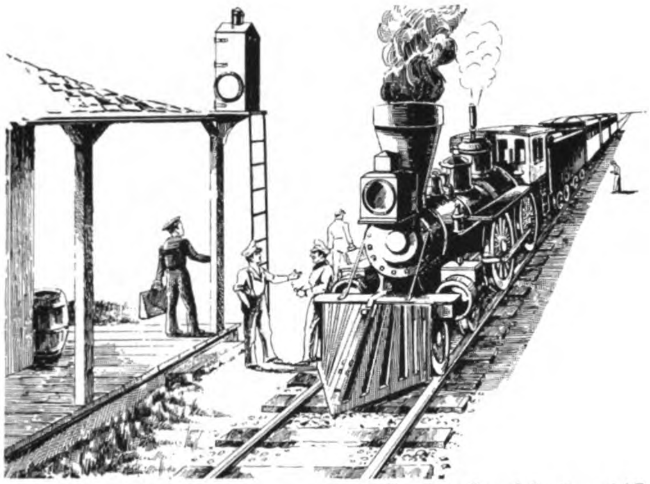
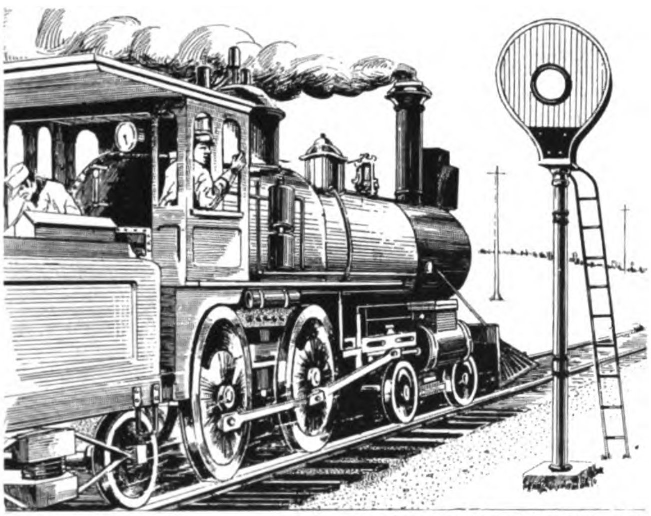
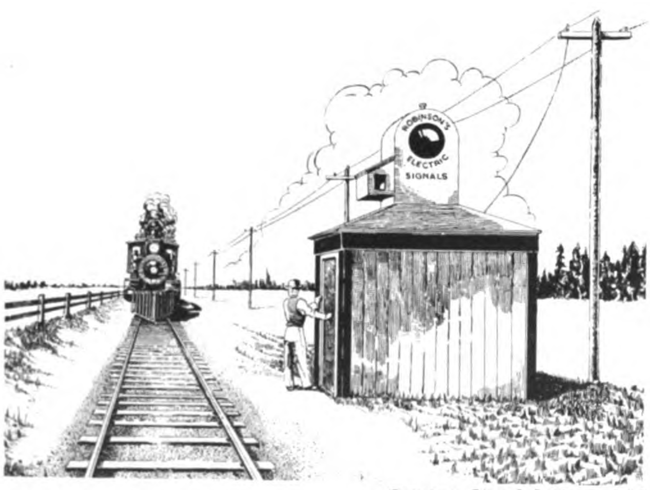
Signaling . . .
Manual to Automatic



First manual block on UNJR&C in 1863



First automatic block controlled by track circuit, 1872



Automatic block, controlled by treadles, on NH in 1867

In the 50 years since this magazine was started in 1908, the several forms of signaling and practices for authorizing train movements have been consolidated into one system of train operation by signal indication. How and why this was done, and what can be expected for the future will now be discussed.

How Train Movements Were Authorized

In the early days, trains were authorized to move according to strict adherence to printed timetables. If a train encountered delay, other trains were required to wait at the meeting points. Instructions to vary from the timetable, under authority of train orders, were first introduced on the Erie in 1851.

In the timetable and train order practice, if trains are late or extra trains are operated, movements are authorized by train orders issued by the dispatcher. These orders are transmitted by telegraph or telephone to wayside offices where operators deliver them in written form to train and engine crews. This practice, which is still in use on 109,436 miles of road in the United States, limits track capacity, and results in train accidents caused by errors in preparing, transmitting, understanding and obeying train orders.

Manual Block

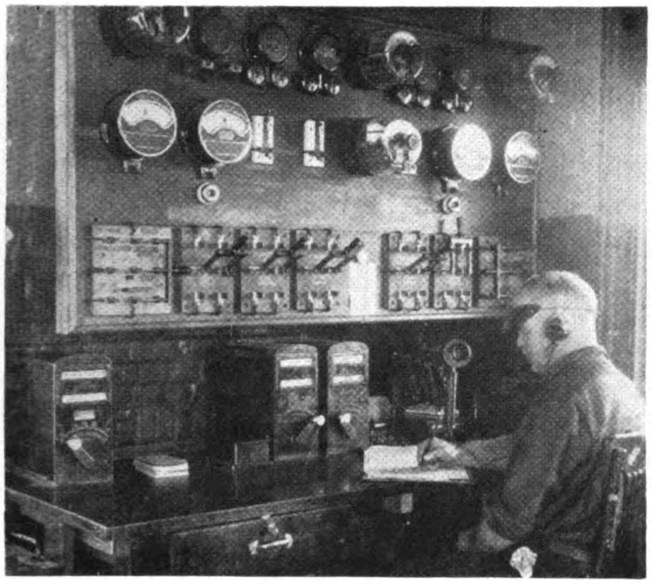
During a dark night in 1863 the United New Jersey Railroad & Canal Company (now PRR) had a disastrous rear-end collision. Soon after, Asbel Welch, general president, developed and installed the first manual block signal system in America. Signals were located at offices about five miles apart, a man being on duty at each office. Telegraph was used as communication. Each signal consisted of a wooden box enclosing a red cloth disk or banner, and a lamp, in line with an opening in the box. Normally the red aspect was displayed. To authorize "Proceed," the operator pulled a rod to hold the red banner in the upper part of the box.

This system was extended on about 90 miles between Jersey City and Philadelphia, and later was applied on extended mileages on numerous railroads. The term "absolute" manual block is applied where use of a block is confined exclusively to the movement of one train. The manual block system limits track capacity and requires numerous block operators. This system is still in service on nearly 29,000 miles of main track in the United States.

Automatic Block for Safety

In 1867 the New Haven installed some automatic signals, made by Thomas S. Hall, Hartford, Conn. These were enclosed disc type signals operated by electro-magnets. They were controlled automatically by wayside treadles mounted alongside the rail. These treadles were operated by the wheels of passing trains.

The track circuit, invented by William Robinson in 1872, was installed in automatic signaling the same year on the Philadelphia & Erie (now PRR). This marked the first use of the closed-rail track circuit, which has ever since been recognized as the only safe means by which



Big three-way knife switches on board controlled signals in this MP control office project in 1925

This is the control machine for first centralized traffic control installation; on the NYC in 1927

Signaling "Came of Age" in '27

Prior to 1925 a great many railroads had two independent signal systems, (1) automatic block to prevent collisions between trains on line of road, and (2) interlockings, each of which was for operation of switches and home signals within a limited area of perhaps 700 ft maximum. However, neither the automatic signals nor conventional interlocking home signals were used to authorize trains to move. This authority, on a large percentage of the mileage, was given by the timetable and train order system, which involved numerous delays and considerable hazard.

On some short sections of single track, such as over long bridges or through long tunnels. track-circuit-controlled traffic locking was in service between interlockings at the two ends, so that home signals were used to authorize train movements either way on the one track.

In 1925, the Illinois Central installed a system of train operation by signal indication both directions on each track of double track on 20 miles, with interlockings for crossover moves, spaced an average of 5 miles. Each track was signaled for train movements both ways just like two single tracks side by side, and all signals were track-circuit-controlled. Thus this project was a "first," in several respects. (April 1925, p 139.)

