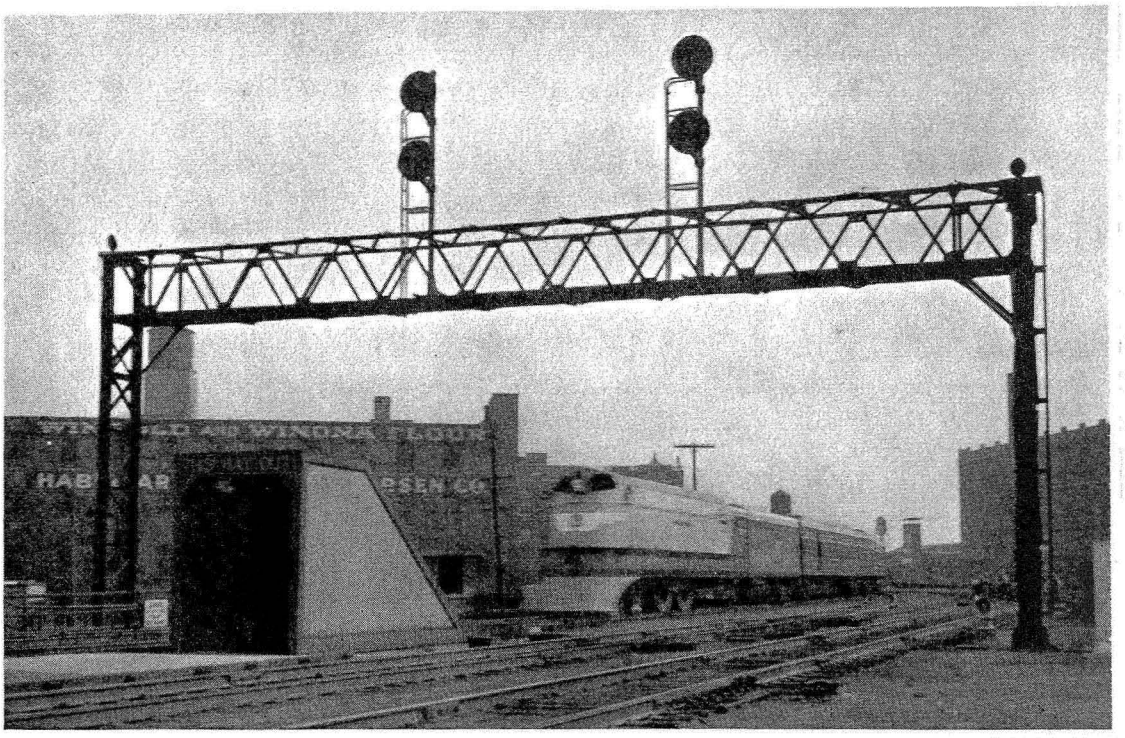


Westbound Hiawatha passing the eastbound home signals on the Milwaukee railroad

Milwaukee Rehabilitates Large Plant

Excellent example of complete replacement of old equipment with modern facilities and improved circuit arrangements to increase safety and facilitate operation

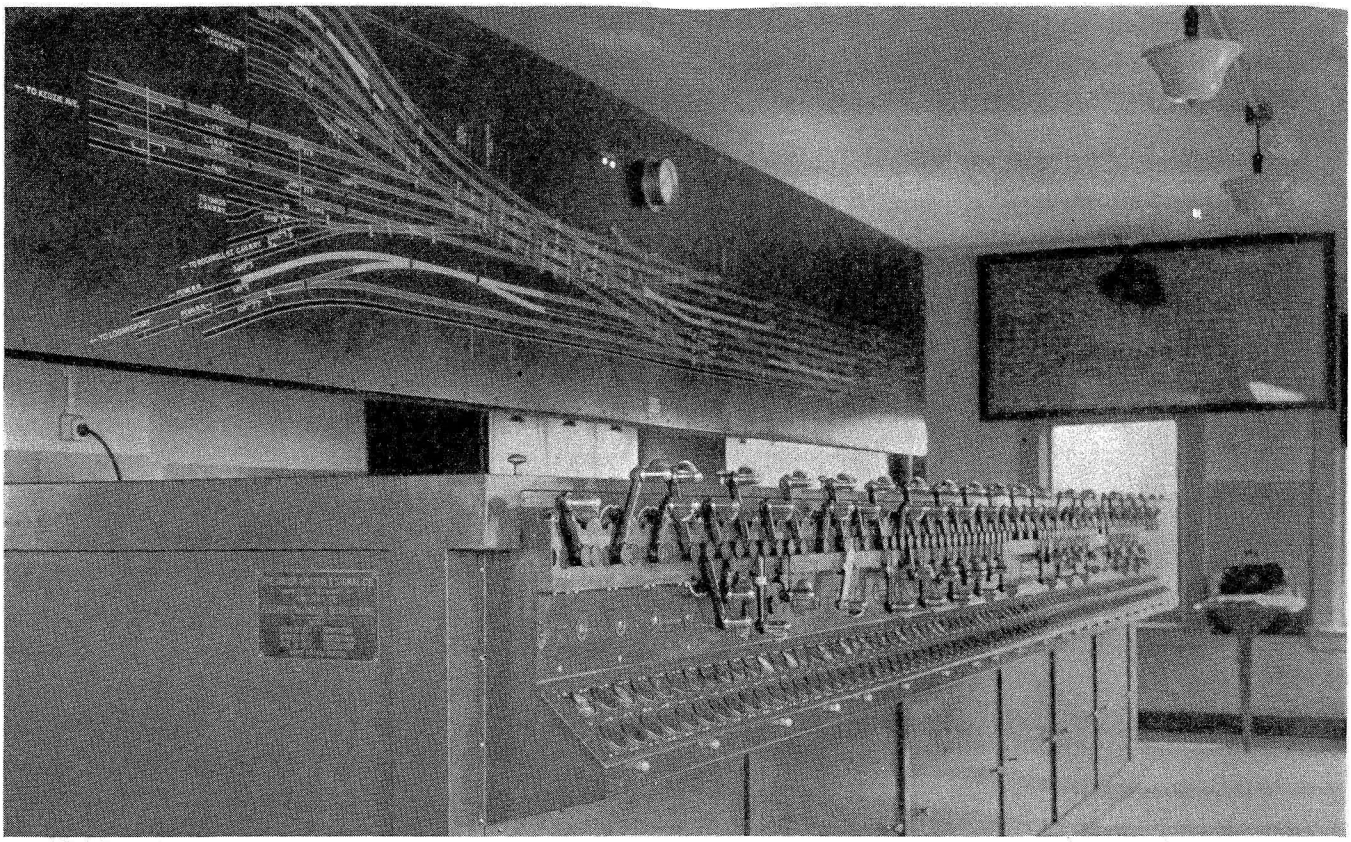
By removing detector bars, providing complete electric locking, replacing semaphores with light signals, installing a new 83-lever interlocking machine and an entirely new system of circuits and wiring distribution, the Chicago, Milwaukee, St. Paul & Pacific has rehabilitated and modernized a large electro-pneumatic interlocking at Western avenue in Chicago. The elimination of 18 main-line derails, 4 switches, and 3 movable-point frogs permitted a reduction in the number of levers required. This change, together with the new directional sectional route locking, permitting quicker changes between routes, has expedited the operation of the plant and reduced train delays.

