a train. Miniature mechanically-controlled switch points on the panel complete the field reproduction on the machine. A train graph, mounted on top of the machine, makes a graphic record of all train movements.

Comparative Statements of Costs

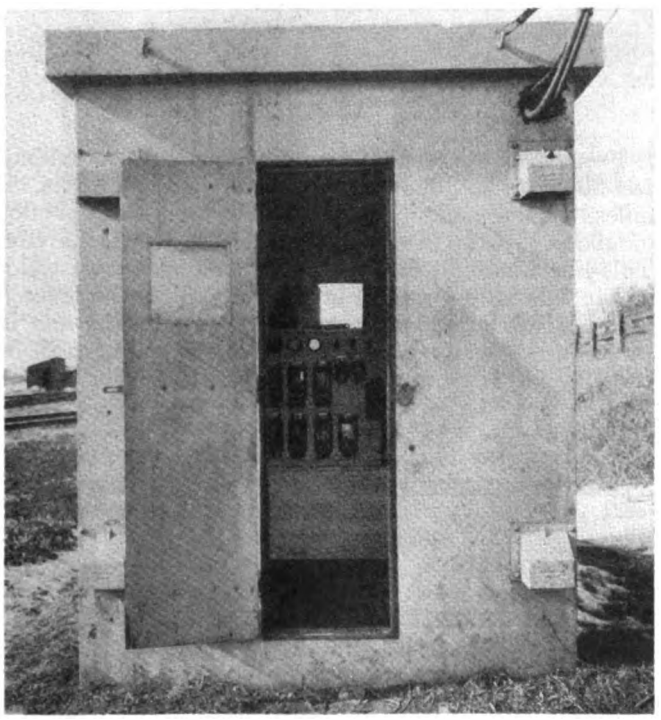
Past Operating and Maintenance Costs

Six operators per year	$11,036
Operating charges for supplies per year	500
Maintenance charges per year	1,800
Interest, depreciation, etc., per year	4,103
Operating charges, primary battery per year	684
Total operating and maintenance charges	$18,123

Present Operating and Maintenance Costs

Operating charges for supplies per year	$ 50
Maintenance charges per year	1,800
Interest, depreciation, etc., per year	6,472
Operating charges for charging current	300
One signal helper per year	1,095
Total operating and maintenance charges	$9,717
Net yearly saving	$8,406

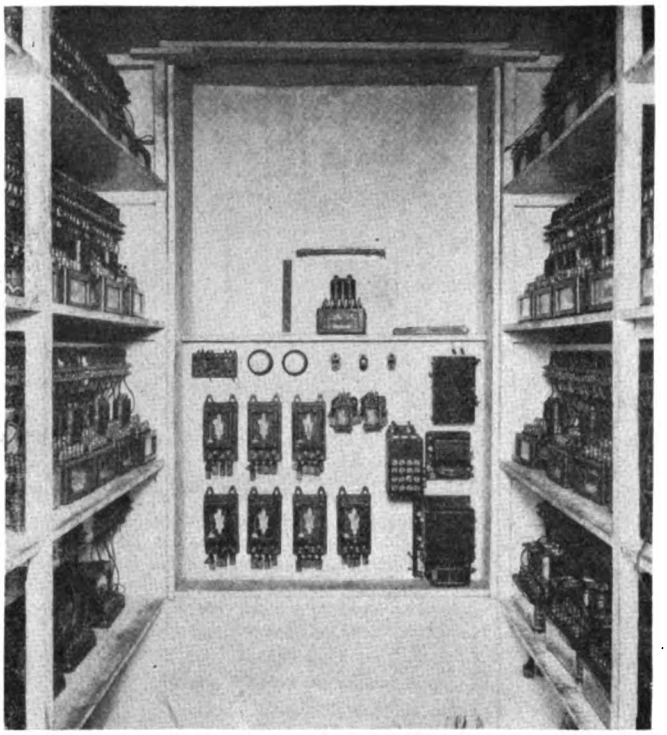
The entire signal arrangement was changed. The semaphore signals were retired and Type S-A single lens, three-color, color-light signals installed on two-track signal bridges. The circuits are of the signal company's standard design, modified to meet the requirements of the railroad. The signals are of the stick type, complete approach, route and detector locking being



The relay, batteries, etc., are located in small concrete houses

used. In fact, interlocking practice was followed. The bridges were located so as to obtain as nearly uniform blocks as possible in both directions on each track, the bridges resting on pre-cast foundations made at the concrete plant and set by crane. This installation was designed to secure a maximum of flexibility, safety and speed of operation, and to be applicable not only for the present operation conditions but to provide also for future expansion of traffic. Since the installation has been placed in service, results have been very satisfactory.

The switch machines are Model 5-B dual-control type with full lock-rod protection when on power operation, but not when on hand throw. The machines are placed on top of ties with very little framing, which locates them above the ground line and reduces frost trouble. Power for the operation of signals, switch machines and line control is provided from Exide stor-



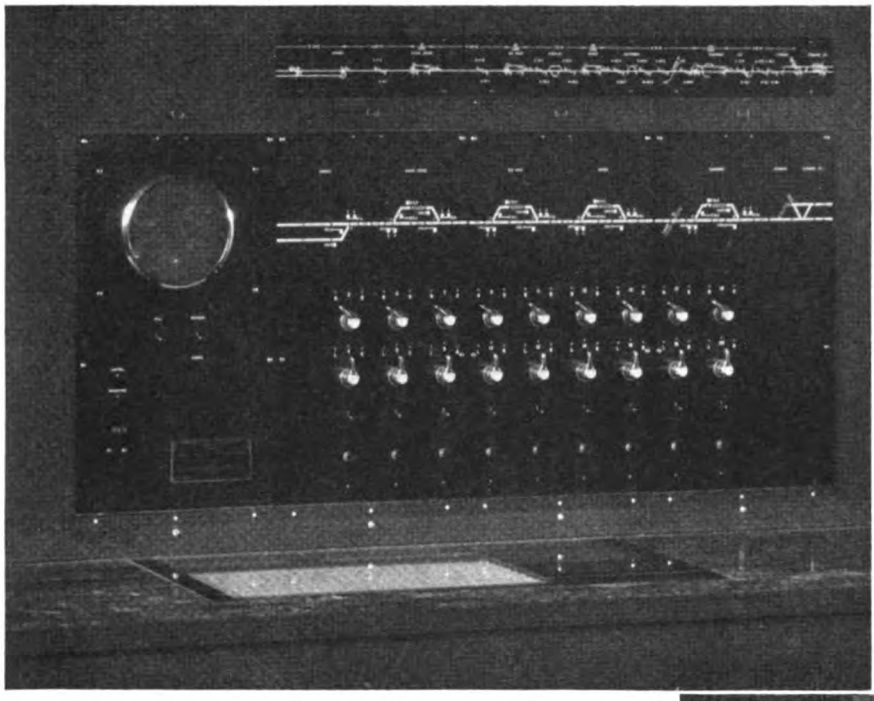
Interior of one of the concrete houses—Note that the terminals are accessible

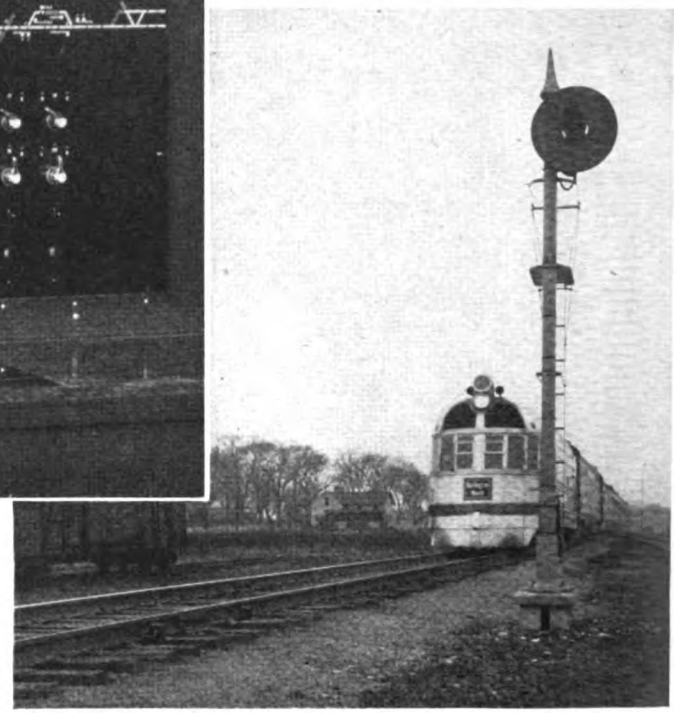
age battery, charged from the 220-volt line by Union rectifiers, the power being bought from the local power company at Rochelle.

The equipment for the centralized-control system including the control machine, the switch machines, signals and detailed apparatus was furnished by the General Railway Signal Company, and was installed by the regular signal construction forces of the Burlington.

On the M-K-T in southern Oklahoma

Centralized





Above—The C. T. C. control machine in the dispatcher's office at Aurora includes a new type all-electric train recorder. Right—Eastbound Zephyr train passing westward C. T. C. signal at the Aurora siding

THE Chicago, Burlington & Quincy has recently installed centralized traffic control on a 39.9-mile single-track section between Aurora, Ill., and Steward Junction, on its Chicago-St. Paul main line. The Burlington line from Chicago to Aurora, 37.7 miles, is multiple track to accommodate local commutation, as well as through traffic. At Aurora, the railroad divides, a double-track main line extending westward toward Omaha and Denver, and another main line extending northwesterly through Savanna, Ill., to St. Paul, Minn., which is 427 miles from Chicago. Between Aurora and Steward Junction, 39.9 miles, this St. Paul line is single track. The 8.5 miles of double track between Steward Junction and Flag Center, which is used also by trains of the Chicago, Milwaukee, St. Paul & Pacific, was equipped with centralized traffic control in 1929, the signaling being arranged for train movements in either direction on both tracks. This centralized traffic control territory is controlled from a machine at Rochelle, Ill., which is about midway between the two ends of the territory. West of Flag Center, the line is single track 59 miles to Savanna, with double track 282 miles between Savanna and St. Paul.

Considering the entire line between Chicago and St. Paul, the bottlenecks were the two sections of single track, between Aurora and Steward Junction, and between Flag Center and Savanna. For this reason, a decision was made to install centralized traffic control on the Aurora-Steward Junction section in 1942, and to make a similar installation on the Flag Center-Savanna territory at some future time.

Character of the Line and Traffic

Between Aurora and Steward Junction, the line traverses rolling prairie country. Between M.P. 76 and 72.3 the grade ascends eastward varying from 0.1 to 0.67 with a short section of 0.82 per cent. On the remainder of the territory, the grades are rolling, with short sections of grade up to a maximum of 0.85 per cent. In general the curvature is light. At M.P. 77.5, just east of Steward Junction, there is a 3-deg. curve. There is a 2-deg. curve at M.P. 55, and a 2-deg. .04-min. curve at M.P. 55.7. Trains operated by steam locomotives are restricted to 60 m.p.h. on the 3-deg. curve, and to 75 m.p.h. on the two 2-deg. curves.

Four light-weight Zephyr trains, hauled by diesel locomotives, and ten passenger trains with standard equipment, hauled by steam locomotives, are scheduled over this territory daily. An average of about 9 freight trains are operated daily. Extra trains are operated as required, so that the total number of train movements daily during a recent month ranged from 24 to 30. A large percentage of these trains are handled over the Aurora-Steward Junction section in peak periods which come during the early morning and late evening hours, as will be explained later when discussing the benefits of the C.T.C.

Layout of Sidings

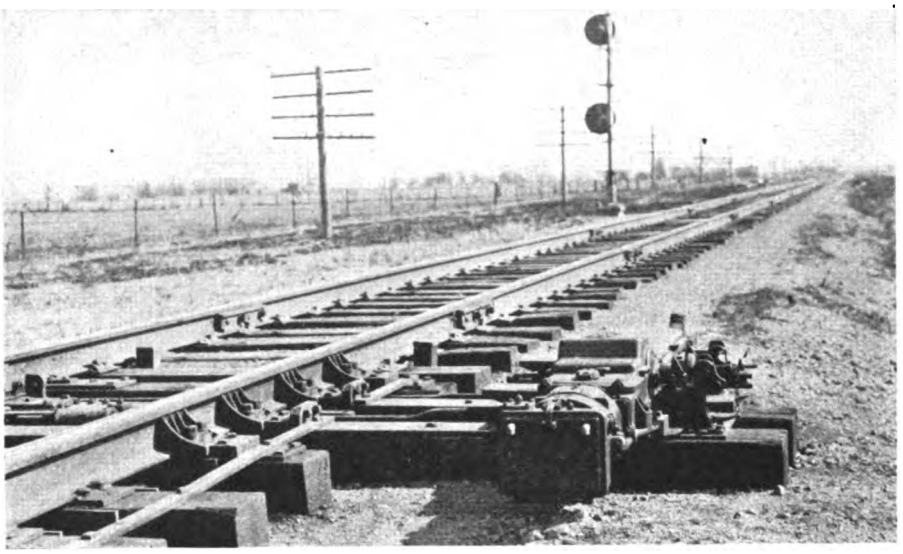
Prior to the installation of C.T.C., sidings were located at Sugar Grove, Big Rock, Hinckley, Waterman, Shabbona and Lee, with advance sidings at Aurora and at Steward Junction. The siding at Big Rock was ex-

Traffic Control Installed on 39 Miles of the Burlington

By W. F. Zane

Signal Engineer,
Chicago, Burlington & Quincy Railroad

Track capacity increased on important single-track line handling up to 30 trains each day Average time of all trains is reduced



One of the dual-control electric switch machines

tended to increase the capacity from 84 to 146 cars, and the siding at Shabbona was extended to increase the capacity from 130 to 228 cars. A new siding, Mored, with 125-car capacity, was constructed at a location where no station or road crossings are involved. With these changes and additions, the sidings at Sugar Grove, Big Rock, Mored and Shabbona, as well as the advance siding at Aurora, were chosen to be equipped with power switches and C.T.C. controlled semi-automatic signals to be used for meeting and passing through trains. New No. 15 turnouts were installed at these siding switches, so that trains can enter or depart at speeds up to 25 m.p.h. Reference to the accompanying plan shows that the distances between controlled sidings are not uniform, being 4.86 miles between Aurora and Sugar Grove, 4.04 miles between Sugar Grove and Big Rock, 6.6 miles between Big Rock and Mored, 8.05 miles between Mored and Shabbona, and 8.83 miles between Shabbona and Steward Junction. This spacing of controlled sidings was planned to provide greater flexibility in making meets on the east half of the territory than on the west half.

