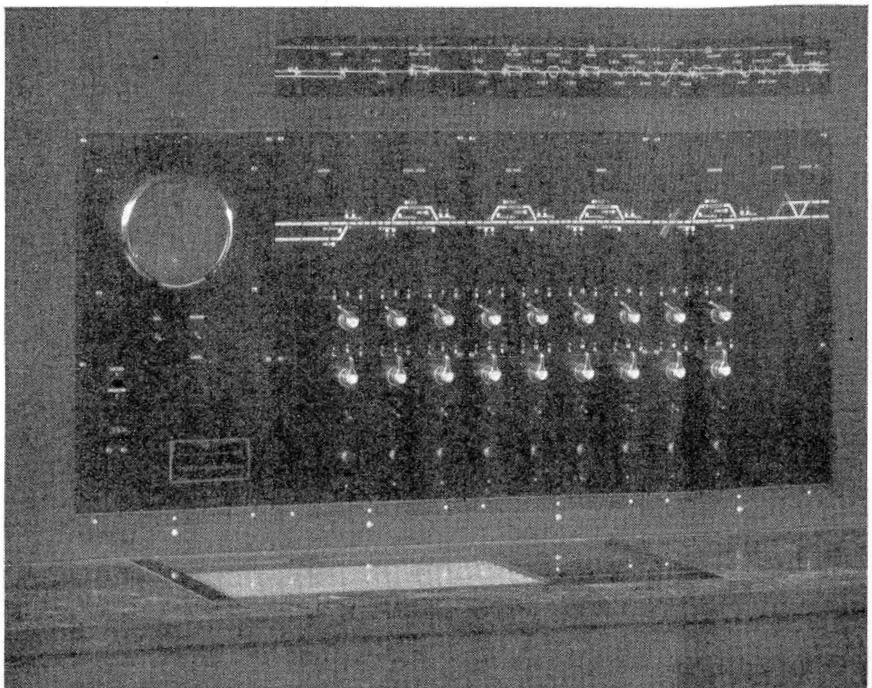
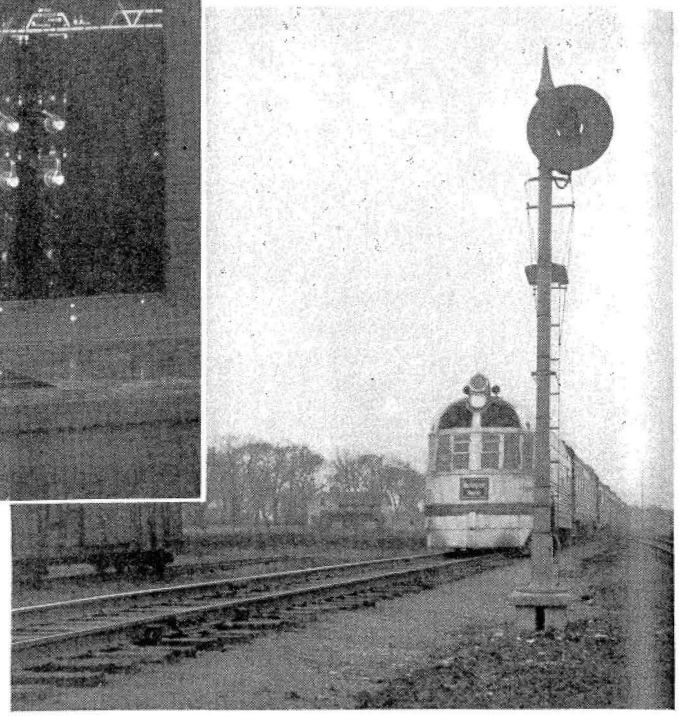
Centralized