On Entire Engine District

Use of signals to authorize train movements over extended sections of track, up to an entire engine district, had been the dream of railroad signal men for years. The principal objective was to eliminate the delays inherent in the timetable and train order practice of authorizing train movements. Another objective was to include power operation of switches at sidings and junctions, thus eliminating train stops and delays while trainmen operated hand-throw switches.

It seems that the Missouri Pacific was the first road to install a complete single-track system, including interlocked switches at ends of sidings, and signals at these switches for authorizing train movements without written train orders, over an extended territory of an operating subdivision. This project, completed in 1925, on 56 miles of single track between Kansas City, Mo., and Osawatomie, Kan., included four separate mechanical interlockings and remote control power interlockings for operation of switches. Track circuit controlled manual block was used between interlockings. This installation, and the one on the IC mentioned above, proved that such a system would accomplish the objectives desired with respect to movement of trains, but the operating expenses for levermen's wages were too high.

This problem was solved by application of two new and important practices. Interconnections of circuits were developed for use at each power switch layout to accomplsh the locking between switches and signals. This eliminated the need for mechanical locking between levers and for electric locks on levers in the control machine.

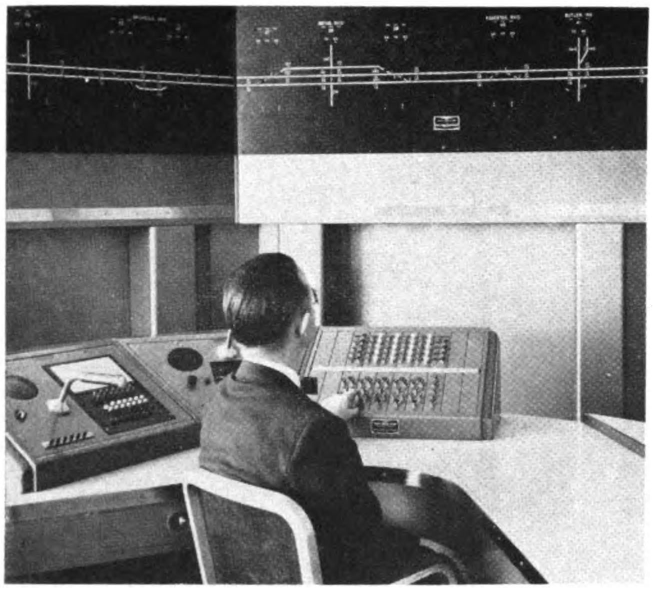
Acceptance of this practice confined the requirement for line circuits to only those necessary to transmit controls from one central office to all field locations, and to return indications from each field location to the central office. This was accomplished in 1927 on 37 miles of single track and 3 miles of double track between Stanley, Ohio, and Berwick, Ohio, on the New York Central. This was called the unit-wire system, in which one wire from the control office to each power switch (in connection with a line common) served to control the switch and signals at the end of a siding, and to carry back the necessary indications.

By 1929, quick-action line-coding equipment was developed, whereby outgoing controls and incoming indications can be handled on one pair of line wires from one central office, through all of the power switch and controlled signal locations on an entire project.

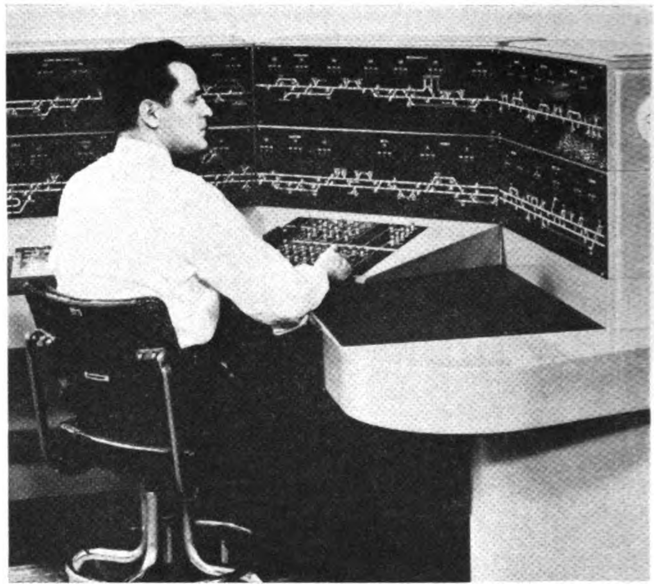
These were the developments, between 1925 and 1927, that enabled the railroads to combine interlocking and automatic block into a new system of signaling, known as centralized traffic control. Thus 1927 marks the date when signaling "came of age" in the field of train operation.

CTC on Single Track

Up to now, centralized traffic control has been installed on about 20,000 miles of single track, most of which can be classed as important heavy traffic



In 1957 a selective type, compact control machine was developed; the first one was installed on NYC at Toledo



Another type of compact control machine was developed in 1958, the first being scheduled for installation on C&O

through routes. Typical modern projects are AT&SF, April 1957, p 22 and SP May 1957, p 26. Nearly all of this CTC is the conventional type, including power switch machines and complete arrangements of dispatcher-controlled signals at both ends of sidings. Railroads will continue to install this type of CTC on heavy-traffic lines.

In addition there is a demand for modified CTC on nearly 35,000 miles, which includes about 10,000 miles not previously signaled, as well as perhaps 25,000 miles where existing automatic block can profitably be replaced with CTC. On such lines, the problem is to modify the signaling so that the CTC can be justified by the traffic volume and reduction in operating expenses. These factors were discussed in illustrated articles, March 1941, p 136; April 1941, p 195; Wabash, July 1945, p 440; CMStP&P, April 1947, p 229; CB&Q, November 1951, p 774; CN, April 1953, p 249; SAL, November 1956, p 13; CN, June 1957, p 31.

Fewer Tracks, More Signals

With diesel locomotives, trains are fewer and are operated at higher average speeds. Therefore track occupancy time is less. Thus, with the same gross ton-miles, fewer main tracks may now suffice on extended mileages. When one track is removed, the installation of CTC on the remaining single track will provide capacity to handle present day traffic efficiently. This has been done in recent years on extended sections of the Rock Island, Milwaukee, GTW, Erie and Wabash. Such a change is underway for 1958 on several hundred miles on the NYC, about 300 miles on the Pennsylvania, 173 miles on the C&NW, over 300 miles on the Milwaukee, and on four sections of the B&M totaling over 200 miles.

An important trend today is to install CTC for train operation both ways on each of two main tracks, just like two single tracks side by side. Power crossovers are located about 10 miles apart, so that fast trains can run around slower ones, and all trains keep moving. Total capacity is thereby increased. This has been done successfully on extended sections of the Rock Island, North Western, Missouri Pacific, Frisco, Union Pacific, and Chesapeake & Ohio. Using this method, the NYC in the last year has cut three-track and four-track back to two-track on several hundred miles. More than 85 trains daily are operated on some of these sections.