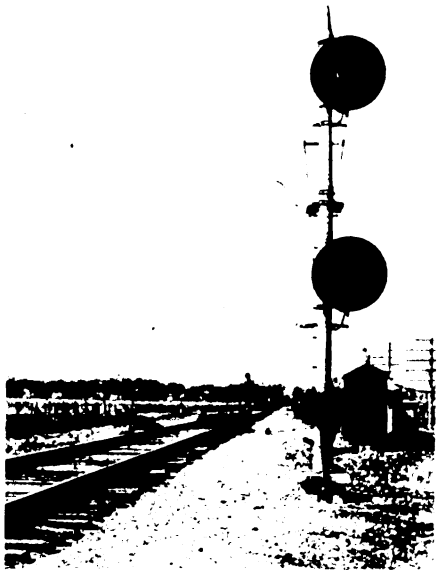
The east end of the advance siding at Aurora is included in the interlocking at Aurora. The sidings at Hinckley, Waterman and Lee were shortened, and their use confined to trains doing local work. All hand-throw switches in the entire territory were provided with electric locks.

The electric switch machines installed at the nine siding switches are the G.R.S. Co. Model 5D, with dual control so that they can be operated manually by train men when making special switching moves. The machines are equipped with built-in controllers including normal and reverse contactors and over-load relays. The brakes are of the new improved outboard type. The motors are designed to operate on 24 to 32 volts d-c., and with 24 volts at the motor will operate a switch in about 7.5 seconds. The new C.T.C. controlled semi-automatic signals are the SA searchlight type, and the new intermediate signals are the color-light type.

When first considering this proposed project between Aurora and Steward Junction, the signal department made preliminary studies based on experience gained by study of projects on other roads, as well as on 221.93 track miles of C.T.C. which has been in service for several years on other sections of the Burlington.

Benefits of the C.T.C.

An analysis was made of train sheets, conductors' delay reports and other operating data. For typical periods, train movements were re-dispatched on the basis of C.T.C. operations and with the proposed arrangement as well as car capacities of sidings. From these re-dispatched charts, conclusions were drawn as to train time, car days and locomotive hours which could be saved. An analysis was made of the results of these savings in the accelerated delivery and later receipt of traffic from and to other portions of this railroad as well as connecting lines. The project was planned in 1940, and materials were ordered promptly, but due to delayed deliveries the field construction was not started until Sept. 21, 1942, the installation being completed and placed in service Dec. 28, 1942.



Westward signal at east end of Big Rock

The benefits in train operations accomplished with the new siding arrangements and the centralized traffic control have been greater than forecast by the preliminary studies. Previously, train movements were authorized by time table and train orders with automatic block signal protection. Although the number of scheduled trains has not increased, more extra trains were operated in later months during which 27 trains have been handled in certain 24-hour periods.

A complication is that a large percentage of the trains must be handled over the Aurora-Steward Junction territory in two peak periods, during the early morning and late evening. For example, three inbound eastward through passenger trains are scheduled through this section between 5:48 a.m. and 7:50 a.m. Likewise, during these hours, several merchandise freight trains scheduled for morning deliveries in Chicago must be handled. Some of these trains are received at St. Paul from connecting roads extending to the West Coast. During January, when temperatures ranged down to 40 deg. below zero, some of these through trains were oftentimes late. As a result, these eastward trains met westward morning trains on the new C.T.C. section, in some instances as many as 7 trains would be on the 40-mile section between Aurora and Steward Junction. A similar peak often occurred during evening hours. As explained by the dispatchers, if the C.T.C. had not been in service, the traffic during the past few months could not have been handled with time-tables and train orders, without excessive delays.

Counting only the scheduled trains, six meets and two passes are made in this territory daily. Under train order operation, each manifest freight incurred considerable delay in this territory. Since the C.T.C. was placed in service, these delays have been reduced to an average of 10 min., thus resulting in a saving of road time on manifest freight trains of from 10 min. to 2 hr. 11 min., or an average of 32 min. Studies of the automatic train graph record show that 66 per cent of the trains move through the C.T.C. territory with no time delay. Another important fact is that the passenger train time has been reduced an average of 5 min., because no speed reductions are required for the engineman to observe train order signals at the intermediate stations. On the average, train time has been reduced about 10 per cent. Considering the sub-division Aurora-Savanna as a whole, the installation of C.T.C. on the 40-mile section has reduced the number of train orders 39 per cent.

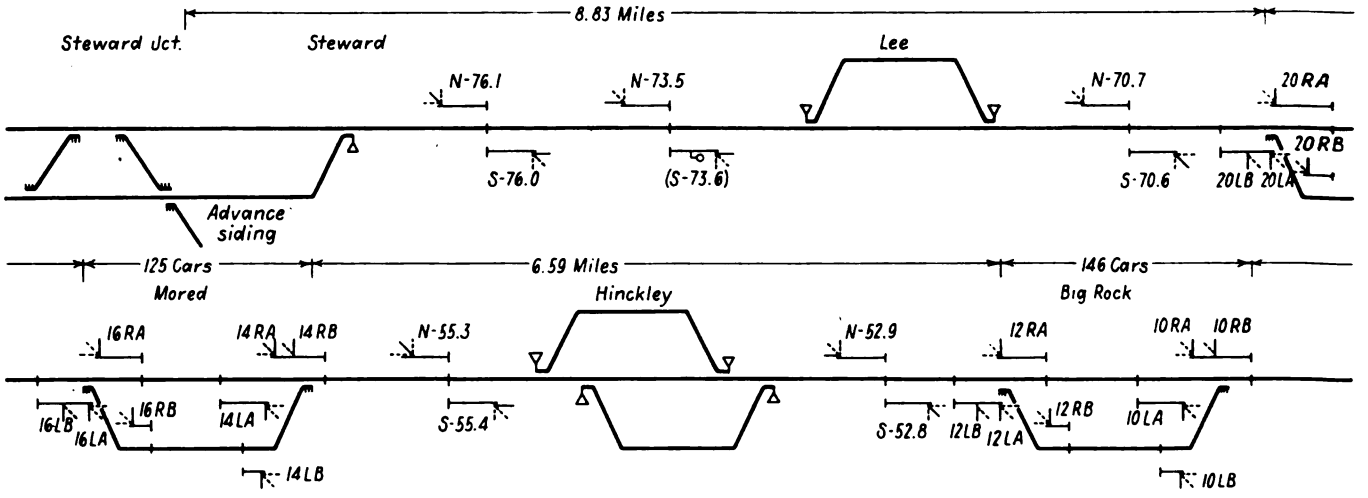
The C.T.C. control machine is located in the office at Aurora and is manipulated by the dispatcher. Nine levers each control an electric switch machine at an end of a siding. Nine signal levers each control four signals at a corresponding end of a siding. Indication lamps above each switch lever repeat the actual position of the corresponding switch in the field, and lamps above each signal lever repeat the aspects displayed by the signals controlled by that lever. The illuminated track diagram has normally-extinguished lamps, each of which is lighted red when the corresponding section of main track is occupied by a train.

A loud-speaker in the dispatcher's office is connected to a circuit which extends to a telephone at each of the switches in the field. If the dispatcher wants to talk to a maintainer who may be in the vicinity of one of the power switches, a corresponding toggle switch on the control machine is operated and a control is sent out which causes a lamp to be lighted and a buzzer to sound at the corresponding field switch location.

An Electric Train Recorder

The desk portion of the control machine includes an automatic train graph. Horizontal lines, on the constantly moving graph sheet, represent the passage of time, and vertical lines each represent the location of OS points which, in the field, are the locations of power switches and the approach annunciator sections occupied by trains when approaching the C.T.C. from either direction.

The train recorder is all-electric in operation. The chart is made of Teledotos paper. When a train occupies the track circuit at a power switch location, a mark is made on the chart



Track and signal plan of the centralized traffic control

paper by electric current passing from an energized stylus through the paper to a platen beneath the paper. If the train occupies the OS track circuit for any length of time, a repeat mark is made every 20 seconds. Each time a semi-automatic C.T.C. controlled signal is cleared at a power switch location, a mark is made automatically on the chart to the right or to the left of the vertical OS line for that particular field station, depending on whether a westbound or an eastbound signal has been cleared. A repeat mark is made every 20 seconds while the signal remains clear.

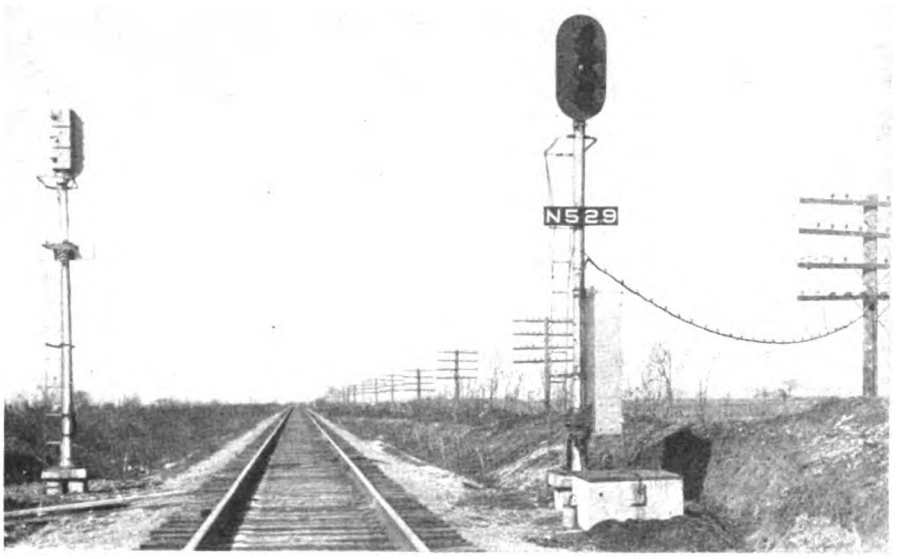
The recordings are visible through a hinged, transparent cover in the control machine desk. To complete the record of train movements, the dispatcher, at his convenience, can raise this hinged cover, and draw pencil lines to connect all of the OS recordings made by any one train, and write in the information such as the train number, etc. The resulting completed record is removed from the recorder in day-to-day portions for office use and permanent filing. Each roll of chart paper is of sufficient length for 31 days continuous recording. A new roll can be spliced on to the end of a preceding roll in such a manner that no interruption occurs when the splice passes through the recorder.

Interesting Change-Over Method

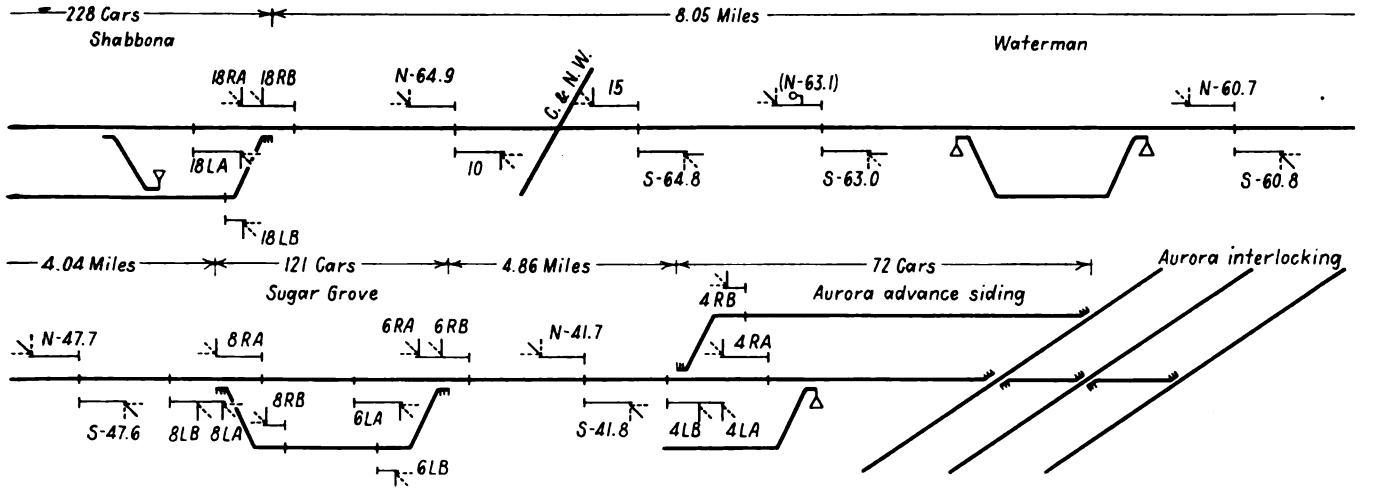
In view of the fact that automatic block signal protection had been in service on this territory previously, this form of protection was continued in service during the construction and change-over to centralized traffic control. As the new color-light signals were installed, the old lower-quadrant semaphore signals were removed. At each siding switch, when the power switch machine was installed and the new signals were complete at such a switch, the power switch and the signals at such a location were cut in service as a remote-control interlocking controlled by the dispatcher, this change being made effective for both ends of any one siding at the same time. Time tables and train orders were continued in effect, the operation of trains through a switch location being under interlocking rules, in which the signal indications direct trains through interlocking limits between the signals at a switch, but these signals give an engineman no authority to proceed unless he is so authorized by time-table and train orders.

Thus the new facilities were placed in service in four separate groups, each consisting of a power siding layout and new intermediate signaling to the next siding. When the construction was complete at Shabbona, the last siding, the territory as a whole was bulletined in service with C.T.C. in effect to authorize train movements by signal indication, thus superseding operations by time-table and train orders. By this procedure, no changes in switches, signals or circuits were required on the day of the change-over, except at the final location at Shabbona. A further advantage was that the dispatchers had an opportunity to learn the operation of the control machine gradually rather than taking over the entire territory at one time.