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

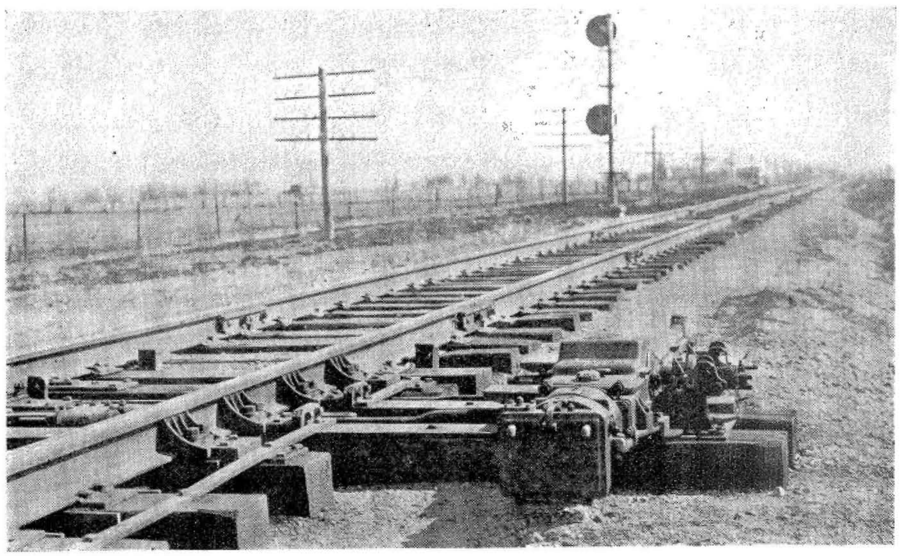
Prior to the installation of C.T.C., sidings were located at Sugar Grove, Big Rock, Hinckley, Waterman, Shabbona and Lee, with advance sidings at Aurora and at Steward Junction. The siding at Big Rock was ex-

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.

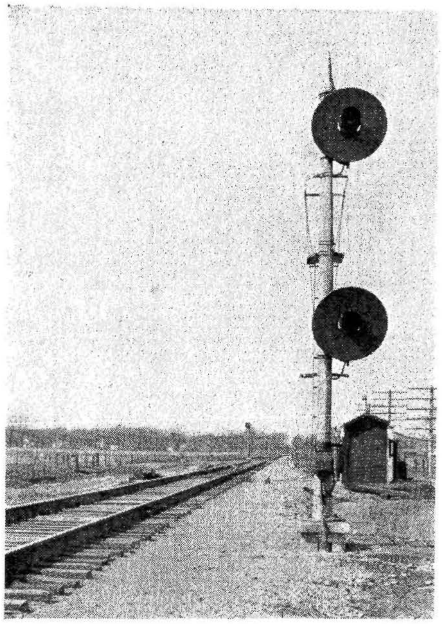
The east end of the advance siding at Aurora is included in the interlocking at Aurora. The sidings at Hinckley, Waterman and Lee were shortened, and their use confined to trains doing local work. All hand-throw switches in the entire territory were provided with electric locks.

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.