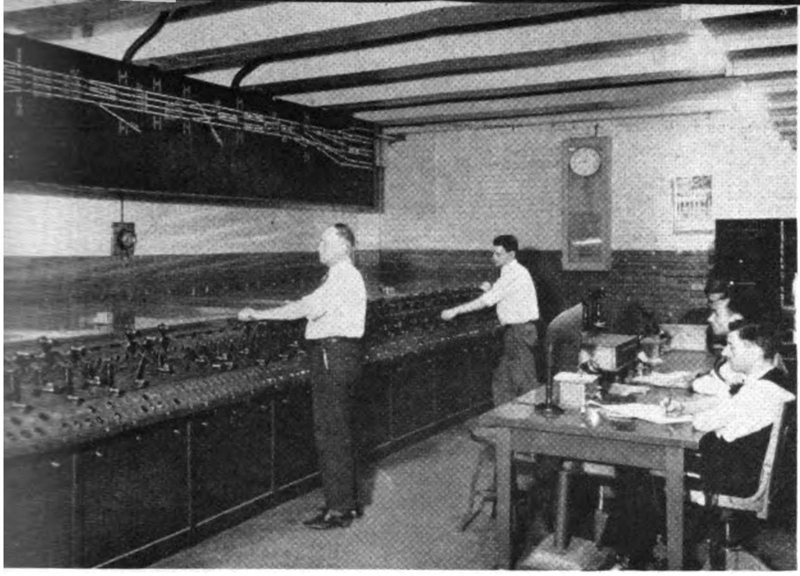
Compact CTC Machines

In conventional CTC machines up to 1957, an illuminated diagram extends across the upper portion of the panel, with two rows of levers under the diagram. One row of these levers controls the switches and the other the signals. Thus, in such a machine the number of levers as well as the layout of the track diagram, are factors in determining the length of the machine. For a long territory of 100 miles or more, two or more panels, each 5 to 7 ft long, were set at angles, partly enclosing the area where the dispatcher's chair is located.

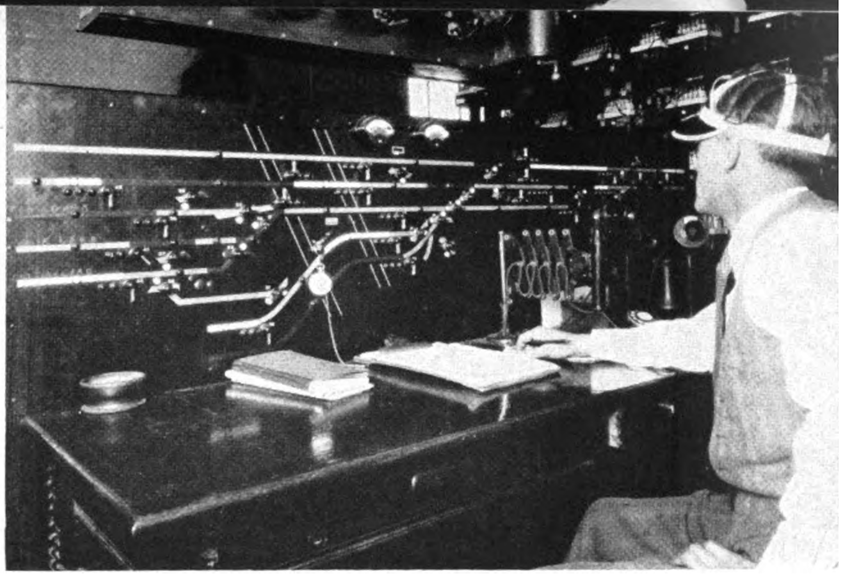
To concentrate the controls for extended CTC mileage (200 miles or more) on a small machine no larger than a double-page spread in this magazine, a new idea was developed, the first control machine of this type being installed on the NYC at Toledo in 1957. The controls for all the switches and signals on 133 miles of double track CTC are concentrated on a panel so compact that the dispatcher can manipulate the entire machine from a seated and stationary position, without turning his chair. This compactness is attained by two new practices: (1) removing the illuminated track diagram (including all indications) from the control machine, and placing these indications on a separate large sized illuminated track diagram mounted on pedestals 5 ft above the floor and about 8 ft from the dispatcher seated at the console.

Successful accomplishment of this objective led to the second new practice: (2) use of one set of push-buttons, which by selective control can be used to control the switches and signals at any one of the 18 layouts on the entire 133 miles. By this means all the controls are concentrated on a panel area only 14 in. by 20 in. wide. A panel this same size, with a few more buttons, could be used to control a much longer territory of 200 to perhaps 300 miles. July 1957, p 23.

In March 1958 another development in compact CTC control machines was announced, the first one of this type being scheduled for installation on the C&O. This type of machine is explained p 11-14 Mar. 1958.



Interlocking machines with mechanical locking were up to 40 ft in length or longer, and as many as four men were required



In 1929 the Rock Island designed and installed the first all-relay free-lever interlocking machine with no mechanical locking

Interlocking Machines: 40 ft to 4 ft—4 Men to 1

In interlockings installed up to 1929 the protection to insure that proper switch levers were thrown for a route and that conflicting signals could not be cleared, was accomplished by mechanical locking actuated by levers or latches on levers.

Up to about 1929 each function, such as a switch or signal in a mannually-controlled interlocking of either the mechanical or power type, was controlled by a separate lever, except that in some types of power interlocking one lever, operating to three positions, controlled two or more opposing signals on the same track or track line-up. Each lever was, of course, connected to the mechanical locking.

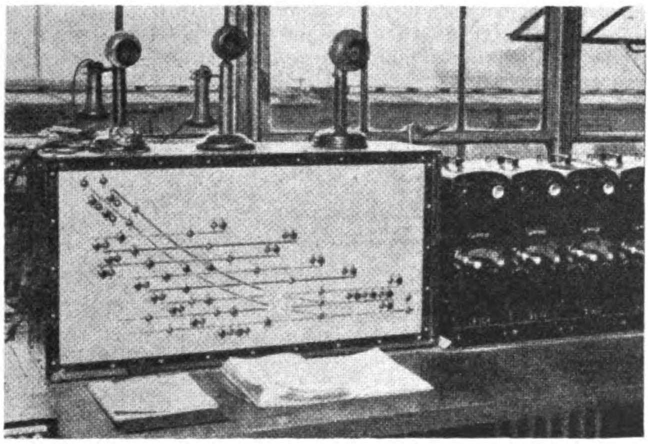
The levers were spaced 2 in. to 5 in. apart, so that a machine of 80 to 100 levers could be 40 to 50 ft long, perhaps more because of spare spaces. Operation of each lever, including time to wait for indication and release, required several seconds. The sequence of operation of levers, necessitated by mechanical locking, also added time. Therefore for a large interlocking, a train director and two or three levermen were required, especially during morning and evening rush hours.

In 1928-1929 the Michigan Central (NYC) installed an interlocking in which switches were controlled by a set of desk levers included mechanical locking between levers, and with electric locks on levers, April 1929, p 128. The new feature was that each signal was controlled by a pushbutton located as part of the symbol representing the corresponding signal on an illuminated track diagram which was on the table beside the set of desk levers. No mechanical locking applied to these pushbuttons, the necessary locking being accomplished by interconnections of circuits through relays. Thus, this may well be called the first step toward all-relay, non-interlocked, free-lever interlocking.

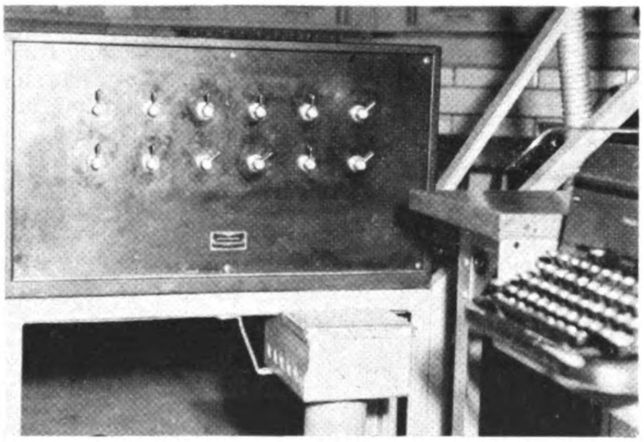
Big Switch to All-Relay

In this trend the next step, made on the Rock Island in 1929-1930, was to design and install an interlocking in which not only the signals but also the switches were controlled on the all-relay free-lever principle. This Rock Island project is a sizable interlocking controlled by a track diagram on a panel 6 ft long, 22 in. high, as explained in the February 1930 issue, p 61. Each switch is controlled by a lever which is a corresponding short piece of the track diagram, hinged at one end. Each signal is controlled by the "arm" of a miniature semaphore signal representing its corresponding signal on the ground. Thus was born the first miniature-lever, all-relay "free-lever" interlocking with no mechanical locking between levers or electric lever locks. This basic practice, but using other forms of control panels and levers or buttons has met with increasing favor, so that practically all new plants installed in recent years are the all-relay free-lever type.