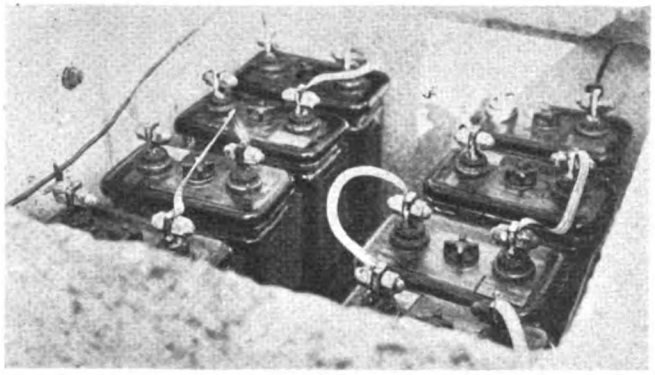
The controls of the power switches and the semi-automatic signals from the machine in the dispatcher's office, as well as the return of indications, is accomplished by means of the General Railway Signal Company's Type-K Class-M coded line system which employs a normally-energized, two-



Typical intermediate automatic signal location



territory on 39 miles of single track between Aurora and Steward Junction



At the intermediate signal location the storage battery is located in boxes

wire line circuit from the office at Aurora to the west end of the territory at Steward Junction. This line circuit is independent of the dispatcher's telephone circuit. At some future time C.T.C. may be installed between Flag Center and Savanna, 67 miles, so that the entire territory between Aurora and Savanna, 107 miles, will be under C.T.C. operation. In this event, the G.R.S. carrier link control will be used to handle the C.T.C. section west of Steward Junction. The control machine in the dispatcher's office is of the sectional type, consisting of an assembly of one master section and three application sections, so that if the territory is extended, more application sections can be added as required.

C.T.C. Line Code Controls

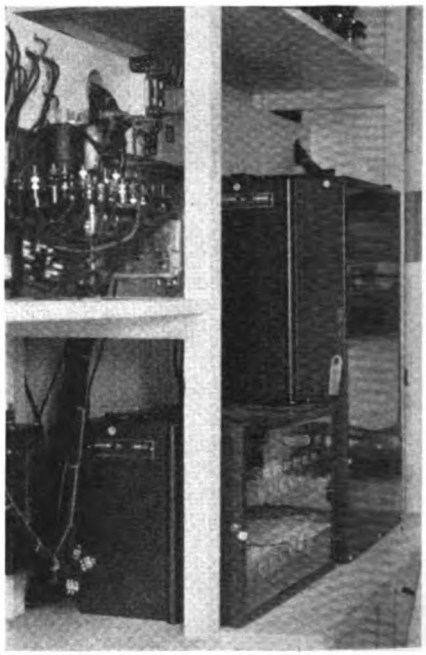
The Type-K coding equipment, now in service, uses cycles each consisting of 10 steps, and has a capacity to handle a total of 64 field stations, thus providing for possible future extensions of the territory. At each field station, a line relay is connected across the two line wires of the code circuit; thus all these relays are in parallel so that the circuit arrangement is referred to as the shunt system. The line circuit is normally energized by a battery in the office. Control code cycles are sent out from the office by long and short pulses, and long and short intervals between the line current pulses. Indications from the field locations are transmitted to the office by field stepping units which shunt the line for long or short periods. The shunted and unshunted condition of the line is detected in the office by an impulse transformer, the primary of which is connected in series with the line circuit so that the secondary operates a control office line relay.

The system is simplex in operation, that is, it transmits controls on one cycle, and indications on another, and is so arranged that controls take prefcrence over indications. A distribution feature prevents field stations close to the office from transmitting indications continuously, to the exclusion of indications from more distant stations. Thus the indications are at no time unduly delayed. This is accomplished automatically by transmitting indication cycles in groups; each group or series of cycles contains a cycle for each field station that may be ready to transmit at the time the group was formed. No one field station is permitted to transmit a second cycle without an opportunity for more-distant stations to transmit. Indications which are stored in the meantime are transmitted in succeeding groups.

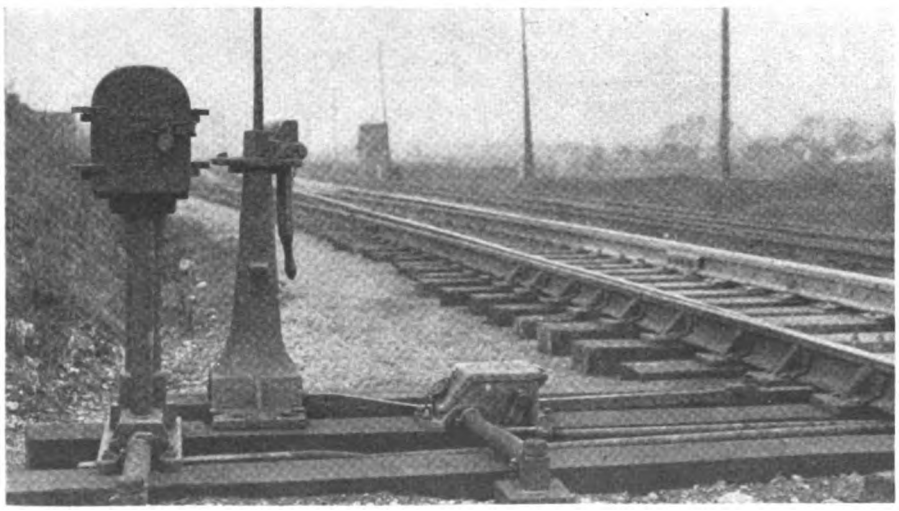
Automatic Controls of Signals

In the previous automatic block signaling the track relays were of the d-c. neutral type rated at 4 ohms. These relays were retained in service and similar relays were provided for the additional track circuit such as the OS detector sections at power switches and in approach to the facing points of the hand-throw switches equipped with electric locks.

The previous A.P.B. line control circuits used five line wires, two wires in connection with common for control of eastward signals and two wires in connection with common for the westward signals. This A.P.B. line control system, using neutral circuits, was replaced with a three-wire polarized line circuit using polar line relays to select controls for the yellow and green aspects. The manner in which these A.P.B. line wire circuits are used also in the controls of electric locks at hand throw switches will be discussed later.



Coding equipment in an instrument house



The electric lock as applied on each of the hand throw main line switches

Control of Electric Locks on Hand-Throw Switches

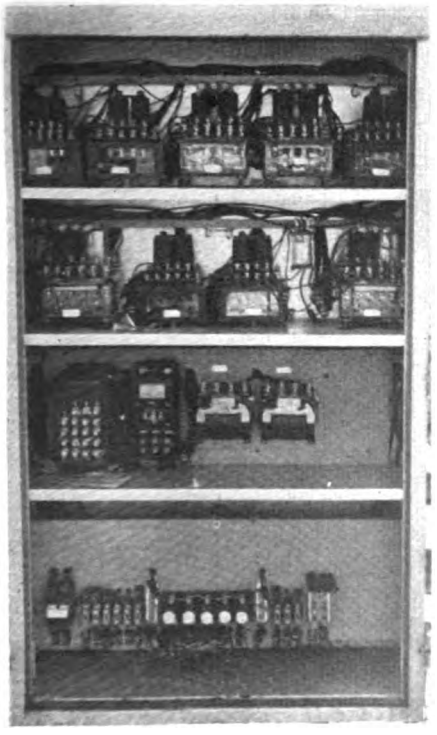
The electric locks on the hand-throw switches are controlled automatically. When a train, such as a local freight, is to use one of these turnouts, the train must, of course, be brought to a stop on the main line. In order to effect a release of the elec-

tric lock, a short track circuit in approach to the facing points must be occupied by a locomotive or car. In view of the fact that the train is thus occupying a main line track circuit,

Electric lock with door open

the first signal in each direction governing toward the switch is displaying its most restrictive aspect, and the second signal in each direction is displaying the Approach aspect.

When the trainman opens the door of the case for the electric lock, a contact is automatically closed which completes a circuit (see Fig 2) starting with positive battery B 10, through a back contact of the track relay F-630, through the door contact, the coil of the lock to negative battery C10. This energizes the lock coil to cause the lock to be released and to operate the indicator to display the word "Unlocked." The trainman can then operate the crank to remove the plunger from the lock rod, after which the switch can be thrown by the lever of the stand. The train can then enter the siding.



Instrument case at intermediate signal

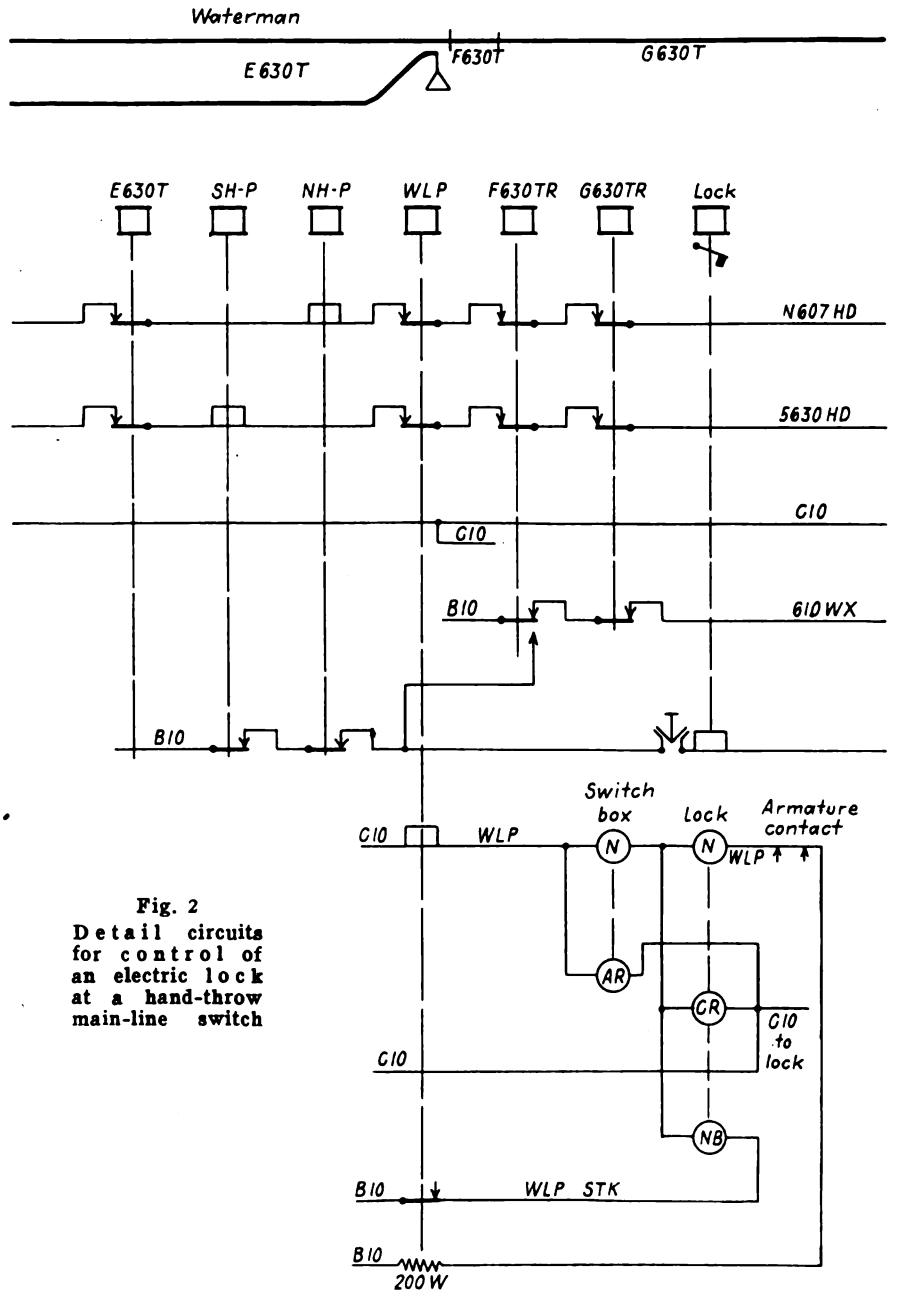


Fig. 2
Detail circuits for control of an electric lock at a hand-throw main-line switch

When a train on a siding is ready to occupy the main line, the conductor or a trainman opens the door of the case of the electric switch lock on the switch to be used. The opening of the door completes a circuit to release the lock, if circumstances are such that safety permits the switch to be operated. In this instance, the circuit to energize the lock starts with positive battery B10 over a front contact of relay SHP which is in series with the line control and line relay S63OHD. Relay SHP will not be in the energized position if a train is occupying any of the track circuits between signal S630 and signal 16R. Assuming in this instance that relay SHP is energized, the circuit for the lock continues over a front contact of relay NHP. This NHP relay is in series with the line circuit and line relay N607HD, therefore NHP will not be energized if a train is occupying any track circuit between signal 607 and signal 18L. Assuming in this instance that NHP is energized, the circuit continues through the door contact and the coils of the lock to negative battery C10, thus releasing the lock and causing the "Unlocked" indication to be displayed.

In addition to checking for track occupancy, the relays NHP and SHP relays will not be energized if a semi-automatic C.T.C. controlled signal

has been cleared to admit a train into this section where the electric switch lock is located. In the event that signal 16R has been cleared, energy is removed from the control circuit of S630 which causes series relay SHP to be released. This is accomplished by taking the control circuit for S630 through a contact of the 16R approach locking relay. If signal 18L has been cleared, energy is removed from the line control circut of signal N607, so that series relay NHP is released. This is accomplished by extending the control circuit for N607 through a contact in the 18L approach locking relay.

Thus, if either the NHP or SHP relay is in the released position, the control circuit for the electric lock is open to prevent release of the lock, while either signal 16R or 18L is displaying a Proceed aspect.

If a Proceed aspect on either signal 16R or 18L is taken away by lever control by the C.T.C. machine, and a train is occupying the corresponding approach section, the approach locking becomes effective so that a predetermined time period must expire before energy is applied to the line control circuit of S630 or N607 to energize SHP or NHP to permit a release of the electric switch lock.