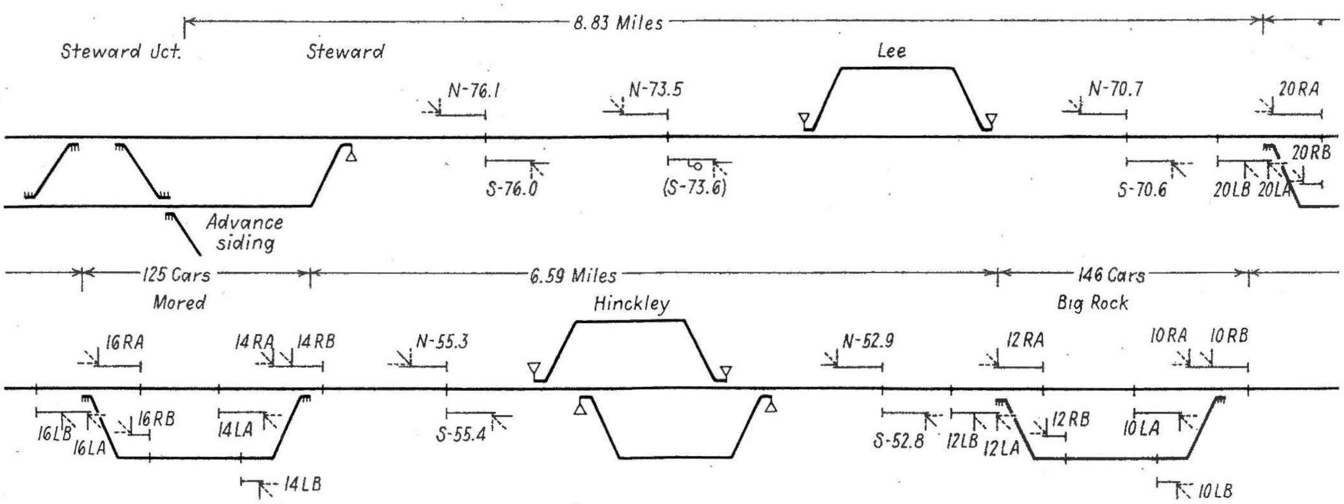
The C.T.C. control machine is located in the office at Aurora and is manipulated by the dispatcher. Nine levers each control an electric switch machine at an end of a siding. Nine signal levers each control four signals at a corresponding end of a siding. Indication lamps above each switch lever repeat 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

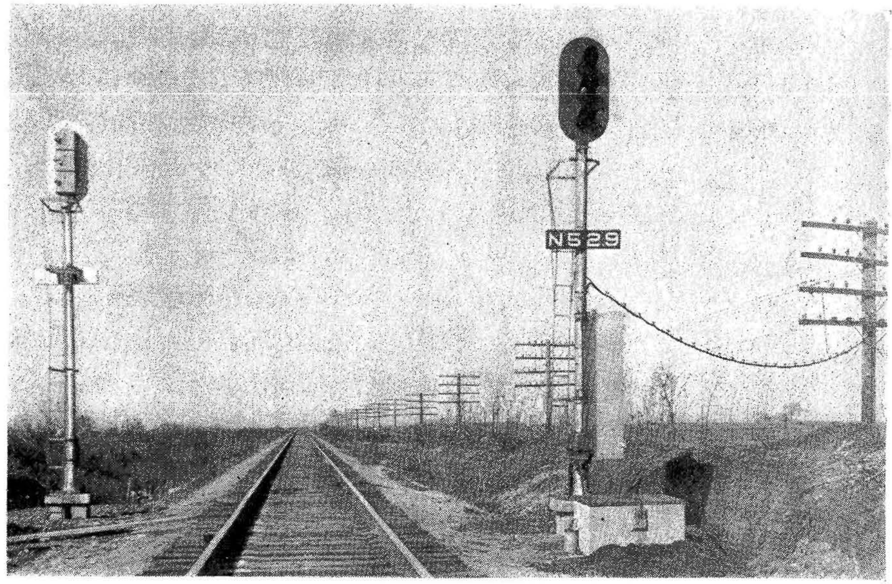
The desk portion of the control machine includes an automatic train graph. Horizontal lines, on the constantly moving graph sheet, represent the passage of time, and vertical lines each represent the location of OS points which, in the field, are the locations of power switches and the approach annunciator 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.