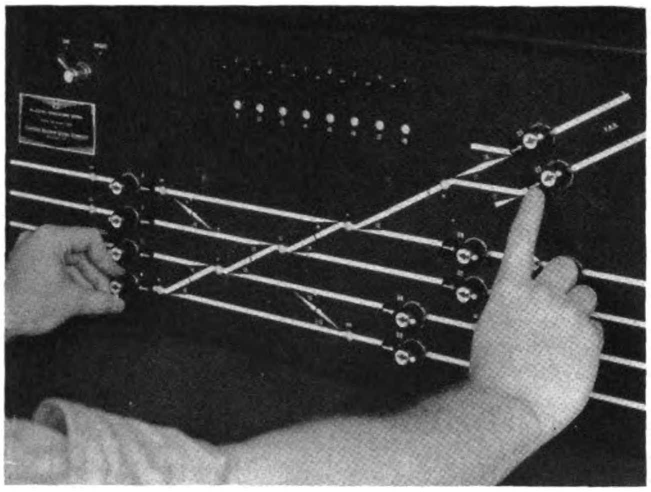
Up to 1937, in nearly all interlockings in the United



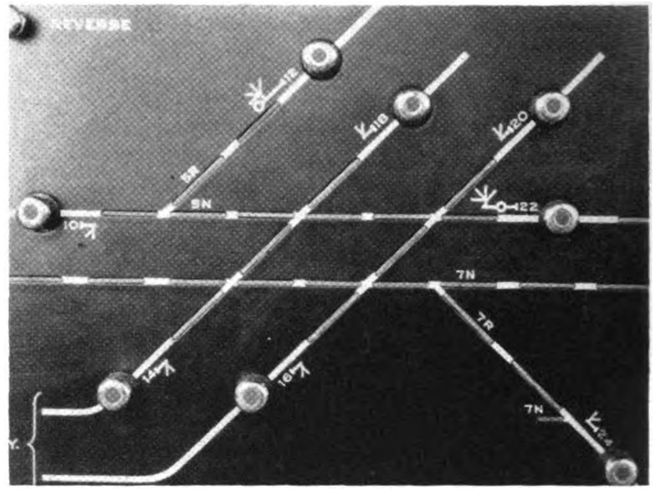
In 1928 MC used interlocked levers to control switches and non-interlocked pushbuttons to control the signals



Each lever controls a route in GN interlocking. GN used this practice in mechanical plant in 1922



In 1937 NYC installed first interlocking in which route is set by pushing buttons representing "entrance" and "exit"



In 1938 B&OCT installed interlocking in which route is set up by pushing buttons representing home signal and departure

States and Canada, each single switch, crossover or signal was controlled by an operation of its respective lever. One exception to this was in a small interlocking on the Great Northern, which utilized the "route lever" practice in which one movement of a lever controlled a switch or switches to complete a track line-up and to clear the signal for that route. May 1923, p 211. This route-lever practice was applied later by the GN in all-relay interlockings. June 1943, p 308 and August 1952, p 530.

Signal engineers and designers in America had known of this route-lever practice as used in some early interlockings in America and as used extensively in Europe through the years up to now.

New Principle of Manipulation

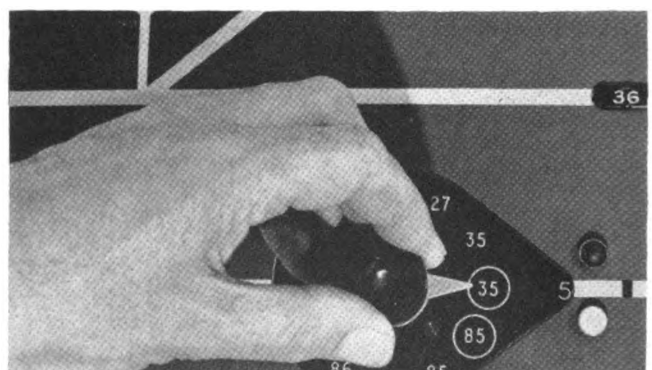
However, except for comparatively simple layouts, the route-lever practice was not considered to be practicable in America for several reasons, one of which is that each track in an interlocking in America must be signaled for train movements both ways, whereas in most route-lever plants then in service in Europe, tracks were signaled for one direction only. After discussing these matters with various men, inventors and engineers in the signal field solved the problem as applied to American practices. The new idea was based on the fact that each route through the home signal limits of an interlocking has an entrance and an exit, applying only to that individual route and direction.

On this basis, circuits were designed to utilize the operation of only two buttons to control the switches and clear a signal of a route for an approaching train. The control panel has an illuminated track diagram, with each home signal represented by a button, and each exit represented by a different button. Thus, no matter how many switches are included in a route, the line-up is completed and signal cleared within a few seconds, merely by pushing two buttons, one representing the signal where the train is to enter home signal limits, and the second representing the location where it will depart from these limits.

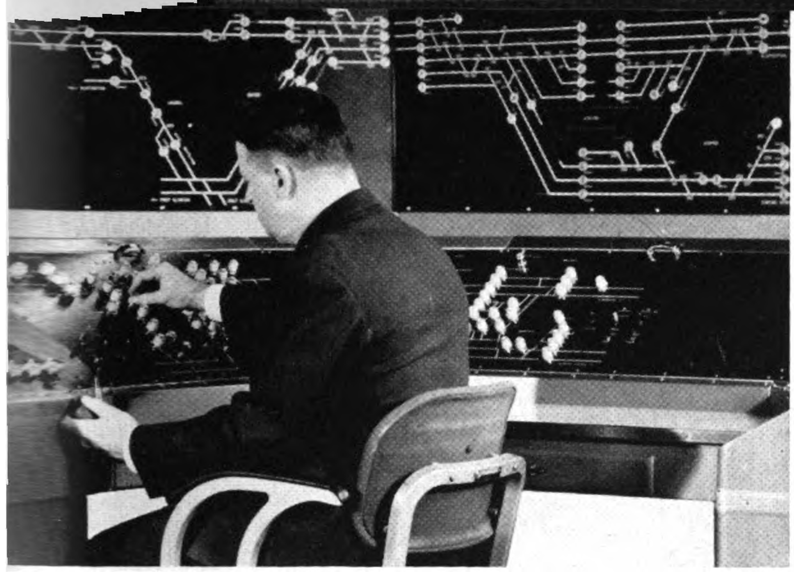
The first interlocking using this entrance-exit practice was installed on the NYC in 1937. Using a similar system known as route control, a plant was installed on the B&OCT in 1938. These systems, known either as entrance-exit or route-control, have been installed since then at numerous interlockings where ease and speed of manipulation are important.

In 1953 the Rock Island installed an interlocking of the route control type. On the lines representing tracks on the diagram, each home signal is represented by a knob which can be rotated. On the panel, each knob has a stationary black escutcheon plate, the point of which extends in the direction in which the corresponding signal controls. In a circular path on the escutcheon are white numbers which correspond with the various route exits which can be entered at the home signal being considered. To clear a signal for a route, the towerman puts his hand on the knob for the home signal, turns the knob so the indicator pointer is over the white number for the exit. Then he pushes the knob. The switches operate to the position called for, and the signal clears. August 1953, p 563.