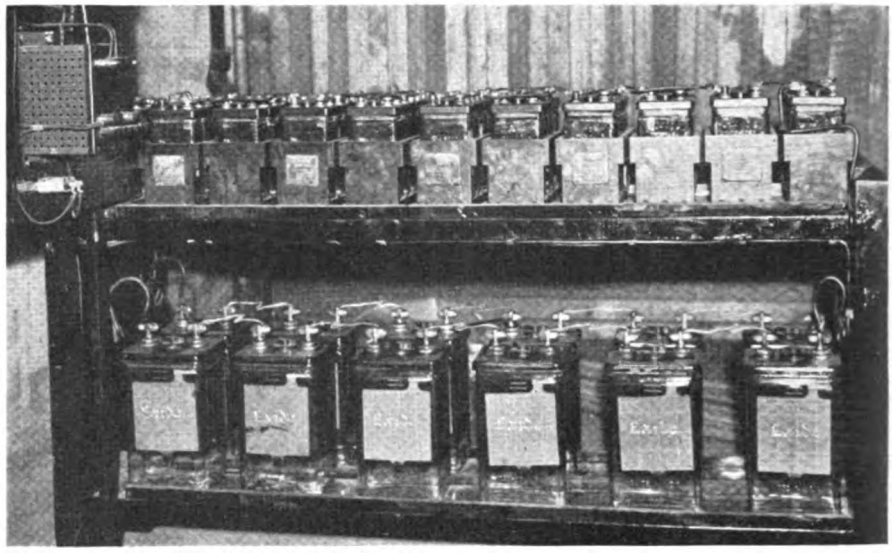
A switch and lock repeater relay, WLP, is used at each lock location. This WLP relay is energized by a circuit which checks the normal position of the switch, the normal position of the lock plunger, and a back contact of the lock armature. The signal control line circuits are taken through front contacts of the WLP relay.

Approach Locking

Approach locking is provided in connection with each power-switch layout. If the dispatcher clears a semi-automatic signal at a switch, and then takes away the Proceed aspect by lever control before a train has entered the approach track section, no locking becomes effective, and he can operate the switch or clear another signal without delay. On the other hand, if a train is occupying the approach section, the switch cannot be operated or a signal cleared until the expiration of a period which is measured by a Type-KB motor-driven time-element relay. For example, the time relay at the switch at the west end of Big Rock is set to operate in 5 min. 48 sec.

Pole Line and Power Supply

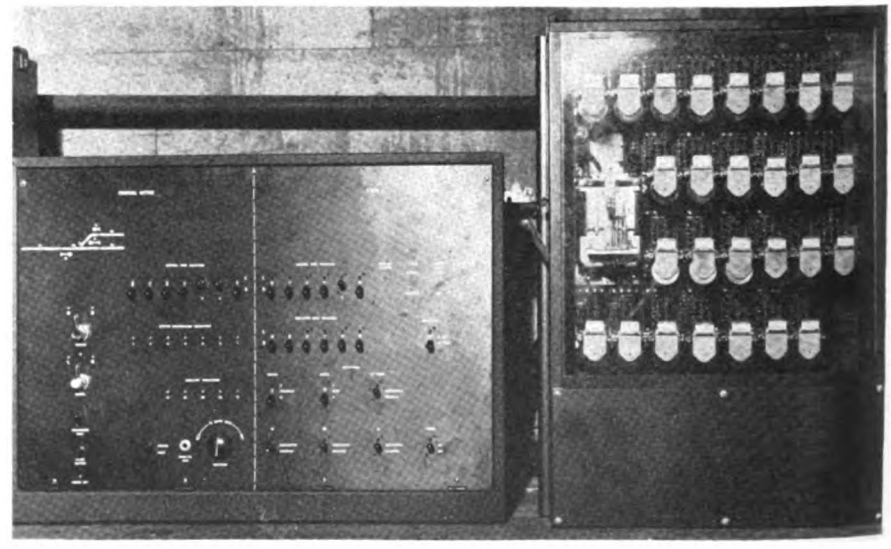
The signaling line wires are on a crossarm on an existing pole line used also for communication line circuits. In order to conserve copper, the previously existing No. 8 bare galvanized iron line wires for the signal line controls were re-arranged as required and were continued in service as a part of the new system. Likewise No. 8 bare galvanized iron line wire was used for the two wires required for the new C.T.C. line code circuit. Two new No. 6 copper wires with weatherproof covering were installed for the 220-volt single-phase a-c. power distribution circuit through the territory.



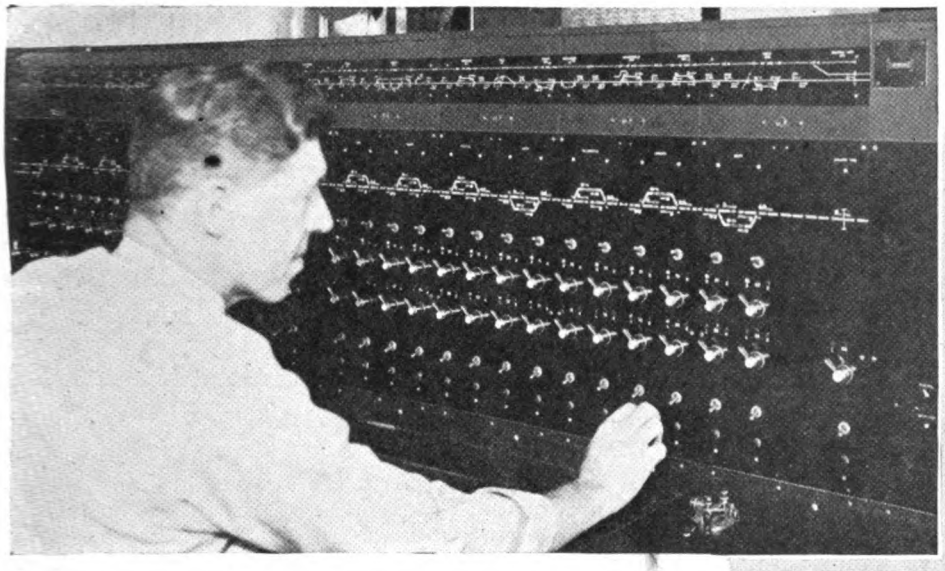
The 115-volt C. T. C. line battery and the local battery in the office at Aurora

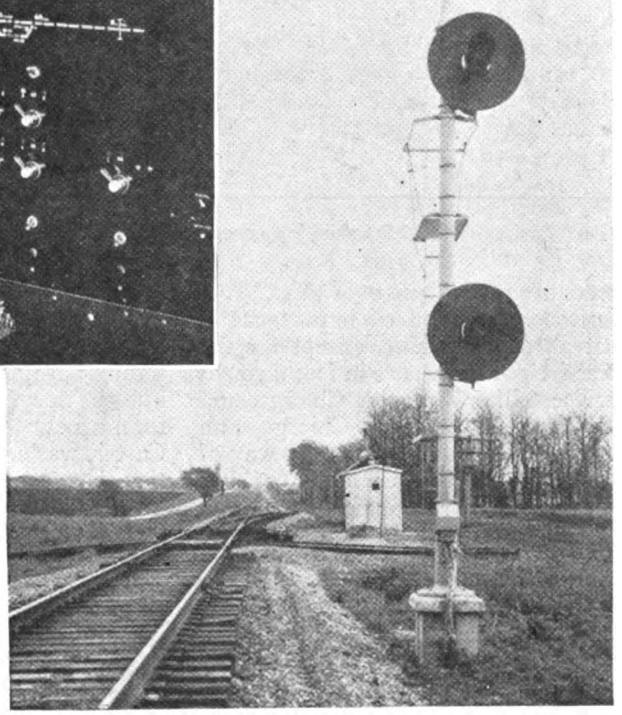
Storage Battery Arrangements

At the various locations, low-voltage transformers feed rectifiers for charging storage batteries. The signal lamps are normally fed from transformers, or are fed from batteries in case of an a-c. power outage. Each track circuit is fed by one cell of 60-a.h. storage battery. At each intermediate signal there are two sets of 5 cells of 60-a.h. storage battery for feeding the line circuit, and as a standby for the signal lamps. At each power switch location there is a set of 60-a.h. storage battery for operation of the switch machine, and this battery also feeds the line coding apparatus. The number of cells in this battery may vary from 12 to 14 as may be required to secure at least 24 volts at the motor. Under normal conditions a machine will operate in not less than 7.5 sec. At the Aurora office, the code line is fed at 115 volts from a set of storage cells rated at 9.2 a h. New insulated wires and underground cables were installed throughout the C.T.C. territory. The battery feed to the switch motors is on No. 6 wire, and the track connections are No. 8 wire.



Line code testing equipment in the shop at Aurora





Above—The train dispatcher at Aurora operates the centralized traffic control machine for Aurora-Savanna line. Right—View of layout at west end of Chadwick which is typical with search-light signals, electric switch machine, concrete house for relays and batteries.

More C.T.C. on the Burlington

By W. F. Zane,
Chief Signal Engineer, Chicago Burlington & Quincy

Project on 59 mi. of busy high-speed single track, includes seven sidings spaced an average of 5.85 mi., switch to switch, thus increasing the number of the non-stop meets

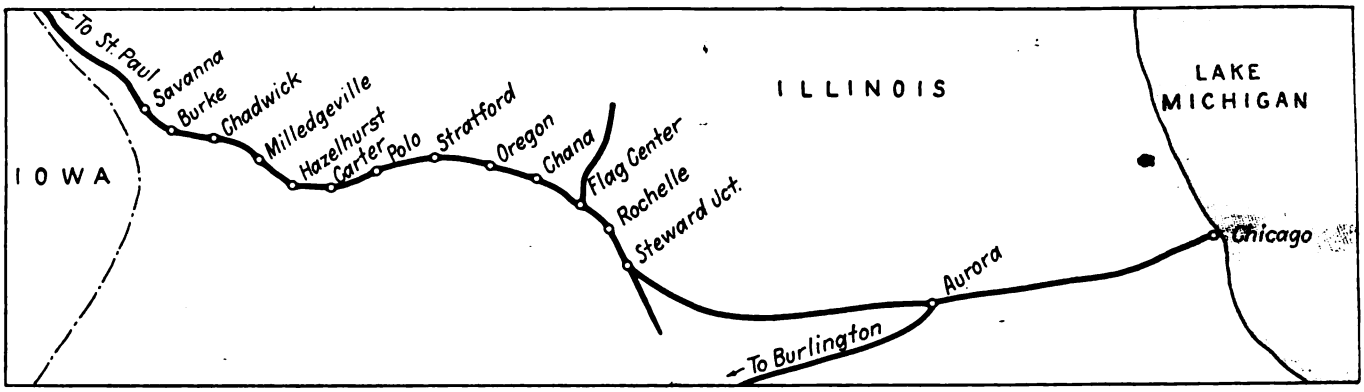
In line with a general policy of installing centralized traffic control on its heavy-traffic single-track lines, the Burlington has completed such a project on 59 mi. of single track between Flag Center, Ill., and Savanna. This project, with the 40 mi. of C.T.C. installed in 1943 between Aurora and Steward Junction, totals 99 mi., which completes all of the single track mileage on the 427-mi. line between Chicago and St. Paul.

The Burlington has three or more main tracks on the 37.7 mi. between Chicago and Aurora, and double track extends 282 mi. between Savanna and St. Paul. The 8.5 mi. of double track between Steward Junction and Flag Center, which is used also by trains of the Chicago, Milwaukee, St. Paul & Pacific, was equipped, in 1929, with centralized traffic control, using direct-wire controls from the machine at Rochelle, which is near the center of this section. Using line code equipment, with a two-wire line circuit, one control machine in the dispatcher's office at Aurora controls not only the 40 mi. of single-track C.T.C. between Aurora and Steward Junction, installed in 1942, but also the recently completed 59 mi. of single-track C.T.C. between Flag Center and Savanna. The operators in charge of the machine at Rochelle, which controls the 8.5 mi. of direct-wire C.T.C. between Steward Junction and Flag Center, works under the supervision of the dispatcher at Aurora. Thus the entire 107 mi. between Aurora and Savanna is now equipped with C.T.C.

Rolling Country

Between Flag Center and Savanna, the railroad traverses rolling country, with numerous short grades ranging up to about 0.8 per cent. Savanna is on the Mississippi river. Starting about three miles east of Savanna, a grade of about 0.8 per cent ascends eastward for about three miles. The curves are few, and most of them are 1 deg. or less, with some 2 deg. and only three 3 deg. The track consists of 130-lb. rail, and rock ballast. Therefore, insofar as grades, curves and track are concerned, this territory can handle heavy traffic at high speeds.

The traffic includes 12 passenger trains and an average of about 9 freight trains, operated daily, with extra trains as required. Thus, a total of about 21 to 24 train move-



Map showing general location of the new C.T.C. territory between Flag Center and Savanna

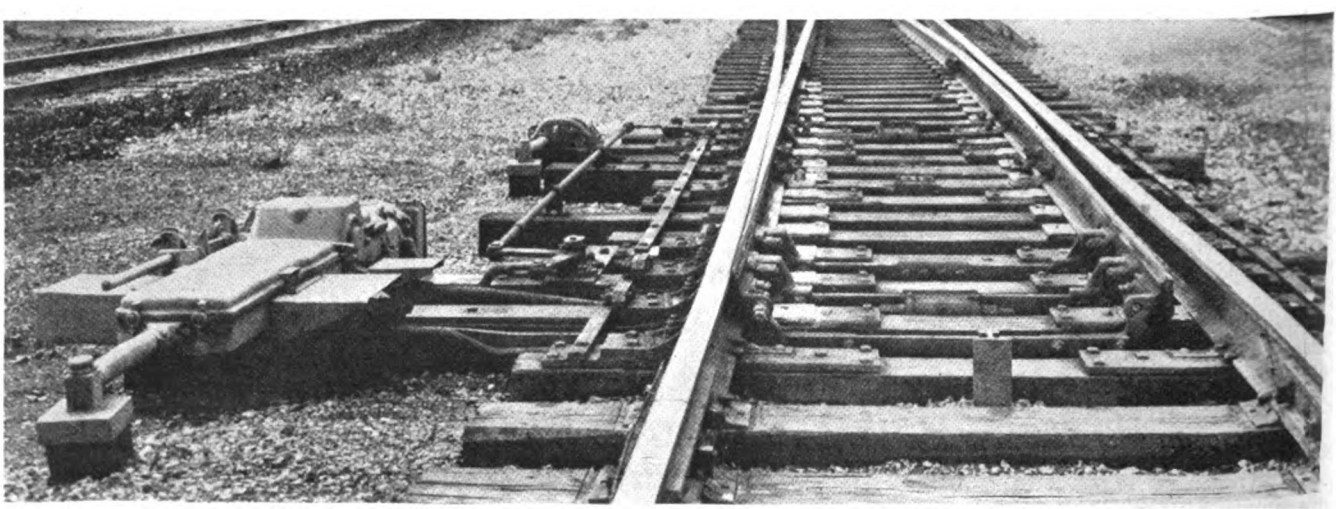
ments are made daily over this C.T.C. territory. A point of importance is that all of the trains, except for the local freight trains, are in fast through service, either between Chicago and St. Paul or between Chicago and cities on the Pacific Coast, by way of St. Paul. A further factor of importance, with reference to the need for C.T.C., is that the preponderance of traffic is eastbound into Chicago during the early morning, and westbound out of Chicago during the late afternoon and evening. Previously, train movements were authorized by timetable and train orders, with automatic block protection. The installation of C.T.C., including power operation of siding switches and the use of signals to authorize train movements, has increased track capacity and facilitated train movements, especially the through freight trains.