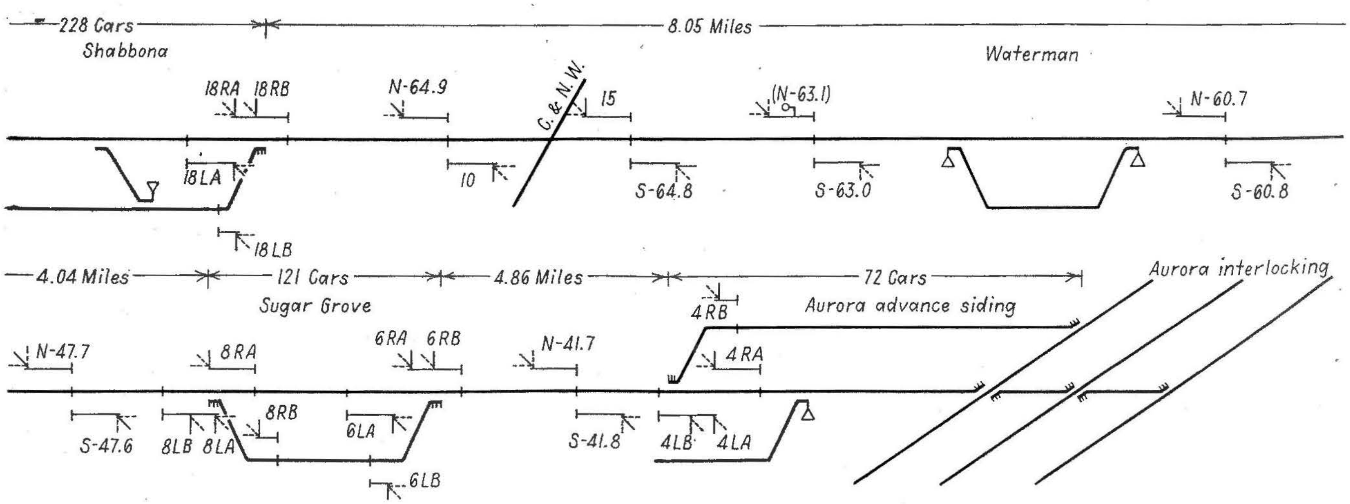


Typical intermediate automatic signal location

Interesting Change-Over Method

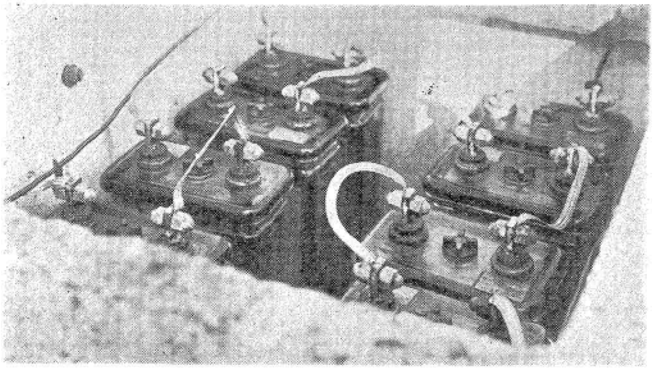
In view of the fact that automatic block signal protection had been in service on this territory previously, this form of protection was continued in service during the construction and change-over to centralized traffic control. As the new color-light signals were installed, the old lower-quadrant semaphore 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.



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

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-



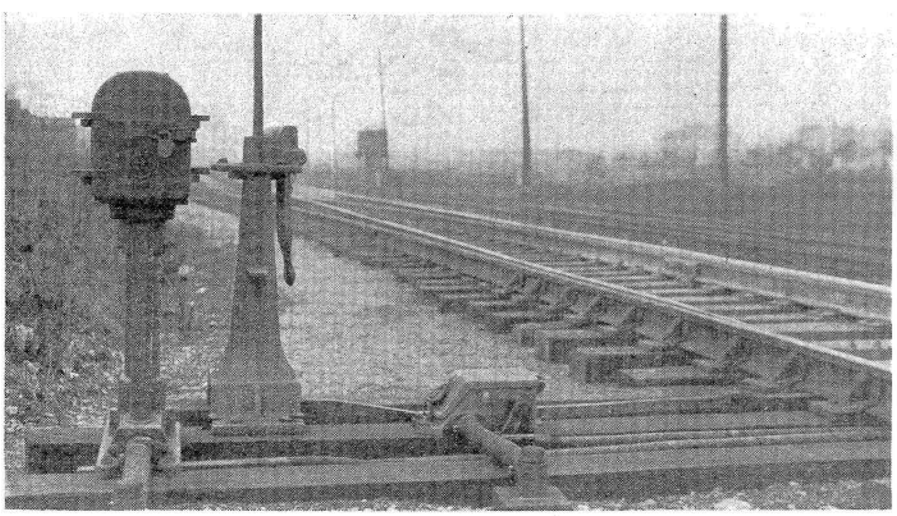
At the intermediate signal location the storage battery is located in boxes