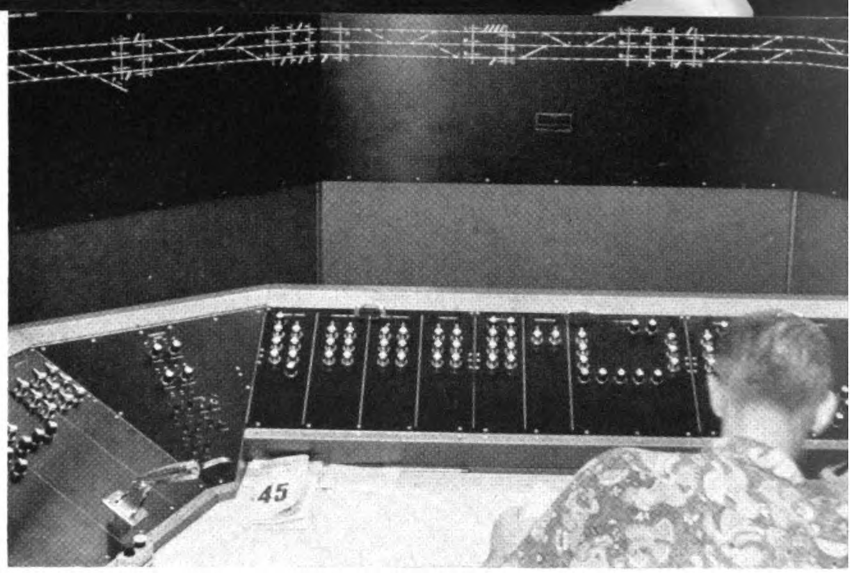
This practice of locating the entrance-exit buttons on the lines representing tracks on the control panel, is satisfactory for one interlocking, even when it is a large layout. However, when some railroads get into projects involving the consolidation of the control of 7 to 14 interlockings all in one machine, the practice of placing the buttons on the track diagram, necessitated a large panel perhaps 30 to 40 ft long. Thus for a busy territory, a train director and two or three



In 1953 RI plant each signal represented by knob—To set up route knob is turned to place pointer over exit number



In 1955 Reading installed compact machine with entrance-exit buttons on the small panel and diagram on big board



CB&Q machine consolidates 14 interlockings, each controlled by two rows of buttons $1\frac{1}{2}$-in. centers

levermen would be required to push the entrance-exit buttons.

This problem was solved in 1955 by placing the entrance-exit buttons on small panels directly in front of a leverman seated at a desk, and the track diagram, with all the indications, on a large-sized panel 6 to 8 ft away from the leverman. Such a control machine is in service to control seven interlockings on the Reading at Reading, Pa. October 1955, p 28.

A second machine of somewhat the same type was installed on the Burlington in 1956, being constructed according to an advance model placed in service in January 1954 at a different location. In the Burlington machine, the control buttons, operating on the entrance-exit principle are arranged in vertical rows 1½ in. apart. Thus each interlocking is controlled by a panel only 4½ in. wide. September 1956, p 17.

This machine is for the control of 14 interlockings on 35 miles, mostly three-track, handling 122 scheduled trains daily. The signals, at these interlockings, authorize train movements the same as on CTC. This control machine is handled directly by the Terminal Division train dispatcher. This operation is practicable because the indication lamps tell the dispatcher where trains are, and, by pushing buttons within his arms reach, he sets up routes and clears signals faster than he could tell someone else what he wants done at 14 other places on the territory.

Thus within the period from the first all-relay plant in 1929, to the control panel as used on the Reading and the Burlington in 1956, large interlocking machines have changed from 40 ft to 4 ft. Furthermore, the complication of manipulating large machines has been reduced to require only one man at only one machine, instead of numerous men at each of 8 to 14 separate machines, at various locations on 35 miles of terminal territory.

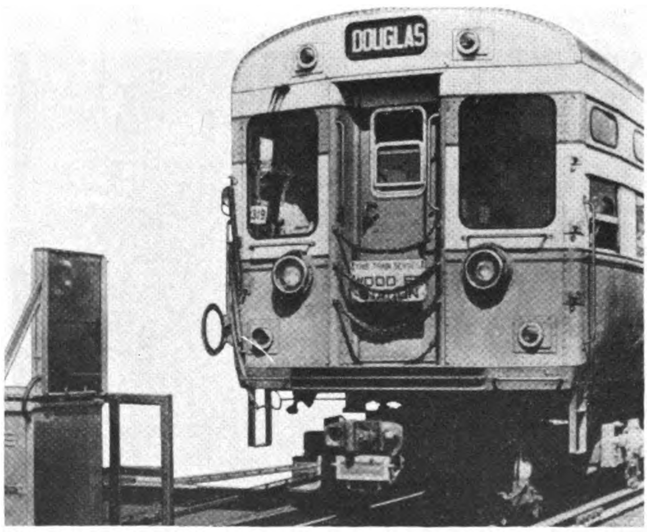
Automatic Interlockings

Automatic control of interlockings at railroad crossings, where the trains that approach on each track all use the same route, has been employed extensively for many years. If trains approaching on the same track are to take different routes at facing-point switches, then selective automatic control is required.

In 1925 the Great Northern made a test installation of an interlocking including selective control of the diverging route at a facing-point switch. Equipment from conventional intermittent inductive type train stop system was used. The "receiver," ordinarily on the locomotive, was mounted on the track ties 6,000 ft from the switch. The magnet, ordinarily on the wayside, was on the locomotive. For routes other than with the switch reversed, the signals and switch were controlled by the approach of trains, in the conventional manner used at automatic interlockings.

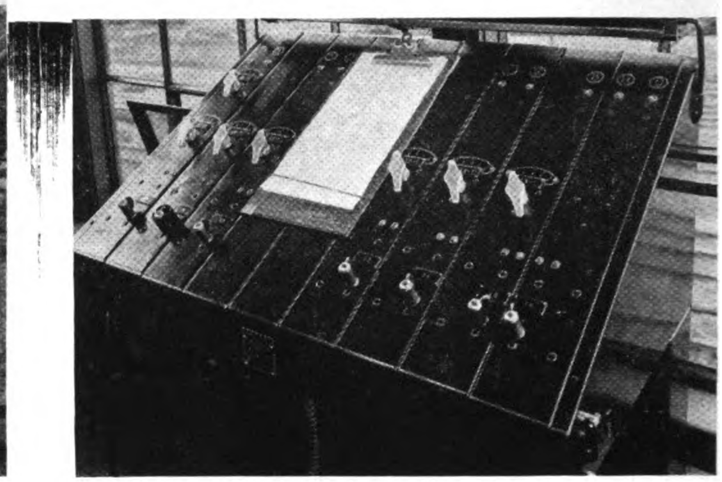
In a system known as automatic electronic train identification, placed on the market in 1954, each train carries an individual inert tuned coil. At each field location there is a fixed coil which is within the field of the coil on the train as it passes. Using such a system, the Chicago Transit Authority installed an automatic selective control of facing-point junction switches in a power interlocking, thus dispensing with the services of levermen. October 1954, p 15. This system or others can be used, where applicable, on trunk line railroads.

Similar automatic electronic systems are being installed on some sections of the subways of the New York City Transit Authority. Trains will automatically line up their own routes as they approach each interlocking. The identity of each train, as well as the occupancy of track routes, is transmitted to a "monitor" control machine for the entire area. Thus, quite possibly, one man can effectively have charge of several large and busy interlockings, with a possible reduction in train delays that may now be caused by the time required to change routes in manually-controlled plants. The trains are made up of multiple-unit cars, using electric propulsion. Trains are not turned at ends of runs. Two coils of the same characteristics are mounted, one on each end of the train.



Electronic train identification for automatic selective control of facing-point switch was installed on CTA 1954

E. M. Wilcox and George Hannauer, inventers of car retarder on the IHB in 1924, standing on one of early type retarders



In yard projects installed 1924-1950 power switches and retarders were controlled manually by small levers on desk panels

Gravity Yards: Man-Power to Automation

Prior to 1924, gravity classification yards were operated manually. Hand-throw switches were operated by switchtenders. As each car or cut went down the hump, a car rider hopped on. He applied the hand brakes to stop the car at the proper place on its classification track. Personal injuries were numerous. Not enough men were available, especially during adverse weather. Damage to cars and lading was excessive. Wage costs were too high.