Layout of Sidings

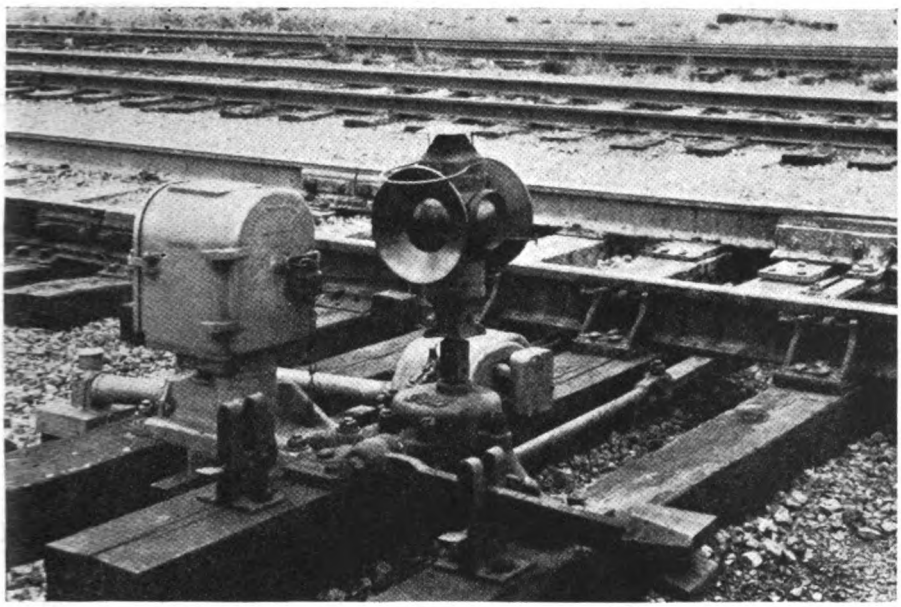
As a part of the improvement program, several changes and additions were made in the lengths and locations of sidings. This was done to improve the uniformity of train time between sidings as well as to take advantage of grades and other local conditions when trains are entering and leaving sidings. The previous sidings at Polo and Hazelhurst were not located properly to be incorporated into the new C.T.C. operation. Therefore, a new 140-car siding, known as Carter, was constructed at a new location between Polo and Hazelhurst. The sidings at these two towns were left in place for use as house tracks, with hand-throw switch stands, and without C.T.C. signals for authorizing train movements onto the main track. All other sidings were lengthened to 140-car capacities except two—one of these being 136-car capacity and the other 76-car capacity. Between Flag Center and Savanna the sidings are spaced as uniformly as practicable on a time-distance basis for trains. On the average, the distance between the west switch of one siding and the east switch of the next siding is 5.85 mi.

As a general rule, the freight trains operated over this territory are made up of about 80 cars, which, of course, is much less than the 140-car capacity of the sidings. One reason for the longer sidings is that trains can enter at the speeds for which the turnouts are designed, and, after the rear end is in the clear, there is plenty of track length left on which to stop. Another advantage is that long sidings are advantageous in making meets in which neither train stops. These non-stop meets save lots of train time, and experience on this project, as well as other installations in service on the Burlington, is that nearly 40 per cent of the meets can be made non-stop, where sidings are arranged as previously explained. As a part of the improvements at these seven sidings, the old turnouts were replaced with new No. 15 turnouts, including 30-ft. points, so that trains can enter or depart from the sidings at speeds ranging up to 25 m.p.h.

As part of the signaling project, electric locks were applied to 12 hand-throw main-track switches; two at Flag Center; four at Oregon; one at a spur west of Oregon; one at Polo; and two at Hazelhurst. The electric switch machines installed at the seven sidings are the G.R.S. Co. Model 5D, with dual control, so that they can be operated manually by trainmen when making switching moves. These machines are equipped with built-in controllers including normal and reverse contactors and over-load relays. The brakes are the outboard type. The motors are designed to operate on 24



Power switch showing pipe and cranks for second connection to mid-section of the long points



Electric lock applied to hand-throw switch

to 30 volts d.c. With 24 volts at the motor, the machine will operate a switch in about 7.5 sec.

New Light Signals

Previously this territory was protected by automatic block signaling including two-position lower-quadrant semaphore signals. When installing the C.T.C., these old semaphores were removed, new searchlight signals being installed at the controlled siding switches, and color-light signals for intermediates.

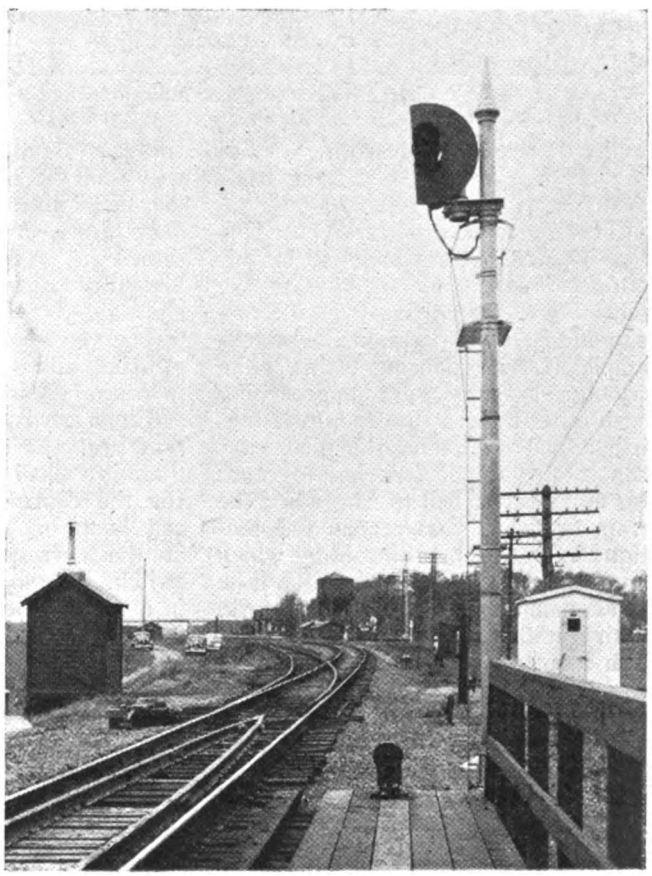
Following Burlington standards, the top signal unit on all high signals govern main-line straight-away train movements. Such a signal displays red for Stop, and either yellow or green for a Proceed aspect, depending on occupancy of the two blocks ahead. The second unit is 5 ft., centers below the top one. This second unit, when used, governs for diverging main-line routes other than to passing sidings. The third unit, 7 ft. 9-in. centers below the second unit, is for directing trains to enter sidings. For example, such a third unit displays yellow, under red in the top unit, as the Restricting aspect to direct a train to enter a siding. A dwarf signal is used to display the Clear Restricting aspect to direct trains to leave a siding and enter the main track. It displays yellow if the first block is unoccupied, or green if two or more blocks are unoccupied. The standard rules and indications applying to these signals are given in the accompanying chart.

The switch at the east end of the siding at Oregon is just beyond the end of the Rock River bridge. In order to locate the westbound station-entering signal so it could be seen by the engineman of a westbound train passing through the bridge, this signal had to be located so close to the track that part of the standard circular background, on the top unit, was cut off to conform with standard clearance requirement. As shown in the accompanying picture, this searchlight signal mechanism is mounted on a special angle-iron bracket to the left of the mast, this being done to place the signal lamp to the left as far as practicable, and, at the same time, place the mast and ladder to the right beyond clearance limits. On account of space restrictions, a dwarf signal, rather than a unit in the third position on the mast, is used at this location, to direct trains to enter the siding.

The C.T.C. Control Machine

The C.T.C. control machine in the dispatcher's office at Aurora has the Burlington's standard panel arrangement. A diagram across the top of the panel shows the track arrangement and car capacities of the sidings, as well as other information for the dispatcher. Above the symbol for each field station there is an opal lamp which is lighted during the time the corresponding field station is coding. This information aids the maintainer in checking that the stations are indicating properly. Below these opal lamps is the conventional illuminated track and signal diagram which includes lamps to repeat track occupancy of all sections of main track: (1) between stations; (2) the OS sections at switches; and (3) the main track through stations, thus providing continuous indication except for the sidings. In each of the symbols representing a siding, there is a hole in which a token can be placed by the dispatcher to remind him of the identification and location of a train using the siding.

Below the illuminated diagram is a row of small toggle switches, one



Signal at east end of Oregon has a special mounting so it can be seen by enginemen when coming through the bridge span

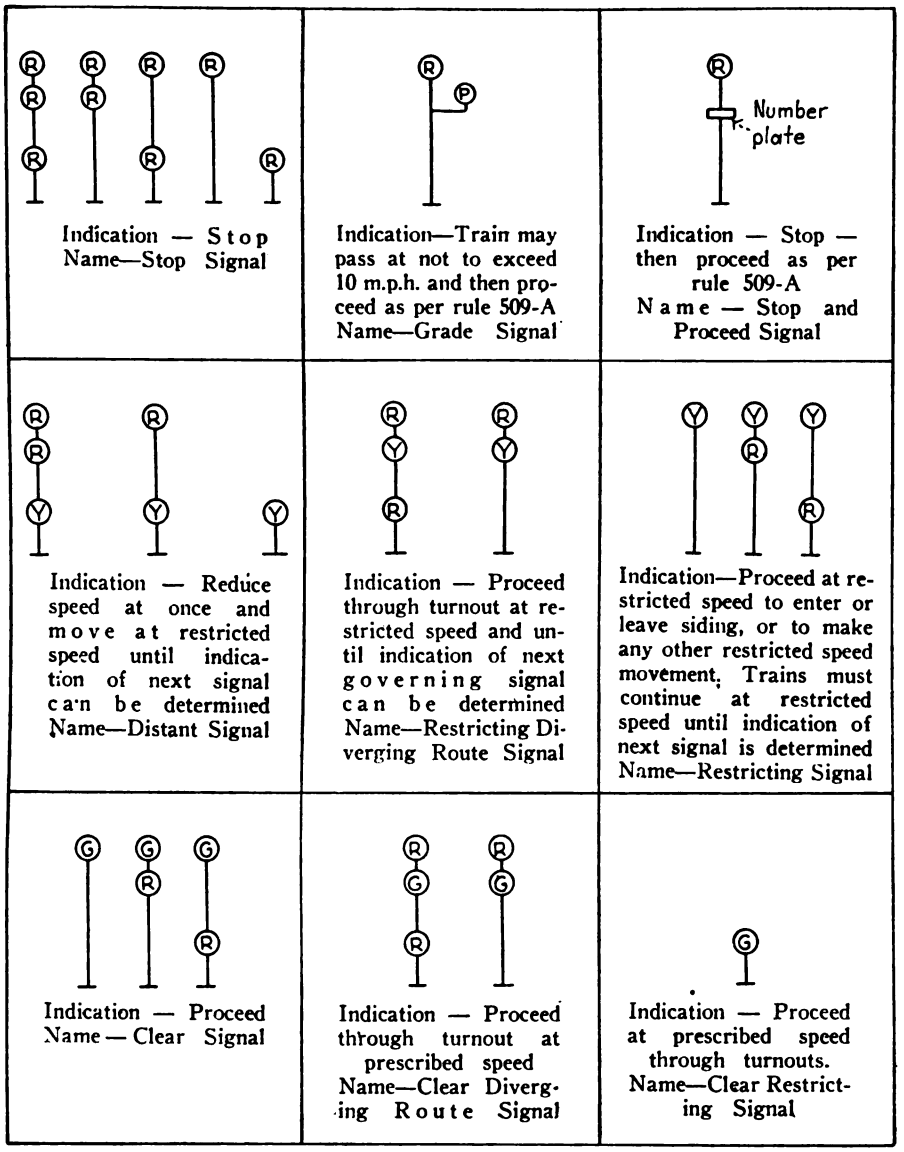


Chart of signal aspects, indications and names

under the symbol representing the OS section at each of the passing track switches.

These toggle switches are used by the dispatcher to cut in or cut out his annunciator bell as applying to the incoming OS indication from the corresponding field location. For example, if two opposing trains, quite widely separated, are approaching each other but it is too soon to establish a meeting point, the dispatcher can set his toggle switches to cause his annunciator bell to ring when the train or trains pass certain OS sections in approach to the siding which he plans to use for the meet. Thus he can devote his attention to other work, with confidence that the bell will call him in plenty of time to set up the signals for the meet as planned; or, if one of the trains does not make as good progress as expected, the meet can be arranged on close time at some other siding. Experience has proved that this Burlington practice of providing the individual toggle control for the annunciator, in connection with each OS section, is a help to the dispatcher in that he can arrange for close meets between trains, and at the same time, he does not have to devote his entire attention to the C.T.C. machine.

The levers for controlling the switches and signals, as well as the indication lamps above these levers, are in accordance with conventional practices. Below each signal lever there is a small toggle switch which is for the control of the maintainer's call lamp on the instrument house at the corresponding passing-track switch. The code-starting buttons are in a row at the bottom of the panel.

Time-Locking Lamps

If the dispatcher clears a signal and then takes it away by lever control, the switch at the field station cannot be operated or a signal cleared until the expiration of a predetermined time interval which is measured automatically by a KB time-element relay. In order that the dispatcher may know when this time has expired, a row of amber lamps is provided below the starting buttons on the dispatcher's control machine. Each lamp corresponds to a respective field station. Each of these lamps is lighted during the time that electric-time locking is in effect at the corresponding power switch location. In addition, the lamp would be lighted, and continue to stay lighted, if the a.c. power fails at that field station.