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 preference 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.

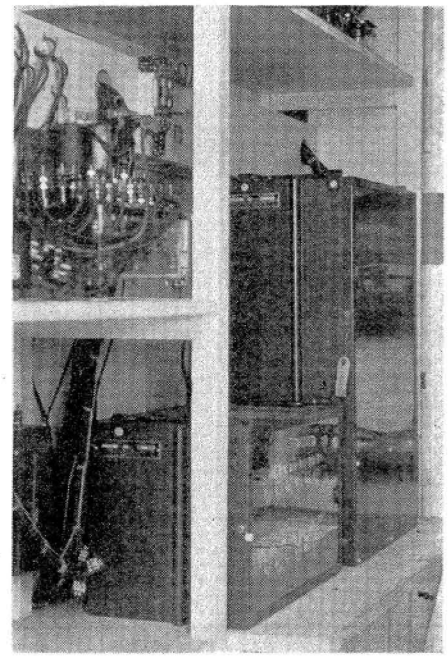


The electric lock as applied on each of the hand throw main line switches

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.

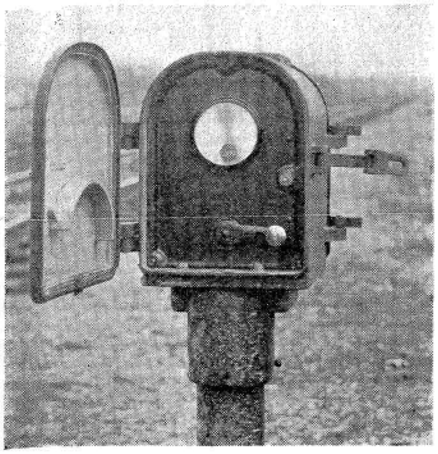
The previous A.P.B. line control circuits used five line wires, two wires in connection with common for control of eastward signals and two wires in connection with common for the westward signals. This A.P.B. line control system, using neutral circuits, was replaced with a three-wire polarized line 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

Control of Electric Locks on Hand-Throw Switches

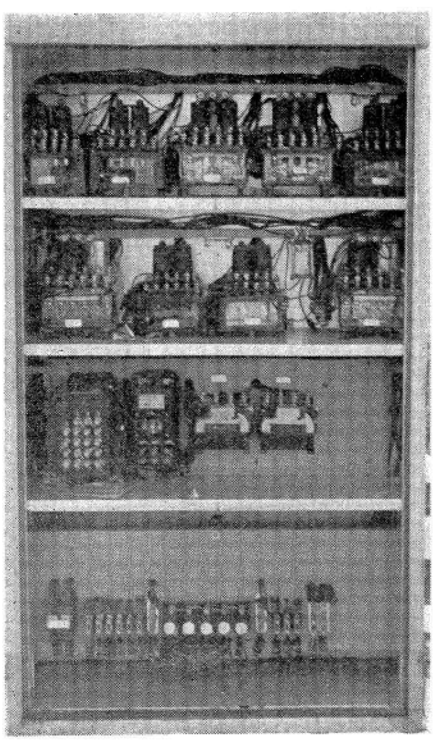
The electric locks on the hand-throw switches are controlled automatically. When a train, such as a local freight, is to use one of these turnouts, the train must, of course, be brought to a stop on the main line. In order to effect a release of the electric lock, a short track circuit in approach to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