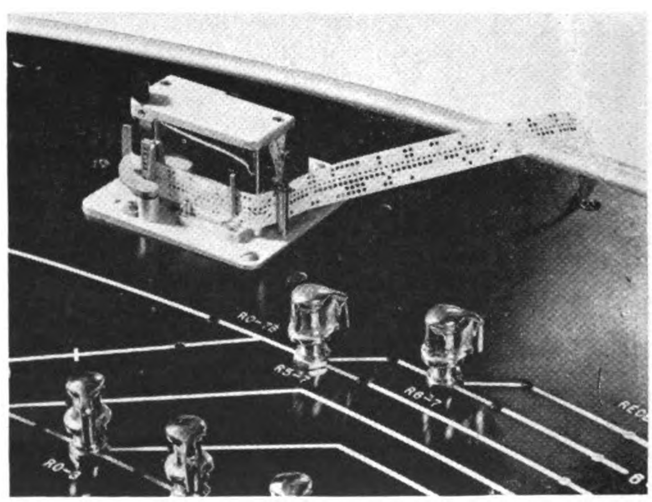
These problems were met by the invention of the car retarder on the Indiana Harbor Belt in 1924 (July 1925, p. 271). Each retarder consists of a set of brake shoes lying alongside of and parallel with each rail. When operated, these shoes move toward the rail to clamp on the sides of the rims of the wheels. By installing these car retarders to eliminate car riders; and power switch machines to eliminate switchtenders; hazards were minimized. Because of reduced manpower, maximum operating capacity was available 24 hours every day. Thus all trains can be humped promptly when they arrive. Retarders and power switches were installed in about 40 major yards in the years 1924 to 1950.

In yards equipped with power operation prior to 1950 the conventional practice was to control the operation of the switches and retarders by small levers and buttons in control machines in the top floor of high towers, so the operators could see the areas controlled. In a yard of 40 to 60 tracks, at least three such towers were required.

In 1950 two railroads, the CP and the IC, made the first installations of automatic switching June 1950, p 346 and November 1950, p 712. This is a system in which controls of the switches in a yard are set up before the cars go over the hump, the controls being initiated by a man pushing a button which corresponds to the classification track to which a car is to be routed. The use of automatic switching made it possible for the control of all the retarders, as a separate proposition, to be concentrated in one machine in one tower, as was done on the CP project, and on several installations on other roads.

In 1955 the N & W developed the idea of initiating automatic switching controls on Teletype tape, which is punched for cars of an entire train before it is pushed up to the hump September 1955, p 27. As cars go over the hump, the tape feeds through a telegraph printing transceiver which initiates control for the switches. A further advance, placed in service last month on the NYC, uses magnetic memory cores, rather than tape, these memory cores being the same as used in Tele-

Automatic switching control, initiated by pressing button corresponding to track for car or cut, was developed in 1950



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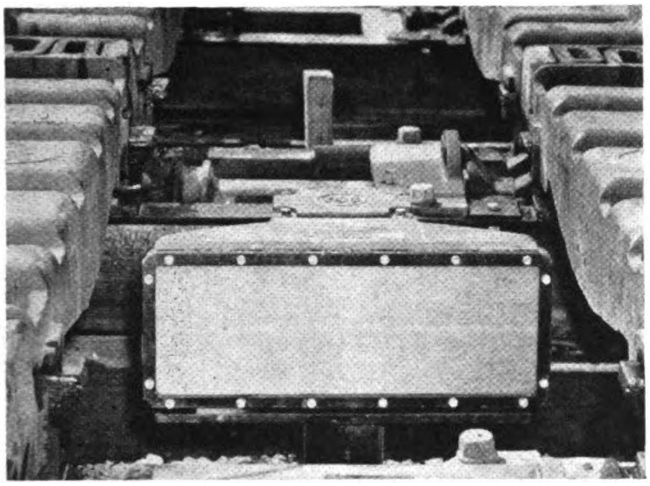
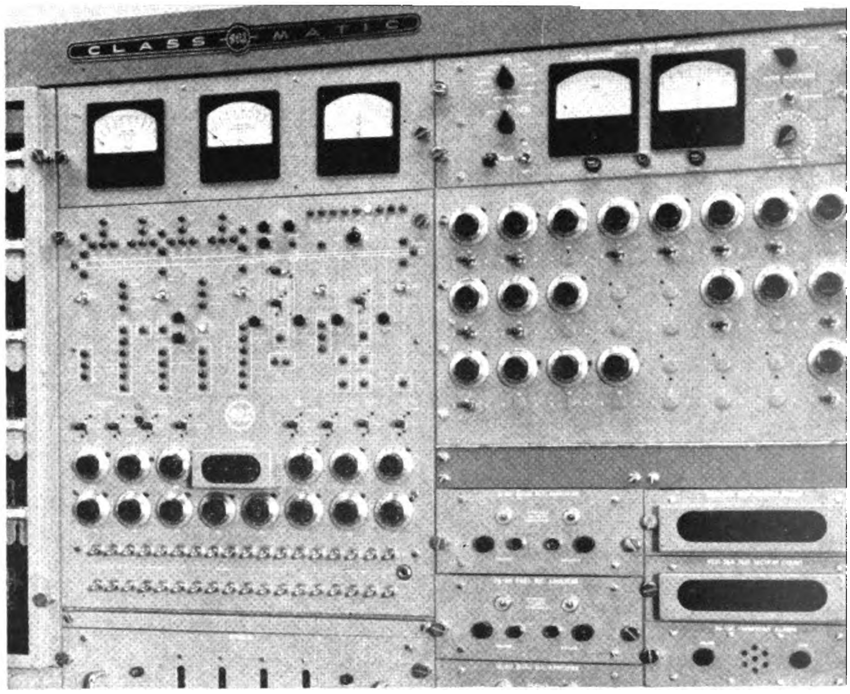


Radar for measuring car speeds to control retarders automatically was first installed in 1953, on the EJ&E



Electronic analog computer in service at New York Central's Elkhart yard calculates release speed of cars from retarders

register electronic ticket reservation systems.

After automatic switching, the next step was automatic control of retarders, first installed in 1953. December 1953, p 882. Radar equipment is used to measure the speed of cars as they pass down the hump and through the switches and retarders. Similar automatic retarder controls are now in service in a dozen yards and are to be installed in several more this year. In such systems, car characteristics and performance are determined as follows: relative weight, rollability on tangent, rollability on curve, length of cut, characteristic of route and fullness of destination track. Electrical values of these factors are fed into an electronic analog computer. The result automatically controls the final retarder to achieve the desired coupling speed, all by automatic control. September 1957, p 29, and March 1958 p 28.

In a yard with 40 to 48 tracks, using previous conventional manual control, a typical arrangement includes three towers, requiring nine operators for round-the-clock duty. With completely automatic control of switches and retarders, only one man is needed, his duties being to monitor operations.

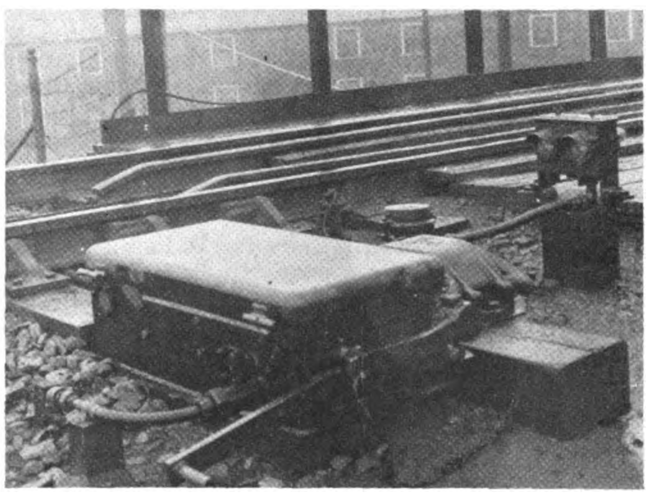
In receiving yards, conventional practice is that the switches leading from the ladder to the individual tracks are equipped with hand-throw switch stands. In some yards, when a road train is entering the receiving yard, the train must stop to permit the head brakeman to run on ahead to line the switches. This causes delays and extra train stops that are objectionable. In some other yards, switchtenders are on duty to line up the hand-throw switches. This practice is too expensive in wage costs.