Graphic Train Chart

In the top of the desk portion of the control machine, there is a graphic train recorder with pens which indicate not only the passing of trains at certain field locations, but also record the clearing of signals. Corresponding to each passing-track switch location, there are two pens. One is operated when a signal at the corresponding location is cleared, and the second pen is operated when the OS section is occupied. Thus the record on the chart shows how long the signal was cleared before the train arrived. The lack of a continuous "signal clear" record, with an OS track-occupancy recorded, shows that the train has passed a red signal. A very short "signal-clear" record shows that the man in charge of the machine is not lining up the signal in time for the train to get a green instead of a yellow at the distant signal.

Local Automatic Controls

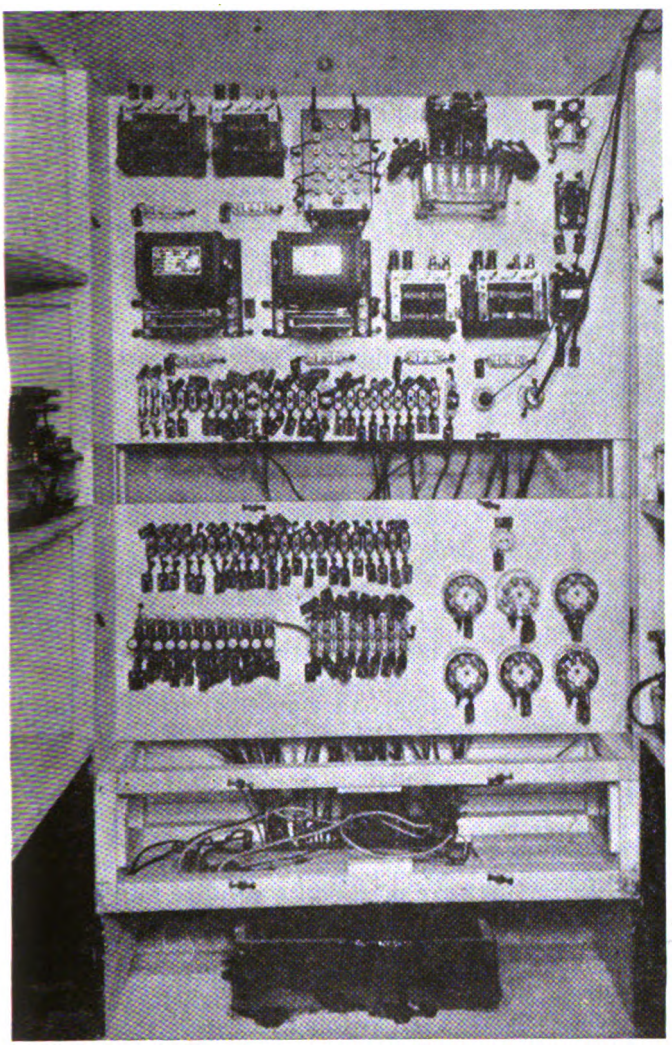
The previous automatic block signaling included d.c. neutral track circuits, and these were retained in service, although they were rearranged as required when the intermediate signals were relocated. The local signal line circuits are the either-direction type, in which two line wires, through a station-to-station block, serve to control either the eastward signals or the westward signals, depending on the direction established by C.T.C. control. An important feature of this two-wire either-direction circuit, as used on the Burlington, is that when in the dormant condition, battery is connected to the line at both ends. Therefore, code is required to be sent to only one field station to clear a signal. For example, if the eastward signals are to be cleared, one code control is sent from the office to the field station at the signal to be cleared, which in this case, is at the west end of the station-to-station block. Another feature of these circuits is that, at the intermediate double locations, the line circuits extend through back contacts of the HR and SR relays for

the opposing direction of operation.

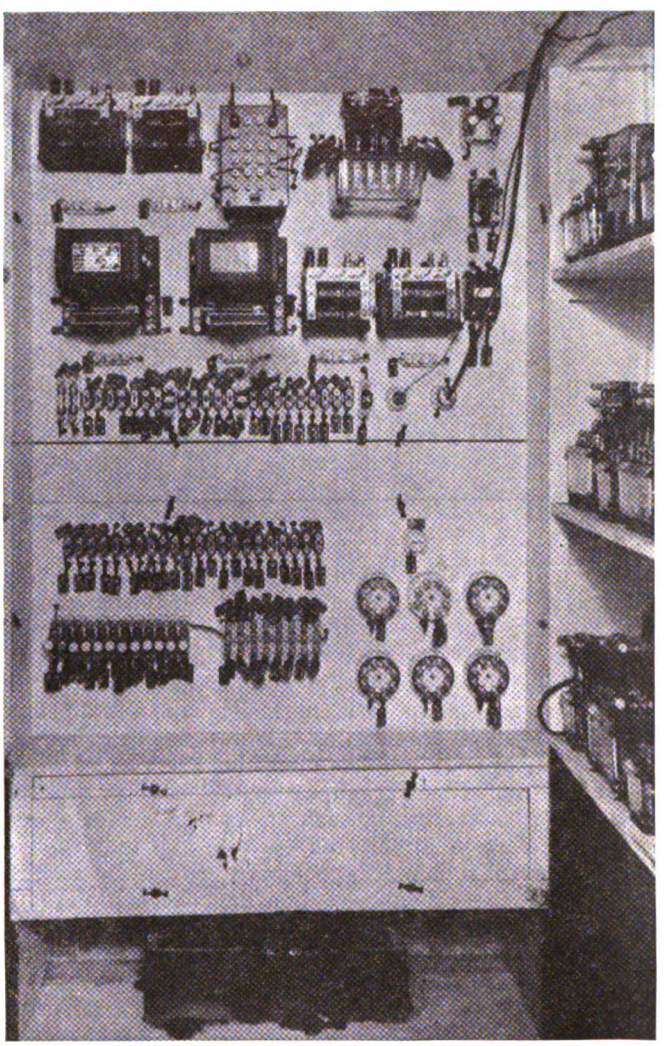
At the intermediate automatic signals, the selection to display the yellow or green aspect is accomplished by the use of a neutral and biased-neutral line relay rather than by the conventional past practice of using a polar line relay. The neutral relay is the HR relay which is so connected to the full-wave rectifier that the current flows in the same direction through the coils of the relay for either polarity of the line wire circuit. The biased-neutral relay DR has two coils and a permanent magnet, so arranged that if the electro-magnet force in the coils is of the polarity to aid that of the permanent magnet, the relay will not pick up. But if the polarity of the line circuit is reversed, so that the electro-magnetic forces oppose that of the permanent magnet, the relay will pick up. With only the HR relay picked up, the yellow aspect is displayed, the biased-neutral relay then can be furnished as polar contacts in a polar relay.

The controls for the electric switch locks on the hand-operated switches is carried on the two wires of the line control for the signals. The controls of these electric switch locks are as explained in my article on page 439 of the July, 1945 issue of *Railway Signaling,* excepting a later feature has been incorporated which is a check to be sure the door of the case of the lock is closed. If the train crew leaves without closing the door of the case, the track-occupancy lamp for the short track circuit will continue to be lighted. When such a condition happens, the dispatcher must call some one to go to the switch and close the door, and this also gives him a check on the crew that failed to operate correctly.

The C.T.C. line coding equipment is the General Railway Signal Company's Type K Class M using two line wires from Flag Center to Savanna, which is an extension of the two wires previously installed between Aurora and Steward Junction. Thus the control of signals and the power switches as well as the return of indications from the field is accomplished by conventional d.c. code impulses on these two line wires. No carrier is used.



Panel in rear of instrument house with the boards removed for access to the wire space

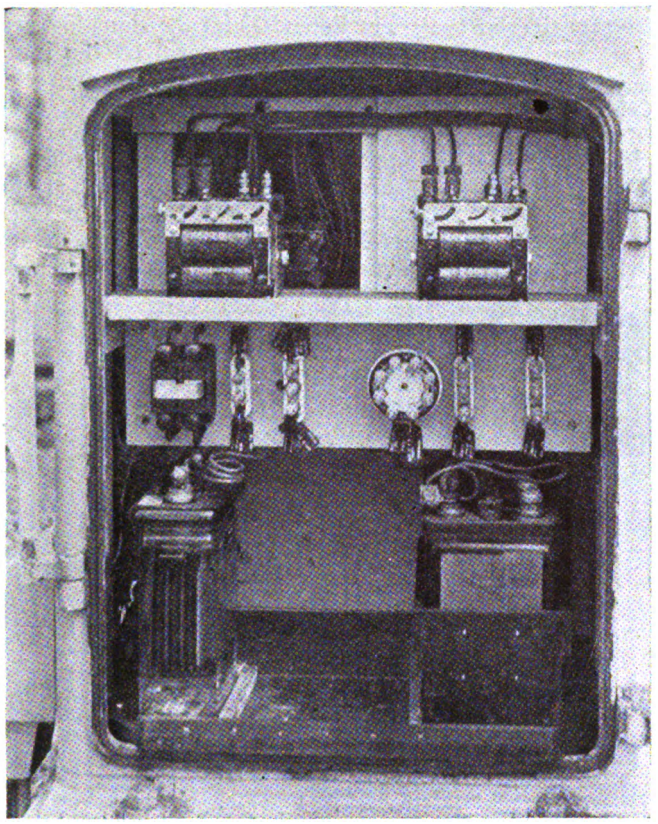


The same view of panel with board in place. Cables coming through floor are encased in box filled with sealing compound

Pole Line Wires

The line wires for the signaling system are on a crossarm on the same pole line with the telegraph and telephone wires. The two C.T.C. code wires are No. 6 AWG 40 per cent Copperweld with 3/64-in. Neoprene insulation. The tie wires which are 23 in. long, are No. 9 AWG, soft Copperweld with 2/64-in. Neoprene insulation. The line wires for the local signal line control circuits are the same wires that were used for this purpose in the previous automatic block signaling. The two wires for the 220-volt a.c. power distribution are No. 6 copper with tape and braid weatherproof covering. Commercial power at 220 volts a.c. is purchased at several towns, and is fed in both directions from each such town to include all signal, switch and track feed locations. At these locations the a.c. feeds through transformers and rectifiers to

charge storage batteries. Each track circuit is fed by one cell of 80-a.h. storage battery. At each power switch location there is a set of 12 cells storage battery which feeds the switch machine and the line code equipment.



Case containing a track battery and battery for an electric lock and circuits at hand-throw switch

At each intermediate signal location there is a set of 5 cells of battery. All this storage battery is the 9-plate chloride accumulator type, rated at 80 a.h.

The signal lamps are normally lighted through transformers from the a.c. supply. If the a.c. fails, the power-off relay cuts the lamps over to feed from battery but in such an instance, the lamps are lighted on approach control rather than constantly.

At each power switch location the relays, code equipment and storage batteries are in a 6-ft. by 9-ft. concrete house. From the factory these houses are shipped to our signal shop at Aurora where the shelves, wiring and apparatus is installed complete. Then the houses are shipped out to their respective final locations and set in place by a power crane in a work train. Then the outside wires or cables were brought into the houses and connected.

Placed in Service in Sections

As the power switches and signaling at the ends of a siding were completed, this layout under control by the dispatcher was placed in service as a remote control interlocking. With the timetable and train orders being continued for authorizing train movements, the dispatcher used the corresponding levers to control the switch and the signals at a given end of siding just as at any ordinary remotely-controlled interlocking. This practice was continued until reaching a station at which operators were on duty 24 hr., so that train orders could be issued for the territory beyond to the west. Then the section from there back to Flag Center was bulletined in service as centralized traffic control, the only difference being that the train movements were then authorized by the indications of the signals rather than by timetable and train orders. Thus the C.T.C. between Flag Center and Savanna was bulletined in service in three sections. One advantage of this procedure is that the dispatchers and the enginemen had an opportunity to become acquainted with the new signaling gradually. Another advantage is that the signal forces can check and place in final service each of the siding switch layouts as a single unit, rather than being required to change over a great many such units at a predetermined time.

This C.T.C. was engineered and constructed by the signal department forces of the Burlington, the major items of equipment, such as power switch machines, and control machine, being furnished by the General Railway Signal Company.

False Clear Signal

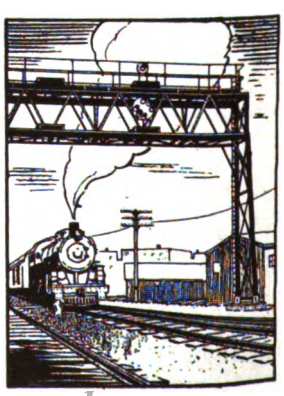
(*Continued from page* 488)

roneously thought that this condition was the result of their having made incorrect connections to the coil terminals of this relay, and they transposed the coil wire connections. After this change was made, the polar contacts were in normal position, and the control-panel indicated that the positions of the crossover switches were in correspondence with the position of the control lever, and the signalmen thought the north crossover switch also was in normal position. After completing further tests, the signalmen proceeded to the yard office at Champaign to test the interlocking machine. Before leaving the vicinity of the crossover, they did not examine the north crossover switch to determine whether this switch was in the position corresponding with the position of the control lever of the interlocking machine, and they did not look at the signal to determine if this signal was displaying a proper indication. The last test of the interlocking machine was conducted by the signalmen about five minutes prior to the time the accident occurred, and they observed no unusual condition.

In tests after the accident it was found that an error had been made in making the connections to the switch-control-lever repeating-relay. As a result of this condition, together with the transposing of the connections of the switch repeating-relay, the north crossover switch was in position for entry to the crossover when the lever in control of this switch was in normal position, and false proceed indications were displayed by the signals.

It is found that this accident was caused by a train entering a crossover at a high rate of speed, as a result of approach and home signals of an interlocking displaying false proceed indications.

By the Commission, Commissioner Patterson.