The Western Avenue plant is located about two miles west of the Chicago Union station, the Milwaukee passenger trains being operated between the Union station and Western avenue over two tracks of a four-track line operated jointly with the Pennsylvania. Within the limits of the interlocking at Western avenue, the Milwaukee has four main tracks extending across four main tracks of the C. & N. W., and the Milwaukee tracks connect with the Pennsylvania tracks. In so far as the crossing of the tracks of the Milwaukee and the North Western is concerned, seven double-slip switches, including movable-point frogs, are provided so as to permit full use of all of the tracks for entering or leaving the North Western coach yard and making transfer and switching movements to and from the Milwaukee freight yard.

All passenger trains of the Milwaukee going into and out of Chicago pass through this interlocking. Passenger trains of the North Western on the lines to the west to Omaha, Neb., pass over this plant. Coach yards of both roads are located west of Western avenue so that numerous empty train and light locomotive movements are made over the plant. Each road operates switch engines through this territory to pick up and deliver freight cars at freighthouses and various industries between Western avenue and the business district. The Pennsylvania has not operated passenger trains on this route for several years, but does operate several switch engines to serve freighthouses and industries. On the average, about 550 train movements are made over the plant daily, the traffic being especially heavy during the morning and evening rush hours.

Reasons for Replacing the Old Plant

A Union Switch & Signal Company electro-pneumatic interlocking was installed at this layout in 1907, the machine having a 119-lever frame. Model-14 electro-pneumatic machines were used to operate the switches, derails and frogs, and the semaphore high signals and dwarfs were operated by electro-pneumatic mechanisms. On account of the numerous train movements daily during the last 30 years, the plant as a whole was worn to the extent that extensive replacements were needed. Furthermore, certain improvements were needed to increase the safety and to



The new machine was set up and connected before the old machine was taken out of service

expedite the operation of the plant. After various conferences, it was decided that a complete replacement of the plant was advisable.

When making a study with a view to simplifying the layout, it was decided that one of the Pennsylvania tracks crossing four of the Milwaukee tracks could be dispensed with, thus eliminating 3 movable-point frogs and 3 single switches. A single switch leading to an industry track from the westward passenger track of the Milwaukee was equipped with a hand-throw stand and excluded from the interlocking. Derails on all main tracks were eliminated, being retained only on the tracks leading to coach yard tracks and an industry track of the C. & N. W. A total of 18 derails were eliminated.

Condition of Old Machine

The old interlocking machine was worn beyond the stage of being rehabilitated economically, and the application of electric locks and controllers, required under the new circuit arrangement, was not practicable. Therefore, a new Model-14 interlocking machine was provided, which has an 83-lever frame using 69 working levers, as compared with 88 working levers in the previous layout. This machine has 2 levers for releases, 22 signal levers to control 47 signals, and 45 switch levers to control 30 single switches, 8 derails, 5 sets of movable-point frogs, and 9 double-slip switches with movable-point frogs.

Decision as to Type of Machine

Prior to the decision to use a Model-14 interlocking machine, including regular mechanical locking, an extensive investigation was made of the possible use of an all relay interlocking using either the route-control system or a non-interlocked miniature-lever machine. Some of the signals control as many as 35 routes each, and for this reason the route-control system required so many relays and circuits that it was considered to be impracticable as well as too expensive. The same reasons applied to a more limited extent to the all-relay system using individual miniature non-interlocked levers. Further study showed that the use of a regular interlocking machine with a limited amount of mechanical locking would permit the use of comparatively few relays and simple circuits. A further consideration was that the revised track layout, using a Model-14 machine, could be handled by two men during each trick. It was seriously questionable whether a smaller force of levermen could handle the plant even if a different type of control were used.