For these reasons, an important trend in the last few years is to install non-interlocked power switch machines at these switches, not only at the entering end of tracks in receiving yards, but also at the leaving ends of tracks in departure yards.

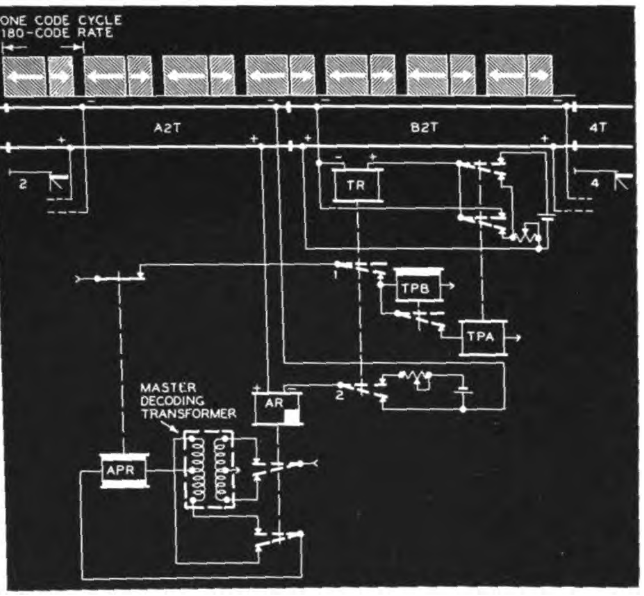
The switch machines that are especially useful for such installations have no lock rods and are constructed so that the switch can be trailed through without damage. Dual control is provided so the switches can be operated by hand when making moves locally.

In some installations, such as on the EJ&E, groups of these yard switches are controlled by a panel type machine in the interlocking tower at the main line entrance to the yard. In other projects, such as at Elkhart on the NYC, explained in the March issue, a group of such switches is controlled by a panel in a switchtender's cabin in the yard. Other good practices in this field, as used on the RF&P, will be explained in an article scheduled for an early issue.

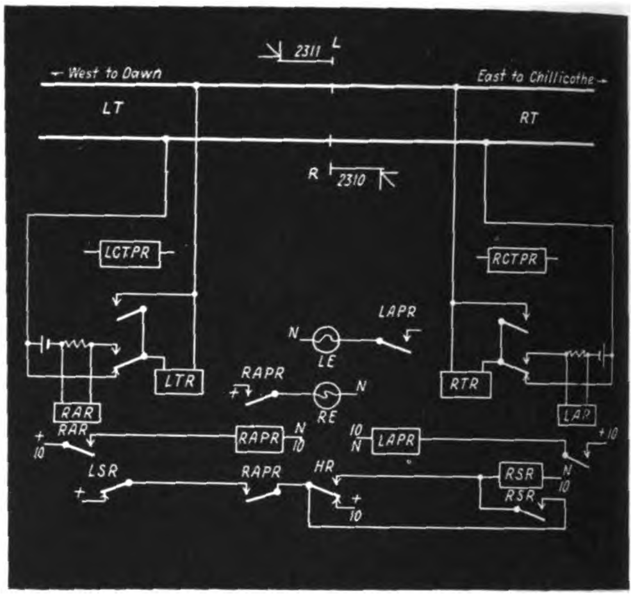
Track-fullness indicators are included on panel of "monitor" machine in automatic retarder yards



Special types of non-interlocked switch machines are used on switches on lead at entrance of receiving yards



Simplified circuit for 2-block 3-indication coded track circuit without signal-control line wires



Double-end track circuit in single-track CTC installed on the Milwaukee in 1944

The Track Circuit Changed Fast 1908 to 1958

The closed-track circuit as invented by William Robinson in 1872 included both rails, a neutral relay and steady flowing energy. Some years later when installing consecutive automatic blocks, someone applied the polar principle, so that current in one direction controlled the signal to display the yellow aspect; or current in the opposite direction, the green aspect. Thus a three-aspect signal could be controlled without a line circuit. Because of failures caused by high resistance in light-pressure polar contacts, most roads preferred to use neutral track circuits with a line circuit. No further changes were made in the basic principle of the track circuit for many years.

Better Bonds Were a Help

Better bonds and insulated joints reduced failures. Crushed rock ballast, instead of cinders and gravel, along with better bonds, were factors in making track circuits longer, and in improving shunting characteristics.

Prior to about 1912 practically all track circuits, except on roads using electric traction, were fed on steady-energy direct current from batteries. About 1912-25 several "steam" roads made extensive installations of a.c. signaling, including a.c. track circuits. Some of the advantages were elimination of batteries and oil lamps, as well as longer track circuits. Some of the disadvantages were the expense for maintaining the power distribution line, and the train delays when the a.c. failed. About 1923, suitable rectifiers were developed to convert a.c. power to d.c. at signal locations, for charging storage battery or to be connected across sets of primary battery. Accordingly, most all track circuits installed since 1925, except on electric propulsion territory, are d.c.

The use of an electronic device as an amplifier was the missing link that made possible the system now known as continuously-controlled inductive cab signaling, with or without automatic train control. The problem was to amplify relatively weak current that coils on the head end of the locomotive, picked up from relatively weak current in the rails. Back in 1916, the same year that DeForest first applied his filament-grid-plate vacuum electronic tube in broadcast radio, signal manufacturers started developments which led to the use of such a tube in continuous cab signaling and train control.

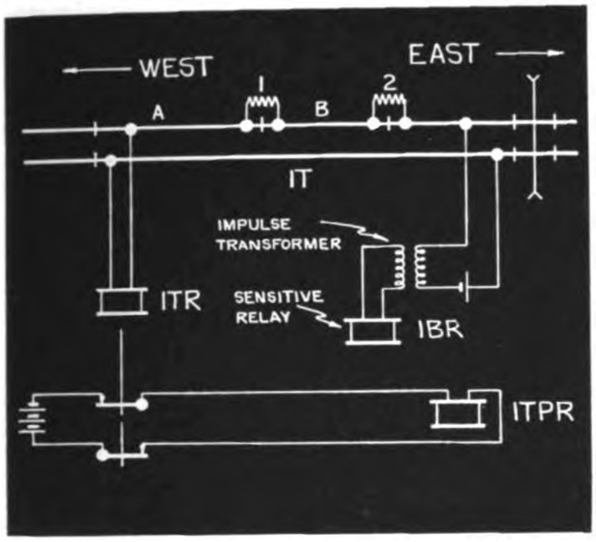
How Coded Track Was Developed

About 1923 developments of continuously-controlled cab signaling and train control included the use of coded impulses fed in rails of each track circuit, to be picked up inductively by coils on the pilot of the locomotive. Code rates were such as 75, 120 and 180 per minute.

The next step was to develop devices so that these same codes in the rail would also control the wayside signals. This practice came to be known as coded track circuits, in contrast with conventional track circuits in which the energy normally flows constantly. One advantage of coded track circuits is that signals can be controlled to three or more aspects as required by codes in the rails, thus dispensing with local line control circuits. This practice has been applied extensively for control of wayside signals where no cab signaling or train control is used.

The double-end track circuit was developed about 1943, as a means for controlling signals without line wire circuits, for train movements either one way or the other in an overall block between two sidings in single-track CTC. A double-end track circuit has interconnected circuits so that either a relay or a battery can be connected at either end of the track circuit. As part of the preliminary of control sent out by the dispatcher, relays at the sidings are actuated to cause track battery to feed cascade from one track circuit to the next, throughout the siding-to-siding block in the direction opposite to the direction of the train movement for which the signal is being cleared. Systems of circuits such as this were installed on the Milwaukee, April 1945, p 225, and on the D&RGW, March 1946, p 194.