New Signal Control Line Circuits

in Centralized Traffic Control Territory

on the Burlington*

By W. F. ZANE
Signal Engineer
Chicago, Burlington & Quincy

Two-wire either-direction line circuits, controlling the signals in both directions in C.T.C. station-to-station blocks, have battery connected at both ends when dormant

THE Chicago, Burlington & Quincy has installed centralized traffic control on a 131-mile subdivision between Hastings, Neb., and McCook, this being a portion of the through route between Chicago and Denver. Color-light automatic block signals, previously in service on this territory, were retained in service as intermediate signals, but new searchlight type signals were installed at C.T.C. controlled locations. The automatic block signaling previously in service included d.c. neutral track circuits, and these were continued in service. The additional OS track circuits are the same type.

Two-Wire Either-Direction Line Circuits With Biased-Neutral Relays

The A.P.B. signal line control circuits were converted to new two-wire either-direction line circuits, which in a station-to-station block, are used to control the eastward signals for an eastbound train movement, or the westward signals for a westbound train movement. An important new feature of the circuits as used on the Burlington is that when in the dormant condition, battery is connected to the line circuits at both ends. Therefore, when eastward signals, for example, are to be cleared, one code control is sent out from the office and that goes to the field station at the signal to be cleared which, in the example being discussed, is at the east end of the station-to-station block. Another new feature of the Burlington circuits is that at the intermediate double signal locations the line circuits extend through back contacts of the HR and SR stick relays for the opposing direction.

Neutral and Biased-Neutral Line Relays

At the intermediate automatic block color-light signals, the selection to display the yellow or the green aspect is accomplished by the use of a neutral and a biased-neutral line relay rather than by the conventional past practice of using a polar line relay. The two relays are connected as shown in the accompanying diagram.

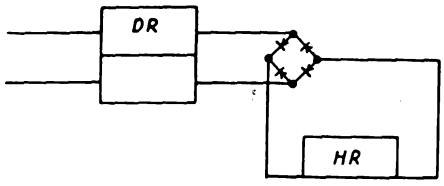
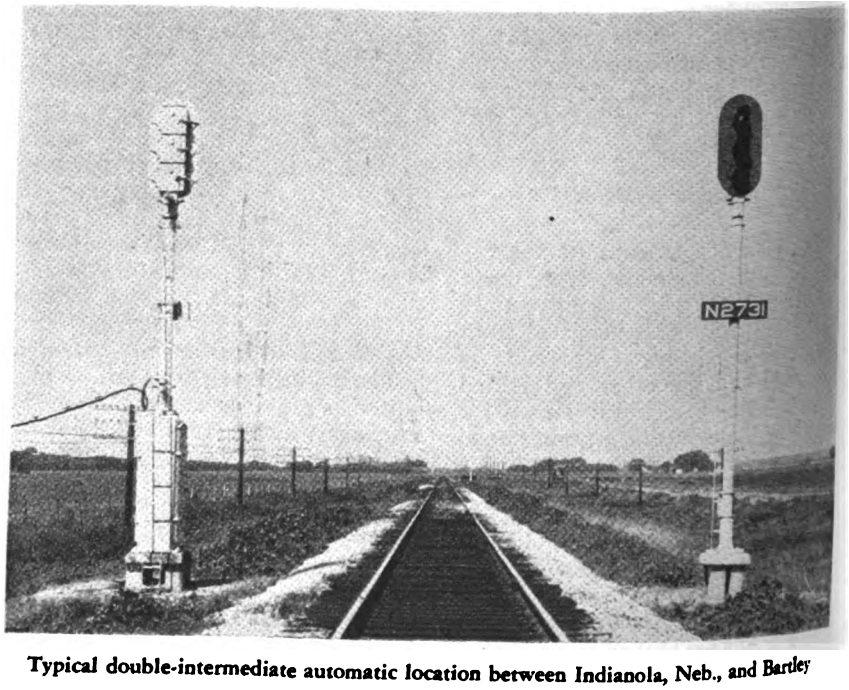


Fig. 1—Connection of relays

Fig. 1. The neutral relay is the HR relay which is so connected to the full-wave rectifier that the current flows in the same direction through the coil of the relay for either polarity of the line wire circuit.

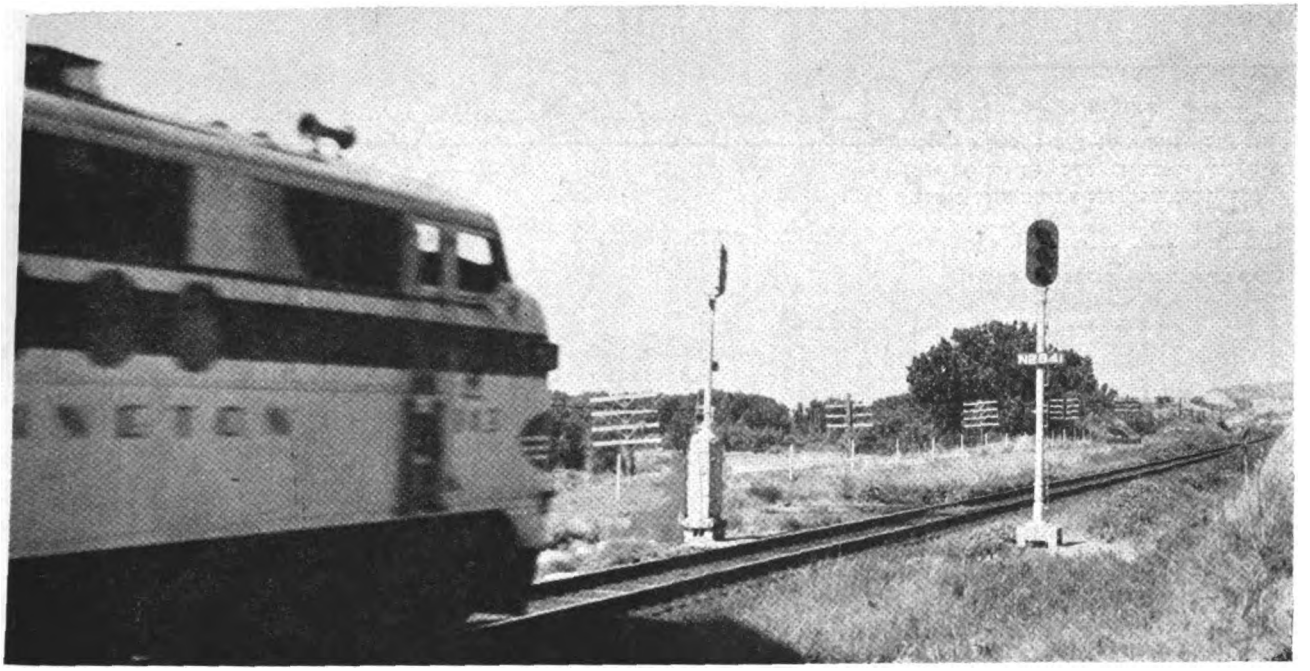
Two-Coil Relay

The biased-neutral relay DR has two coils connected, as shown in Fig. 1, and this relay has a permanent magnet so arranged that if the electro-magnetic force in the coils is of the polarity to aid that of the permanent magnet the relay will not pick up, but if the polarity of the line



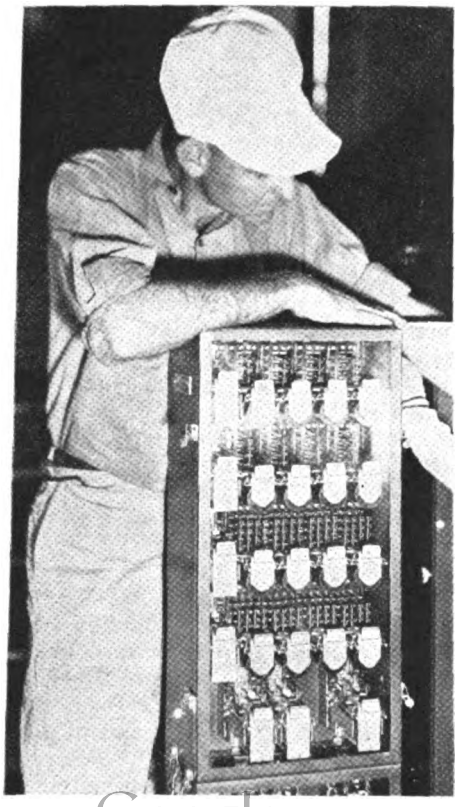
Typical double-intermediate automatic location between Indianola, Neb., and Bartley

*This article is the second of two to appear on the installation of C.T.C. on 131 miles of the C.B. & Q. between Hastings, Neb., and McCook. The first article appeared on page 528 of the August issue of *Railway Signaling*, and should be read first in order to obtain a full understanding of the entire installation, operation thereof, and the circuits explained in this article.



Westbound freight at double-intermediate location N2841-S2842 in the Narrows along the Republic river east of McCook, Neb.

Left—Interior of concrete instrument house at Oxford, Neb., showing part of the equipment. Right—Maintainer E. B. Bright working at rear of C.T.C. machine at McCook



circuit is reversed, so that the electromagnetic force opposes that of the permanent magnet, the relay will pick up. With only the HR relay picked up, the yellow aspect is displayed, but when the polarity of the line circuit is reversed, the DR relay is picked up also to cause the green aspect to be displayed. An advantage is that more contacts are available in the biased-neutral relay than can be furnished as polar contacts in a polar relay.

Details of Circuits

The accompanying diagrams, Fig. 2, show a typical station-to-station block with two double-intermediate automatic signal locations. In this arrangement the circuits are so designed that traffic direction between the two passing tracks is always set

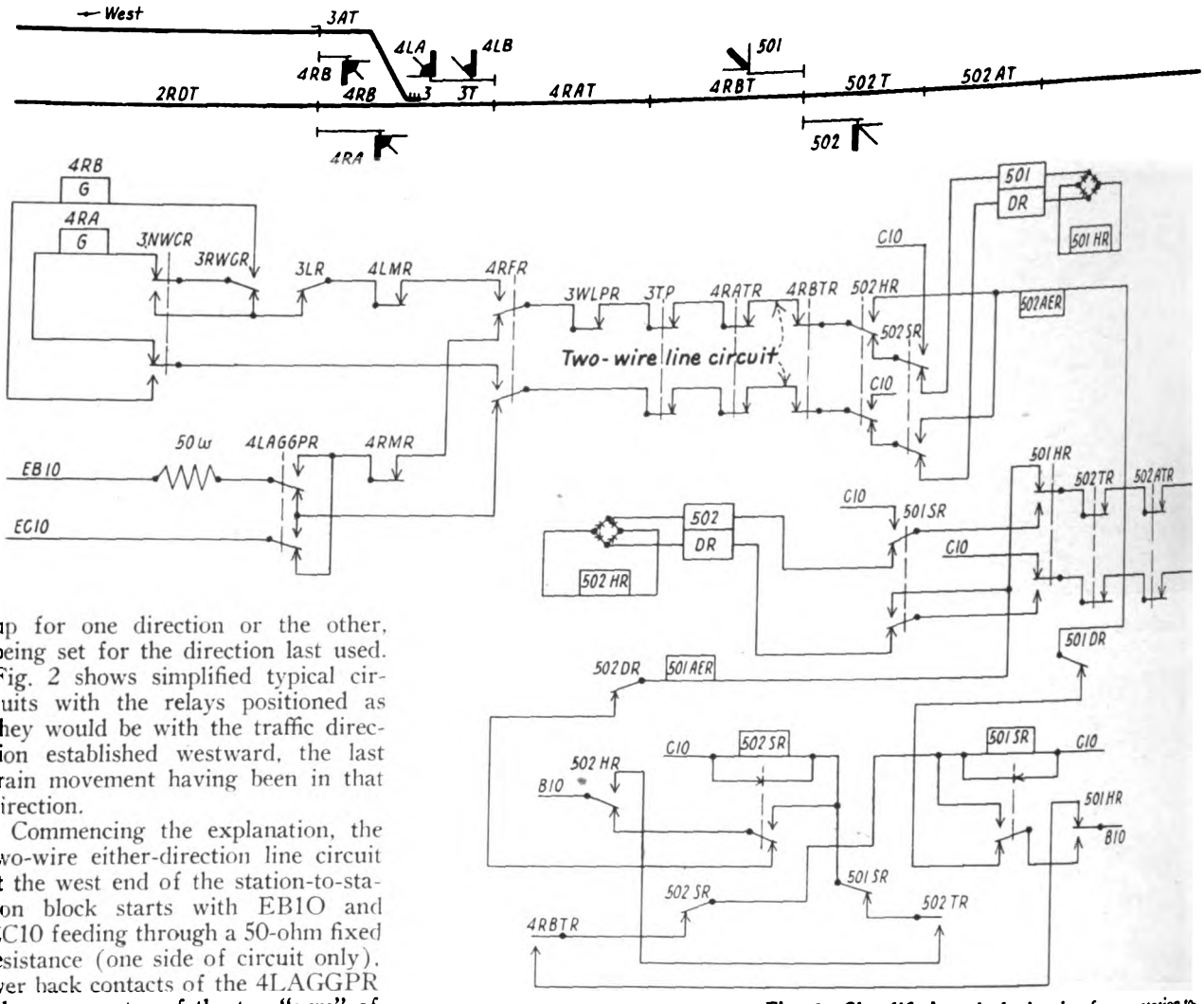


Fig. 2—Simplified typical circuits for a station-to-

up for one direction or the other, being set for the direction last used. Fig. 2 shows simplified typical circuits with the relays positioned as they would be with the traffic direction established westward, the last train movement having been in that direction.