Following the final decision to use a regular interlocking machine, an intensive study was made to co-ordinate the use of mechanical locking, electric lever locking, and circuit interlocking to the greatest possible advantage with respect to simplicity and safety, as well as rapidity of operation of the plant. The primary use of the new arrangement of mechanical locking is for the signal lever of a route, when reversed, to lock the switch levers mechanically. The simplified mechanical locking arrangement predetermines that the levers for the switches in a route are properly positioned before the signal lever can be reversed. The signal lever, reversed or in normal-indication position, locks the switch levers. There is no mechanical locking between switch levers in a route, except on the yard tracks where derails are in use. Therefore, switches can be operated behind a train, moving in either direction, as fast as the directional sectional locking is released.

Signal Control Network

The signal control circuits are arranged as a network, utilizing certain features included in a certain route-interlocking scheme, the circuit arrangement including contacts in switch and signal-repeater relays so that the interlocking between signals and routes is accomplished electrically, and this interlocking is not duplicated mechanically in the machine. Several other modern circuit schemes for elec-

tric locking and release locking were utilized, as will be explained later.

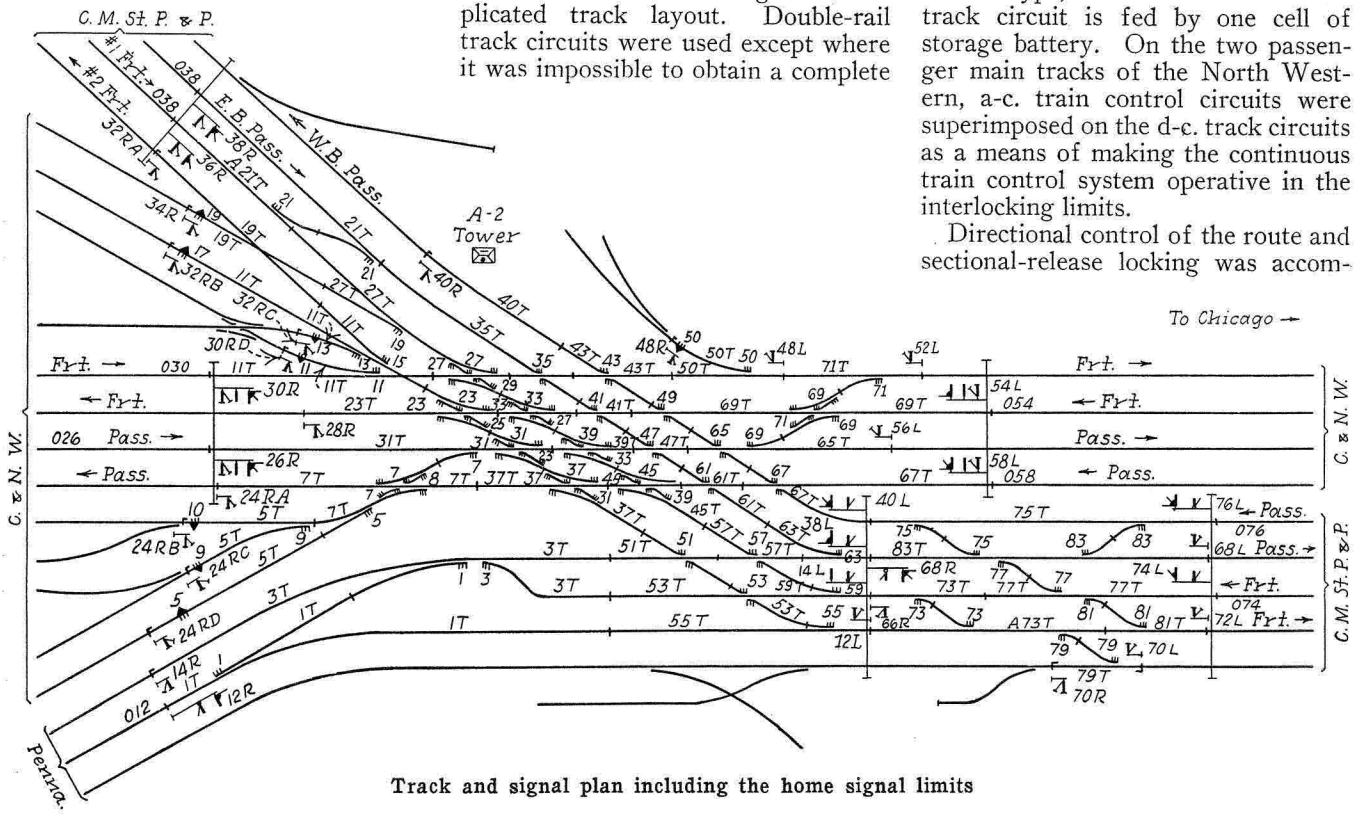
Electric Locking

An important phase of the improvement program was to eliminate the detector bars and provide complete electric locking. In the previous plant, electric locks were provided on the signal levers for approach locking for the high-speed signals on the passenger main tracks, and also for indication locking. The switch and derail levers were equipped with electric locks for indication locking. The mechanical locking was arranged for a complete route. Therefore, in addition to increasing safety, it was desirable to provide directional sectional-release locking behind trains so that routes could be released in sections, and line-ups could be changed more quickly.