Most systems using different rates of code to control corresponding aspects require devices to originate different codes at the feed end, and to detect these different codes at the receiving end.



Special impulse recurrent timing circuit for crossing protection on the UP in 1954

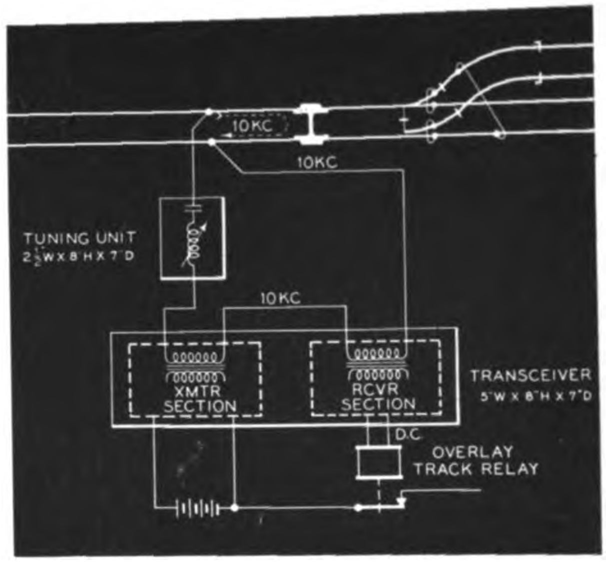


Diagram of series connected electronic overlay track circuit developed in 1956

In addition to detecting occupancy by trains, codes or impulses in track circuits are used to transmit information. For example, information concerning occupancy of intermediate blocks in CTC can be transmitted through other non-occupied blocks to a CTC field station at a siding.

Difference Between Impulse and Code

In 1946 the Rock Island installed two-aspect siding-to-siding single-track automatic block, using dependent impulse track circuit operation. An impulse about 0.4 seconds long feeds cascade from siding A to siding B. Then a return impulse feeds back the other way. Such a round trip may require two or three seconds. This system, requiring no line wires, was installed on more than 500 miles. April 1946, p 264 and May 1946, p 342.

About 1954-56 several roads, including the Canadian National and Texas & Pacific, installed a system of conventional three-aspect Absolute Permissive Block on single track, using a later track circuit system in which the impulses each way, on each track circuit, are at the rate of about 20 per minute in dependent operation. Impulses either way can be positive or negative. Thus adequate controls for APB are accomplished without line wires and without code transmitters or code detectors as such. May 1957, p 32 and August 1957, p 42.

For use in car retarder yards and other interlockings where needed, a special high-sensitive track circuit was developed in 1955. When a car enters the track circuit, the shunt, even though it may be intermittent and of high resistance, causes the current in the input winding of an impulse transformer to increase. This circuit as installed on the B&O in 1955 is explained in the August 1955 issue, p 30.

A special arrangement known as the primary-secondary interconnection of track relays is used by some roads on crossing protection or other places where momentary loss of shunt might interfere with sequence of operations.

A special impulse recurrent timing track circuit which is useful in control of highway crossing protection was developed on the Union Pacific in 1954, as explained in the December 1954 issue, p 47.

Years ago the maximum length of track circuit was 2,500 to 3,000 ft. Now, with well-drained rock ballast and modern bonding, relays, and batteries—track circuits can be up to 10,000 ft. long. In too many instances, however, short track circuits must be cut for the control of crossing protection; electric locks on hand-throw switches; sectional route releases in interlockings, etc. Each such extra track circuit requires additional insulated rail joints, battery, relays, and wiring to connect overall signal controls through contacts of each and every track circuit in a block. All this is expensive, especially in continuously-controlled cab signal territory.

Electronic Track Circuits

To meet this situation, someone hit on the idea of using high-frequency energy—about 10 kilocycles—superimposed on a short section of the overall track circuit for the entire block. No insulated rail joints are required to limit the effective length of the overlay track circuit, because the distance that the 10-kilocycle energy will go is limited by the relatively high reactance of steel rail at the frequency used. For a frequency of 10 kilocycles the maximum length from the feed end to the far end of a track circuit is roughly 200 ft. By adjustments of the feed the effective length of the track circuit can be controlled closely within a foot of a desired length. Explanations of these electronic overlay track circuits were published on pages 48 and 58 of the May 1956 issue.

A railroad in England has listed a total of about 24 uses for electronic overlay track circuits, such as in highway crossing protection, sectional release route locking, etc. Two uses for such circuits in CTC are explained in the article on the Grand Trunk Western CTC to be published in an early issue. Also another article in an early issue will explain how overlay electronic track circuits are being used in crossing protection controls.

In 1947 the Signal Section, AAR, originated Committee XII—Circuit Design. This committee is doing excellent work in preparation of diagrams and explanations of many of the more important modern developments not only in track circuits, but all other forms of circuits used in signaling.

THIS MAGAZINE: Its Name and Editorial Policy

This issue of Railway Signaling and Communications completes 50 years of editorial service to the railroad field, for it was in May 1908 that the first issue, "The Signal Engineer," forerunner of the present magazine, was published.

The idea of publishing a magazine devoted to signaling and kindred subjects was developed on the Illinois Central. At that time Mark H. Hovey was signal engineer of the IC, and L. B. Mackenzie was office engineer. They organized the Signal Engineer Company, Mr. Hovey becoming president and Mr. Mackenzie vice-president.

"The Signal Engineer" was purchased by The Railway Gazette, Inc., in June 1910. In January 1912 the Simmons-Boardman Publishing Company was organized to combine the Railway Gazette with other magazines, including the Railway Age. "The Signal Engineer" formed a unit of the new organization and has continued as such.

In the first issue, May 1908, the masthead included the statement, "Correspondence relating to signaling and kindred subjects is cordially invited." Four months later, in the August issue, the magazine broadened its scope beyond signaling subjects to include discussions of telephone train dispatching. Although signaling was the principal subject dealt with, space was devoted from month to month to communications subjects of that day. In 1921 a series of articles was published on "The Simplexing of Railroad Telegraph Circuits." During the next two and a half years a series of monthly articles was published on Railroad Telegraph and Telephone Practices. Conventions of the Communications Section, AAR, were reported in somewhat the same form as reports of the meetings of the Signal Section. In the January issue each year we included statistics furnished by each railroad, listing the new communications and signaling facilities installed in the preceding year.

During World War II, radio equipment was developed to operate in high frequency ranges so that plenty of channels would be available for long time assignment by the FCC to the railroads. Microwave had proved to be practicable during the war, and was available for railroad use. Recognizing the possibilities of microwave for long-haul commercial telegraph, the Western Union Telegraph Company became active in terminating its agreements with railroads for ownership or co-ownership and maintenance of pole lines on railroads. Another new field was being opened by applying paging and talk-back loudspeakers in railroad freight yards and passenger station layouts, as well as in lcl freighthouses.

Because of these changing circumstances and new developments, there was a need for increased editorial reporting on railroad communications facilities. In 1945 and 1946 we published at least one communications article in each issue, sometimes more. Railroad communications men aided us in writing these articles and encouraged us to expand our editorial service in this field. Accordingly, effective with the January 1949 issue, we expanded the name of the magazine to "Railway Signaling and Communications." In a statement of policy which we made in announcing this change nine years ago, we said:

"Our part is to provide, in printed form, a medium of exchange of current information and new ideas on engineering, construction and operation of not only signaling, but also communications. These two phases of railroading, in our opinion, are separate and distinct technical fields, and therefore, we propose to so treat them in our columns."

This has been, and still is, our editorial policy. This is consistent with our constant objective to publish an independent technical engineering journal that reports current developments and new installations of both signaling and communications.

John H. Dunn, **Editor**