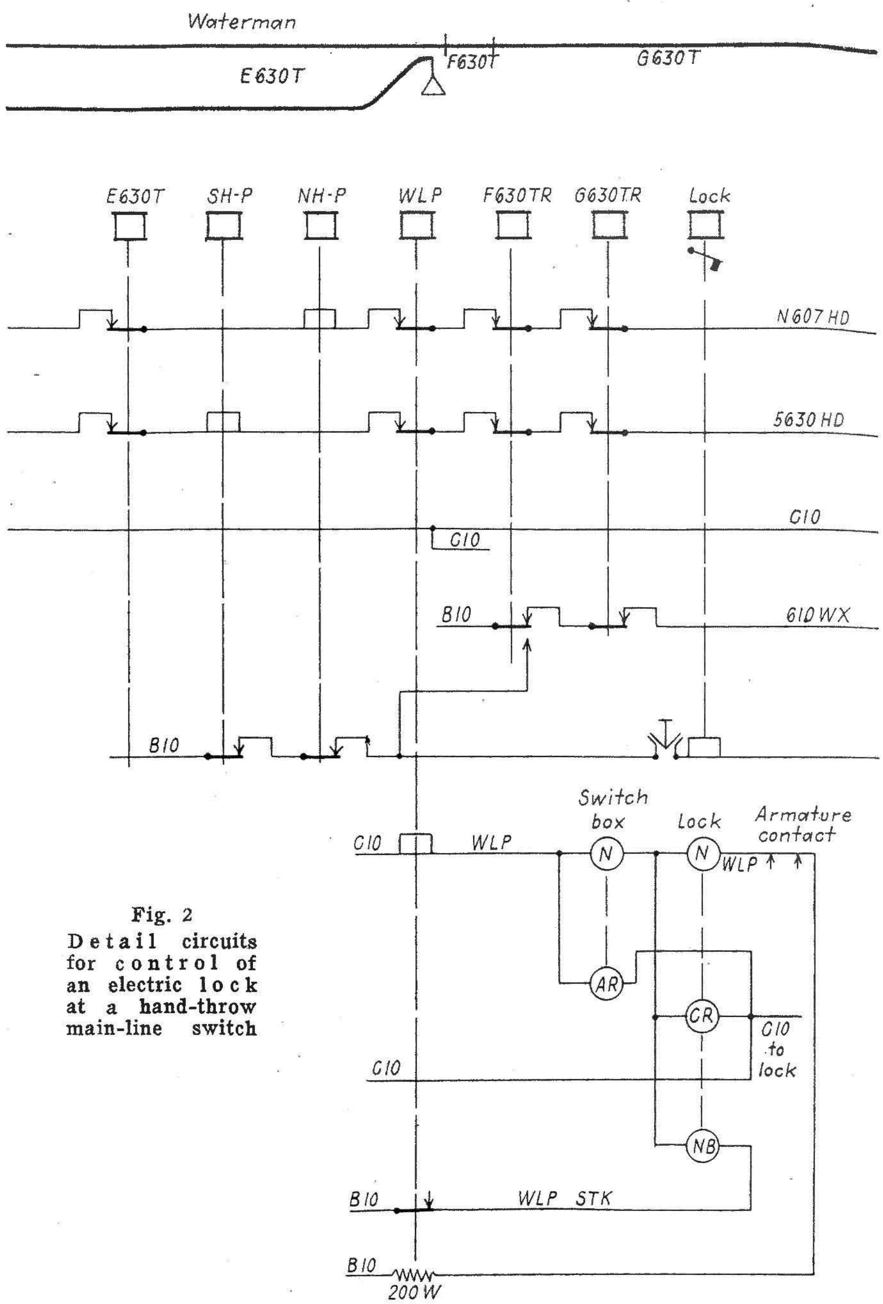


Fig. 2
Detail circuits for control of an electric lock at a hand-throw main-line switch

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 S630HD. 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.