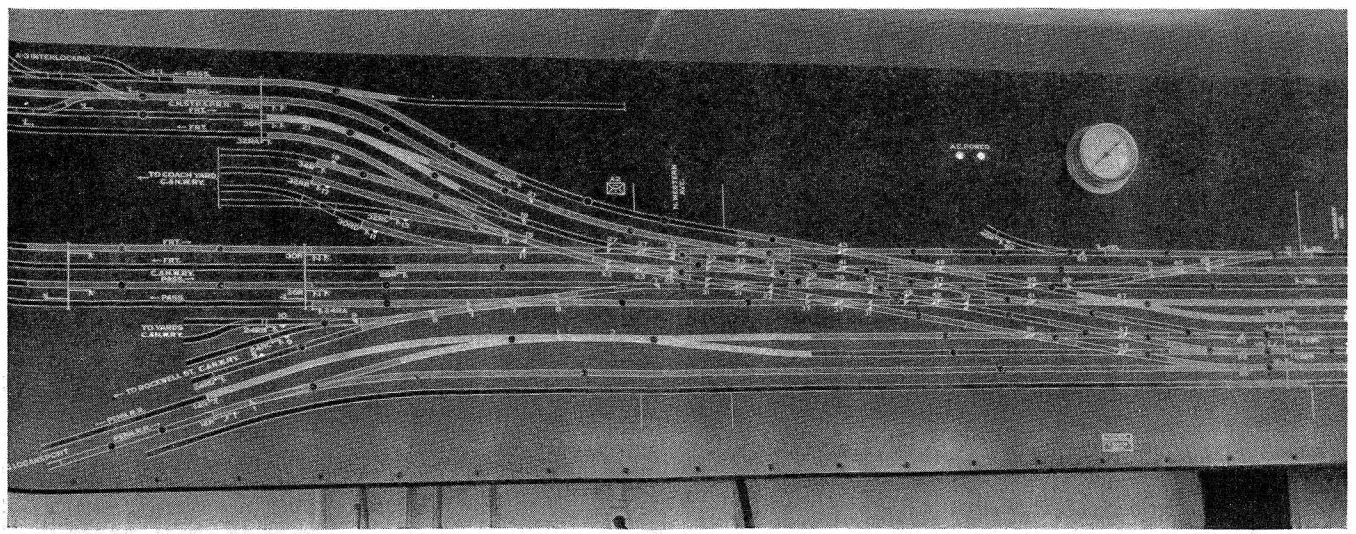
One of the first problems in providing the new electric locking was to install track circuits through the complicated track layout. Double-rail track circuits were used except where it was impossible to obtain a complete track circuit without long dead sections at the track intersections. In these more complicated sections, within the intersections of Milwaukee tracks with the North Western tracks No. 3 and 4, single-rail track circuits were used, and so arranged that all the rail is energized. The staggered sections, in which a shunt would not be effective, do not exceed 4.5 ft. in track length. A total of 39 track circuits, including 14 single-rail and 25 double-rail, were used, requiring the installation of 131 insulated rail joints, which are of the continuous type furnished by the Rail Joint Company. The new track relays are the DN-11 type, rated at 4 ohms. Each track circuit is fed by one cell of storage battery. On the two passenger main tracks of the North Western, a-c. train control circuits were superimposed on the d-c. track circuits as a means of making the continuous train control system operative in the interlocking limits.

Directional control of the route and sectional-release locking was accomplished by using directional stick relays. As a means of reducing the number of selections in the circuits, the control of a stick relay breaks down through contacts of stick relays for functions in adjacent sections.

Within the crossing layout, the elec-



Track and signal plan including the home signal limits



The illuminated diagram reproduces in detail the entire track layout

tric detector locking is effective for any function, not only while the local track circuit is occupied but also while the second and/or third circuit, beyond that in which the function is located, is occupied. This feature not only insures a more adequate shunt, but also provides protection in case a train stops on the crossing and then, when taking up slack, lets a rear car drift backward.

New and Simplified Time Releasing

In contrast with previous practice of using hand-operated clock-work releases, mounted above the interlocking machine or on the wall, a new and simplified system of releasing was used at this new Western Avenue plant. The clock-work releases, one operating in 30 sec. and the other in 120 sec., are built into the interlocking machine case and are operated by a lever. One such lever could have been used to control the time-releasing of all signal levers on the plant by providing the necessary contact drums for the selections. However, two levermen are used at this plant, and, therefore, to reduce interference between the work of the two men and to make releasing most convenient, two release levers were used, one for the signal levers in approximately each half of the machine. For the sake of brevity, the discussion will be confined to one of these release levers.

When a route which has been lined up and not accepted by a train is to be released, i.e., taken away so that some other route can be lined up,—the signal lever is moved from the reverse position toward the normal position as far as the normal-indication lock will permit. Then the release lever affecting that particular signal lever is reversed. This action winds up both the 30-sec. and the 120-sec. clock-work releases connected to that release lever. In order to be sure that the clock-work releases are fully wound, contacts made only when the release lever is fully reversed are included in the control of normally-de-energized stick relays, one of which is included in the circuit of the lock for each signal lever. Each stick relay control is in turn properly selected to control its pick-up and release. After the release lever is fully reversed, it is then moved to the normal indicating position, where it is held by the electric lock until the release interval expires.

During the releasing interval, the levers for the switches in the route are locked mechanically, on account of the signal lever being held electrically. A lamp below the release lever is illuminated as soon as the time release has completed its operation, at which time the release lever must be placed full normal to obtain the release of the signal lever for the route being released. The operation of the release lever affects only the particular signal lever to be released for the route being taken away, and does not interfere with the operation of levers controlling signals for other routes, although the releases for such signals are also controlled by the release lever. Furthermore, when two or more routes are to be released, one operation of the release lever affects release for all of the routes for which the signal levers have been placed in the normal indicating position.