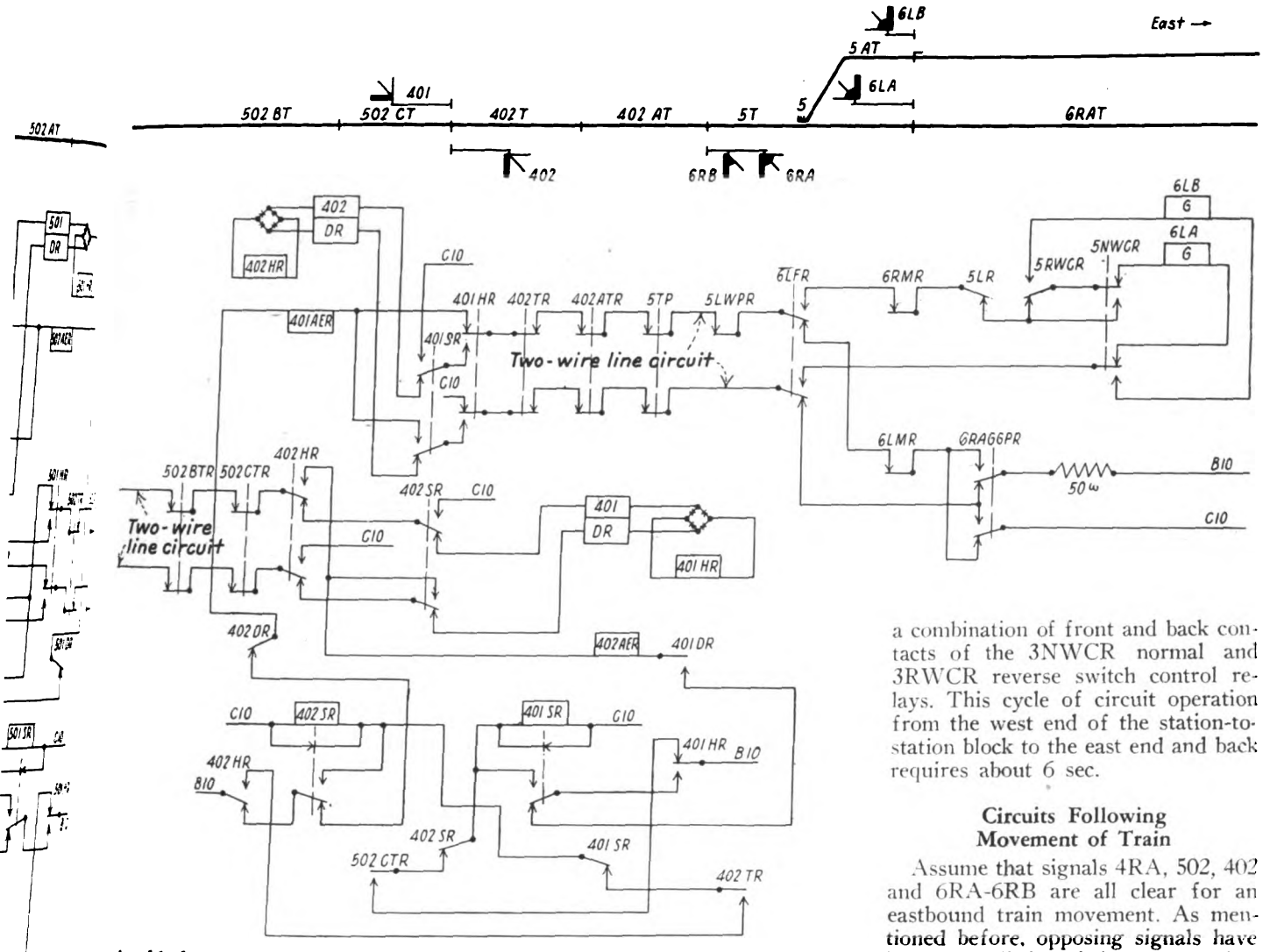
Commencing the explanation, the two-wire either-direction line circuit at the west end of the station-to-station block starts with EB1O and EC10 feeding through a 50-ohm fixed resistance (one side of circuit only), over back contacts of the 4LAGGPR relay, a repeater of the top "arm" of signal 4LA-4LB cleared to green, over a front contact of the 4RMR relay (one side of circuit only), a red repeater of signal 4R, over back contacts of the 4RFR eastward traffic relay, over a front contact of the 3WLPR switch lock repeater relay (one side of circuit only), over front contacts of the 3TP track repeater and 4RATR track relays, and thence to line eastward. This circuit continues eastward to the first double-intermediate signal location 501-502, where it breaks over front contacts of the 4RBTR track relay, back contacts of the 502HR home and 502SR stick relays, through the two coils of the neutral-biased distant relay 501DR, the principles of which were described heretofore, and thence through a full-wave rectifier to the 501HR home relay.

From signal location 501-502, a similar two-wire either-direction line circuit extends to the next double-intermediate signal location 401-402, and then another extends from the latter location to the east end of the station-to-station block. The description thus far has treated these circuits in their normal state, all C.T.C. controlled signals being at stop, and the direction of traffic being established westward due to the last train movement having been in that direction. Consequently both eastward intermediate automatic signals are knocked down to their most restrictive aspect, and westward signals are cleared to the most permissive aspects.

When code for clearing eastward station-departure signal 4RA or 4RB is received at the field station at the west end of the station-to-station block, the eastward traffic relay is picked up over a front contact of the eastward signal control code application relay RGZ in the field coding unit. Neither the RGZ nor 4RFR relay controls are shown in the accompanying circuits.

With the 4RFR relay up, positive battery EB10 and negative battery EC10, which had ben feeding eastward over the line circuit, as described heretofore, is opened. This makes no difference in the position of the 501DR relay at signal location 501-502, as it was already down. However, the line energy having been opened, does result in the de-energization of the 501HR relay, causing the westward automatic signal 501 to assume its most restrictive aspect. With the 501HR relay down at signal location 501-502, positive battery B10 and negative battery C10, feeding eastward over the next two-wire line circuit, is also opened, which results in the de-energization of both the 401DR and 401HR relays at the next intermediate signal location 401-402. At this location, with both the 401DR and 401HR relays de-energized, signal 401 is, likewise, controlled to its most restrictive aspect. The 401DR and 401HR relays down, positive battery B10 and negative battery C10 feeding over the next two-wire line circuit eastward from signal location 401-402 to the east end of the station-to-station block, is similarly opened. However, the line circuit extends eastward to positive battery B10 and negative battery C10 at the east end of the station-to-station block.

With the line circuits in this con-



station block, showing the two-wire line circuit

dition, the positive battery B10 and negative battery C10, just mentioned, feeds westward over the line circuit to signal location 401-402 to control the 402HR and 402DR relays. Since the 401HR relay is down, this is accomplished by the circuit extending over back contacts of the 401HR and 401SR relays. Relay 402HR is a neutral relay and relay 402DR is a biased-neutral relay, as described before.

If signal 6RA-6RB is at Stop or Restricting, the 6RAGGPR relay will remain down, and, therefore, only the 402HR relay will pick up for controlling signal 402 to Approach. On the other hand, if signal 6RA-6RB is cleared to a more favorable aspect than Stop or Restricting, the 6RAGGPR relay is energized. This action pole changes the line circuit westward, causing the 402DR biased-neutral relay to pick up, as described before, and in addition, to control signal 402 to the Clear aspect.

The 402HR relay energized results in positive battery B10 feeding over a back contact of the 401HR relay, de-energized as described before, over back contacts of the 401SR and 401DR relays, de-energized as explained heretofore, through the coils of the 402AER approach-lighting relay, over a front contact of the 402HR relay and thence to line and westward over a front contact of the 502CTR relay.

Negative battery C10 for this circuit is picked up over another front contact of the 402HR relay. Thus, the line circuit is energized westward to signal location 501-502. The operation of the circuits at this location is identical to that at location 401-402, and which cascades the energized line westward to the west end of the station-to-station block.

As described before, the 4RFR relay is up, and as a result the energy on the line from intermediate location 501-502 is fed over front contacts of that relay ot the searchlight operating mechanism of signal 4RA or 4RB, breaking on one side only over a front and back contact of the 4LMR and 3LR relays, respectively. Clearing of either signal is selected over a combination of front and back contacts of the 3NWCR normal and 3RWCR reverse switch control relays. This cycle of circuit operation from the west end of the station-to-station block to the east end and back requires about 6 sec.

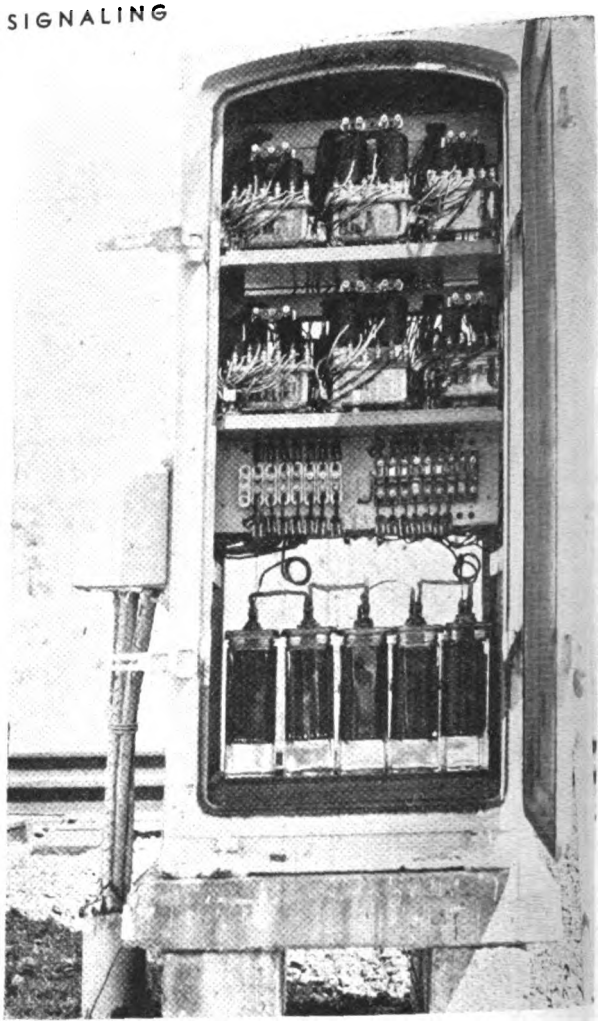
Circuits Following Movement of Train

Assume that signals 4RA, 502, 402 and 6RA-6RB are all clear for an eastbound train movement. As mentioned before, opposing signals have been controlled to their most restrictive aspects. When the eastbound train passes station departure signal 4RA and enters track section 3T, the 3TP track repeater relay drops and opens the line circuit, which causes signal 4RA to display Stop. The line circuit is again opened when the train enters track section 4RAT and drops the 4RAT relay, through which the line circuit passes over front contacts. At signal location 501-502, when the train enters track section 4RBT, the 4RBTR track relay drops, again again opening the line circuit. When the train passes signal 502, the 502TR relay drops, which opens the line circuit from the east, causing relay 502HR to drop and cause signal 502 to display Stop. Also when the 502TR relay drops a circuit is completed, momentarily before the 502HR relay has a chance to drop, to pick up the 502SR stick relay to hold traffic direction eastward. This circuit starts momentarily with positive battery B10 over a front contact of the 502HR relay, back contacts of the 502TR and 501SR relays, through the coils of the 502SR relay, and thence to negative battery C10. When the

502HR relay drops, positive battery B10 feeds over a back contact of that relay and a front stick contact of the 502SR relay to hold that relay up. With the 502SR relay up energy is prepared to be fed westward on the line circuit over front contacts of the 502SR relay, and furthermore the 501DR and 502HR relay circuits are open to retain signal 501 at Stop. When the train clears track section 4RBT, energy again flows westward to permit clearing of signal 4RA or 4RB for another eastbound movement if desired. On the other hand, if the 4RFR relay has been released with the restoration of C.T.C. machine levers to normal, energy also feeds eastward from that location to signal location 501-502, thus placing energy on the line at both ends as mentioned heretofore.

When the train clears the track section between signal locations 501-502 and 401-402 the 502HR relay, but not the 502DR relay, again picks up, controlling signal 502 to Approach. The 502SR relay circuit also is opened when the 502HR relay again picks up, the second pick-up circuit for 502SR relay already being reopened when the 502TR relay again picked up. Signal 501 is retained at Stop, because energy is fed west over the line with the 502HR relay up instead of the 502SR, and relays 501DR and 501HR are still down.

The circuit operation at signal location 401-402 is similar to that at location 501-502. When the train clears signal 6RA-6RB the 402HR relay again picks up and pole changes the line circuit west, causing the biased-neutral relay 502DR to function and clear signal 502 to green. When the eastbound train has cleared the track section between signal location 401-402 and 6RA-6RB, controls are effected to clear signal 402 to yellow. Signal 401 is retained at Stop by controls similar to signal 501.

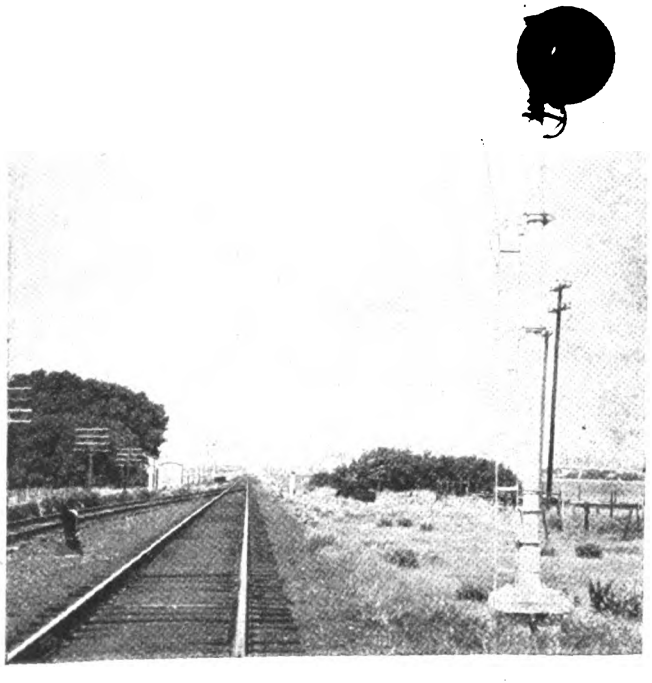


Interior of a typical base-of-mast instrument case at double intermediate automatic signal location

Traffic direction is maintained until the eastbound train is by signal 6LA or 6LB, after which it can be changed if desired. In lining up for a westbound train movement the function of the two-wire either-direction line circuit is similar to that for an eastbound train movement.

The two wires in the line controls for signals are used also in the controls for the electric locks on hand-throw switches. The circuit schemes for the automatic controls of these locks were explained on page 439 of the July, 1945 issue of *Railway Signaling*, a new feature of the 1946 installation being a check to be sure that the door of the lock case is closed. If a train crew departs without closing the door of the case for the electric lock, the track occupancy lamp for the short track circuit will continue to be lighted. In such an instance the dispatcher must call someone to go to the switch and close the door.

This C.T.C. installation was engineered and installed by the Burlington signal forces. The major items of signaling equipment were furnished by the General Railway Signal Co.



Typical high and dwarf station-leaving signals at the west end of Arapahoe, Neb.