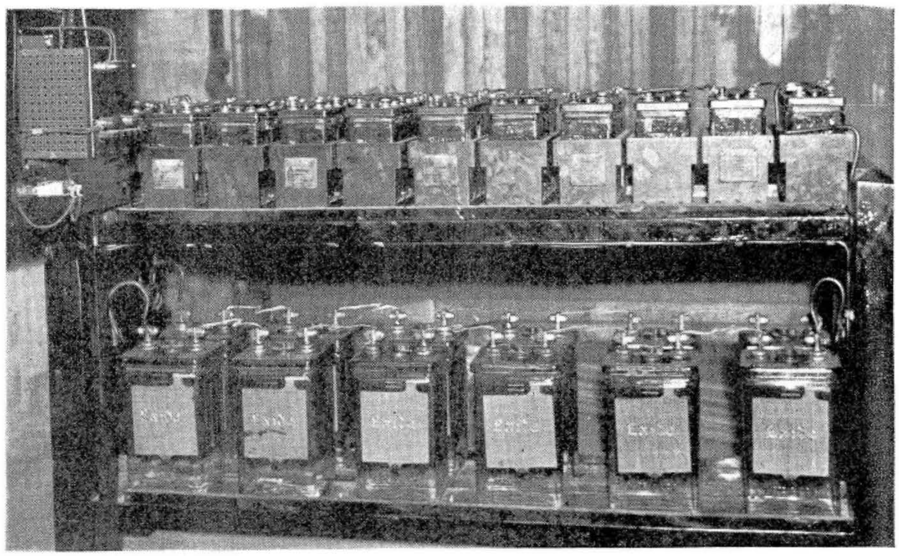
A switch and lock repeater relay, WLP, is used at each lock location. This WLP relay is energized by a circuit which checks the normal position of the switch, the normal position of the lock plunger, and a back contact of the lock armature. The signal control line circuits are taken through front contacts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

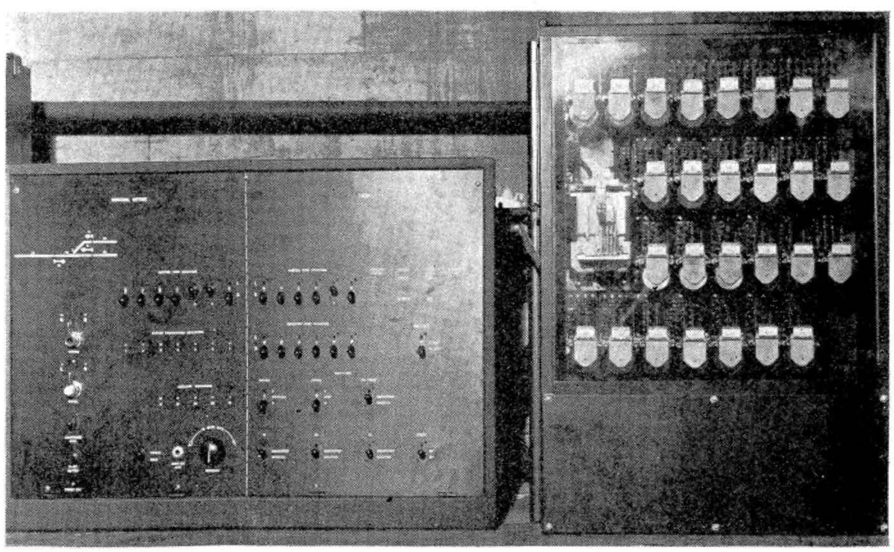
The signaling line wires are on a crossarm on an existing pole line used also for communication line circuits. In order to conserve copper, the previously existing No. 8 bare galvanized iron line wires for the signal line controls were re-arranged as required and were continued in service as a part of 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