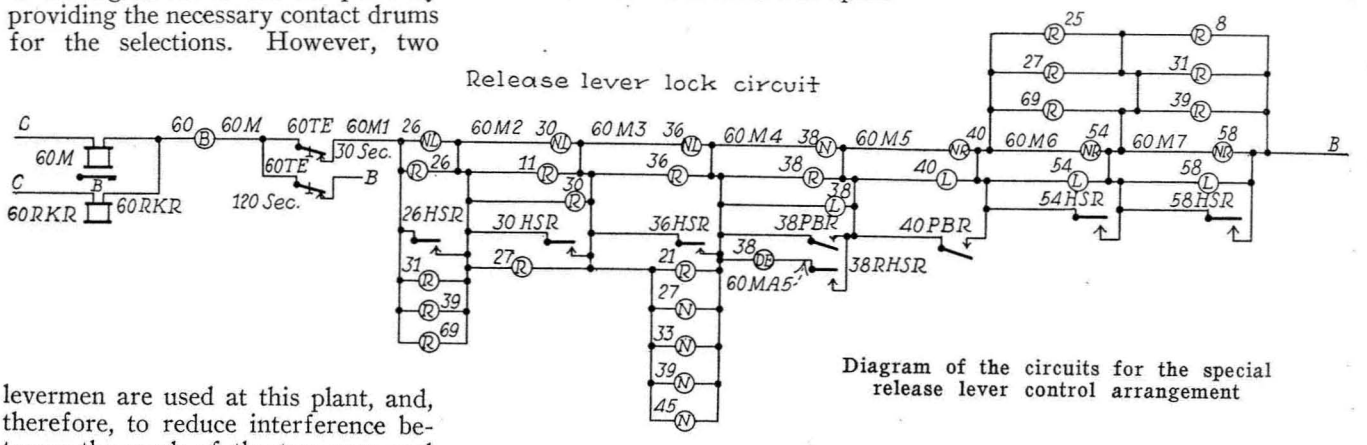


Diagram of the circuits for the special release lever control arrangement

Selective circuits are arranged so that the 120-sec. release is effective for levers when a high-speed signal is displayed and the 30-sec. release effective for slow-speed high signals and dwarfs. Referring to the circuit diagram, the normal-indication lock on the release lever is fed through a band contact and through the 120-sec. release. Thus, the 120-sec. release is effective in all instances unless the feed through the 30-sec. release and its selections becomes effective. The selections to the 30-sec. release are through band contacts operated by switch levers which, when in certain positions, make up routes over which train movements are governed by a certain dwarf signal, so that when the switches for a said route are lined up, and the signal lever is in the normal indication position, the selection is complete to feed the lock of the release lever after the duration of the 30-sec. release period.

A more complicated selection is required in connection with levers which control high-speed as well as low-speed aspects, such as signal 36R, the eastbound home signal on the Milwaukee. In this case, one of the parallel selections to the 30-sec. release is through a back contact of relay 36HSR, which is normally energized but is released when the home signal relay for the high-speed signal is de-energized.

Another phase of the scheme is to provide releasing for call-on signals. For example, signal 40L, the westward Milwaukee home signal, leads to but one through route, but a low arm is provided as a call-on signal for use in case a track circuit is occupied or a track circuit is out of service. In order to clear this call-on "arm," the operator must push a button, after reversing the lever. The action of pushing the button picks up relay 40PBR, which has a front contact in one of the multiple circuits to feed to the 30-sec. release.

Repeater and Control Circuits

The signal-repeater, track-circuit-repeater, and switch-repeater circuits are all of the two-wire type. The signal-repeater circuits for the searchlight type signals are controlled directly by contacts operated by the mechanisms.

The signal control circuits are based on the network scheme. A two-wire circuit extends to the tower from the neutral signal control relay or relays at each signal. At the tower, the wire leading to negative battery selects through a band on the lever controlling the signal. After going through a similar band, the other wire, constituting a single-wire selection, is selected through contacts in the proper switch-repeating relays, band contacts of signal and switch levers, etc., to positive battery. The single-wire cir-

cuit, interior to the tower, is used to control opposing and conflicting signals in the same route. This scheme not only increases the safety of the circuit arrangement but also reduces the number of selections to a minimum. Thus, in so far as signal control circuits are concerned, advantages were taken to utilize the most modern circuits applicable in combination with the Model-14 interlocking machine, which to a certain extent form the basis of the signal controls in some arrangements of route interlocking.

The switch control circuits follow standard practice for the control of electro-pneumatic switch movements of the Model-12 and -14 type, using a lock-valve control wire, a normal-valve control wire, a reverse-valve control wire, and connection to common. Eight movements are equipped with Style-C switch valves which are controlled through a back shunt on the WP relays.

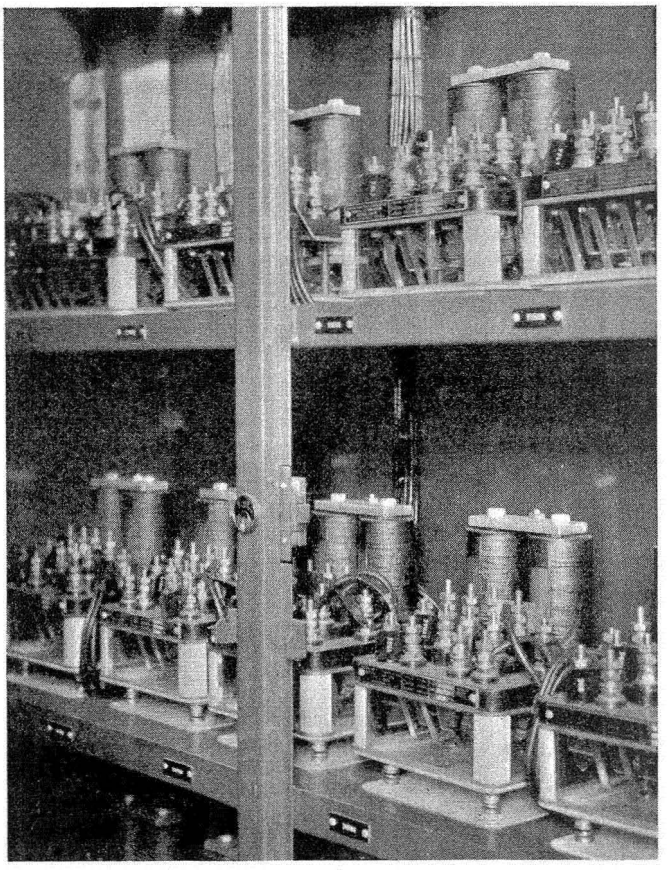
Combination Switch-Repeater Circuit

A new Model U-5 rotary switch circuit controller was installed in connection with each set of switch points and each movable-point frog, and was adjusted to open the contacts when the switch points are more than ¼ in. open. New rotary type indication circuit controllers were installed in the switch machines. The two-wire switch-repeater circuits control d-c. polarized switch-repeater relays. A special circuit was used for the outside portion of the switch-repeater circuit at the double-slip switch layouts with movable-point frogs, for example, in connection with the double-slip layout including No. 33 and No. 39. A two-wire feed, positive and negative, is selected in series through the four switch circuit controllers on the two sets of points and two frogs and also through the contacts in the controllers in the two switch movements and in the pipe-connected unit. The result is that the one two-wire circuit extending to the tower checks all the controllers mentioned. The four possible routes involved are: (a) 33N 39N, (b) 33R 39R, (c) 33N 39R, and (d) 33R 39N.

Replacement of Signals and Switch Machines

The old electro-pneumatic semaphore signals throughout the plant were replaced with light signals, using position-light signals on the Pennsylvania and searchlight type color-light signals on the Milwaukee and the North Western.

The Model-12 and -14 electro-pneumatic switch machines for the operation of the switches, derails and movable-point frogs were completely overhauled and then placed back in service as a part of the new plant. New rotary type circuit controllers were installed on the switches as mentioned previously. A new cast-iron junction box was installed to terminate the parkway cable at each switch movement, and No. 14 flexible was run in flexible metal conduit between the terminals on this box and the machine.



The relays in the tower are housed in sheet-metal cabinets with glass doors hinged at the sides

Wiring Distribution in Cable

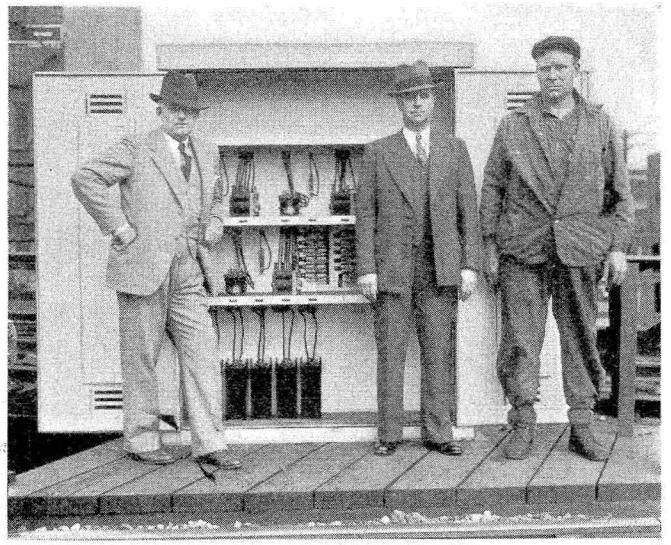
The main wiring distribution of the old plant was in cable and single conductors run for the most part in large-sized, built-up wooden boxing or trunking, much of which was in need of replacement. The cables from the tower to a central location south of the main tracks were run under the main tracks in a cast-iron pipe 30 in. in diameter, this pipe being left in service as a part of the new arrangement. Certain sections of the old cable which were in good condition were cut over to the new circuits and re-used in the new arrangement.

The old wooden instrument cases at the signal bridges were all replaced with new large-sized sheet-metal cases. Also at four other locations over the plant, new sheet-metal cases were located to house relays as well as battery and rectifiers for the new track circuits. An interesting feature is that a special telephone circuit was installed throughout the plant with a jack in each instrument case and manhole so that the maintainer can plug in a portable telephone and talk with the leverman in the tower, or can talk with another maintainer at any outside location or in the tower, when making tests.

Between certain junction boxes and these various cases, an entirely new system of wiring distribution was installed, consisting of Kerite mummy finish underground cables ranging from 2 to 12 conductors each. The track connections between the cases and the bootleg outlets are single-conductor No. 9 cable with Kerite submarine type outer protection.

The relays and other instruments in the tower are arranged in new sheet-metal cabinets, of the enclosed type fitted with doors, all of this equipment being housed in a separate room 12 ft. by 14 ft. at the east end of the ground floor of the tower. The wiring between the machine and the relay cabinets, as well as the runs leading outside of the tower, are all in sheet-metal fireproof chases. All control circuits inside the tower are in No. 14, 19-strand flexible wire with 2/64-in. insulation and single braided covering, about 100,000 ft. of this wire being required.

Compressed air for operation of the



Left to right, O. Jensen, office engineer, E. J. Muckerheide, signal inspector, and Melvin Schmidt, construction foreman

electro-pneumatic switch machines is supplied from compressors located in a Milwaukee coach yard west of the interlocking, and an emergency connection can be made with compressors in the C. & N. W. coach yard. No extensive changes were made in the air-line pipe distribution on the interlocking.

Power at 220-volts, a-c. is supplied to the interlocking from the Milwaukee shop. As an emergency supply, a connection is available with a 220-volt line of a public utility company, an automatic cut-over switch being provided to transfer the feed from the Milwaukee line to the public utility circuit, in case the former fails. The lamps in the signals, in the illuminated track diagram, and in the lever lights, are fed from the a-c. supply with no provision for an emergency battery supply. The change-over switch operates so quickly that the lamp filaments do not cool. The 220-volt a-c. circuit is extended over the plant for the operation of the 220-volt RT-10 rectifiers for charging the storage batteries and to supply the 220-volt W-10 lighting transformers. Each track circuit is fed by one 80-a.h. cell of Edison storage battery, Type-B4H. The tower battery for feeding the relays, indication magnets in the machine, coils on the switch valves, searchlight signal coils, etc., consists of 16 cells of Exide DMGO-9 storage battery. The battery is connected in two sets of eight cells, each set being charged by an RP-41 rectifier.

Change-Over in Four Days

On account of the heavy traffic, it was desirable to plan the construction so that the plant would be out of service a minimum time during the change-over. In order to provide space to set up the new interlocking machine, the old one was set on iron beams, and moved around on the floor to a diagonal position, where it was continued in operation until the remainder of the construction was ready for the change-over. The new machine was set up permanently on 4-in. H-iron beams, so that it could be moved readily on rollers. The old floor was concrete, which caused too much dust, and in order to correct this condition a new wood floor was laid and covered with linoleum after the new machine was in place. The new floor is 4 in. above the old one, thus being on a proper level to compensate for the height of the 4-in. H-irons.

While the construction outside the tower, as explained previously, was underway, the new relays, with complete new tower wiring, were installed and connected to the new interlocking machine. In order to facilitate testing, a set of triple-pole, double-throw knife switches was mounted on a board near the cable entrance inside the tower. Each of these switches was connected in the control and indication circuits of a switch or a derail, so that by throwing the knife switch from one position to the other, these circuits could be transferred to either the old machine or to the new one, thus permitting a complete test of the new wiring and machine. Another advantage of this arrangement was that the switches and derails were controlled from the old machine the first two days and from the new machine the last two days during the four-day change-over period, thus eliminating the necessity of switch tenders and temporary arrangements for controlling switches and derails.

During the four days while the plant was out of service to complete the change-over, an operator was stationed at each home signal bridge, these operators being in communication with the train director at the tower by means of the telephone system explained previously. The switches and derails were controlled by the regularly assigned levers in the new machine during the last two days out of service, after the track circuits had been tested and the detector locking and illuminated diagram placed in service. When the track line-up was complete for an approaching train, the leverman would inform the operator by lighting a lamp in a box at a signal location. The operator would then throw a knife switch in the box which would cause the signal to clear. A speed limit of 8 m.p.h. was in effect for all trains while passing a signal or going through the plant limits. With this procedure, no serious delays were experienced.

During this change-over period, the new signals were installed to replace the old ones, new connections were made to connect the new cables in with the sections of old cable, the knife switches used for testing were removed, and then a complete test was made of the entire plant.

The construction of this plant was handled by signal department forces of the Milwaukee, under the jurisdic-

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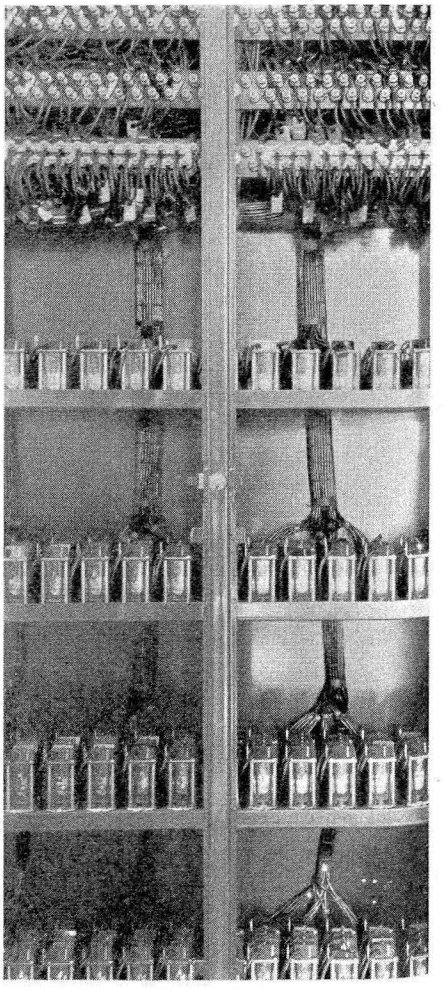


Style L10 indication relays in the instrument case in the tower

(Continued from page 692)

tion of L. B. Porter, superintendent of telegraph and signals, and O. Jensen, office engineer in charge of design. E. J. Muckerheide, signal inspector, was in direct charge of the construction, and Melvin Schmidt was foreman of the crew of from 10 to 20 signalmen. This plant is maintained by one maintainer and one assistant on each of the first two tricks and one maintainer on the third, reporting to L. Gerhart, signal supervisor, the maintenance force and the supervisor co-operating with the construction forces during the construction period and the change-over.

The major items of new equipment used on this installation, such as the interlocking machine, signals, relays, rectifiers, etc., were furnished by the Union Switch & Signal Company, which furnished the circuit plans for the installation.

Accident Due to False-Clear

On September 11, 1938, a rear-end collision occurred between two passenger trains on the Chicago, St. Paul, Minneapolis & Omaha, at Valley Junction, Wis. In the vicinity of the point of accident this is a double-track line over which trains are operated by timetable, train orders and an automatic block signal system. Investigation by the Bureau of Safety, I. C. C., revealed the following facts:

At Wyeville, the Chicago & North Western approaches from the north on a right curve and connects with the Chicago, St. Paul, Minneapolis & Omaha. Interlocking home signal 9, which governs movements from the North Western to the Omaha, is also used as a train-order signal. Automatic signal 1721, Bridge 57¼ and Bridge 58 are located 6,875 ft., 11,440 ft., and 12,812 ft., respectively, west of home signal 9. The point of collision was between the two bridges, 450 ft. east of Bridge 58. It was dark, misty and foggy at the time of the accident, which occurred about 4:45 a.m. There is no maximum speed limit prescribed for passenger trains on the Wyeville subdivision.

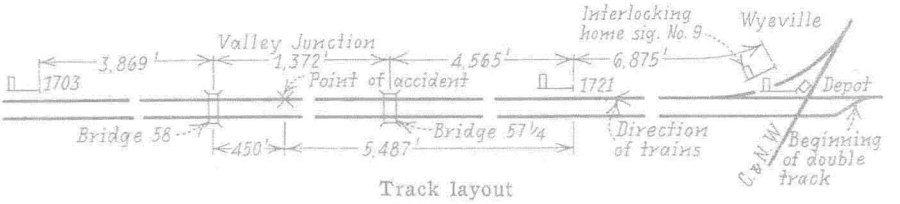
The crew of No. 515, a westbound passenger train, received at Elroy, located 25 miles east of Valley Junction, copies of train order No. 731, Form 19, reading as follows:

"Water very high in the bridge just east of Valley Junction and the culvert just west of Valley Junction where the old depot stood and at the bridge just east of Wyeville depot and the bridge about three-fourths mile east of Stowell. All trains will stop at these bridges and the culvert and get permission from men on ground before passing over."

First 405 left Wyeville at 4:42 a.m., 2 min. late and 8 min. behind No. 515. It passed automatic signal 1721, which was displaying a proceed indication, and shortly thereafter, while moving at a speed estimated at between 12 and 15 m.p.h., struck the rear end of No. 515.

Automatic signal 1721 is of the 1-arm, 3-position, upper-quadrant, semaphore type.

In this signal system, an H relay controls the 0 deg. to 45 deg. movement of the signal arm, and a D relay controls the 45 deg. to 90 deg. movement. The H-relay control selects through all track relays and switch controllers in the block. The D-relay control selects through the H relay and the circuit controller on the signal in advance, thence to the battery; the circuit is closed by the circuit controller when the signal arm is in the 45 deg. to 90 deg. position. The length of the block westward from signal 1721 to signal 1703 is 9,806 ft.; it is divided into three track circuits of 3,752 ft., 2,700 ft., and 3,354 ft. in length, respectively, from east to west.



Track layout

The evidence was to the effect that the engineman of No. 515, in carrying out the requirements of order 731, made momentary stops at Bridge 57¼ and again at Bridge 58, and as a matter of additional precaution he had previously made a brief stop at the section house located a short distance west of Wyeville to consult with the roadmaster who was on the ground at that point. When the first and second of these stops were made, the flagman stepped to the ground with lighted 10-min. fusees which he dropped to the track when his train started, but because of lack of time he did not place torpedoes at either point. When the third stop was made, at Bridge 58, the flagman again stepped to the ground with a lighted fusee and when he was about to board his train as it started to leave he heard First 405 approaching. He started to run eastward, waving the lighted fusee, but was able to get back only about 6 or 7 car lengths when the engine of First 405 passed him.

Both the engineman and the fireman of First 405 stated that signal 1721 was displaying a clear indication as their train approached it, and it was found to be displaying a clear indication with the block occupied when the maintainer arrived at about 8 o'clock. Several tests were made, and it was found that the H and D control relays would become energized and the signal would clear with second track circuit shunted. By means of further tests, it was determined that this was caused by a cross between 1721H and 1721D line control wires in the fourth span east of the cut section location between the first and second track circuits, or approximately 3,100 ft. west of signal 1721. At point of cross, the insulation on these wires was worn and the wires had been twisted together by wind. With this cross existing, the signal would go to stop with the first track circuit occupied, but as soon as the train passed into the second track circuit, the signal would go to clear. If this cross condition existed at the time of the accident, signal 1721 would be in the clear position for First 405, assuming that as First 405 approached the signal No. 515 was out of the first track circuit west of the signal. After the cross was removed, the signals resumed normal operation.

Neither the engineman nor the fireman of First 405 had read order No. 731, which was delivered to them at Wyeville, and it is possible that had either done so the accident would not have occurred, since the order required a stop at Bridge 57¼. The conductor of First 405 had read order No. 731 and was attempting to determine the whereabouts of his train when the accident occurred.

This accident was caused by a false-clear signal indication given by the automatic signal governing the use of the block within which the accident occurred, and failure to provide proper flag protection for the first train.