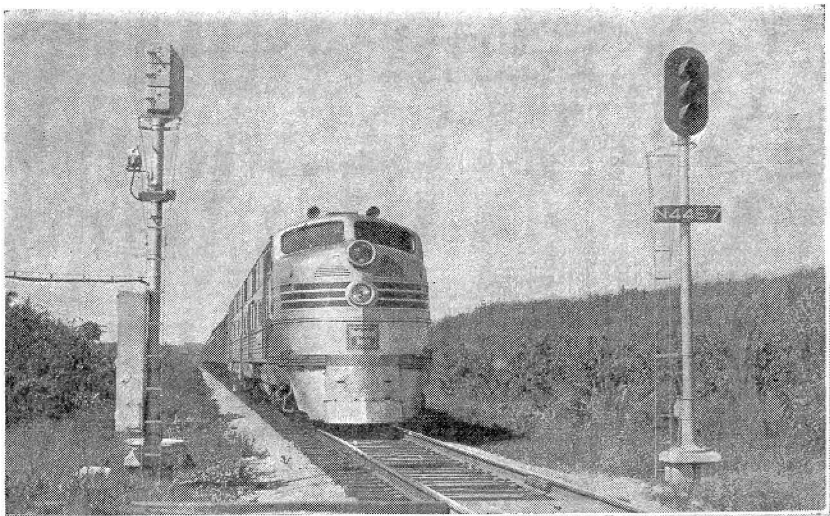
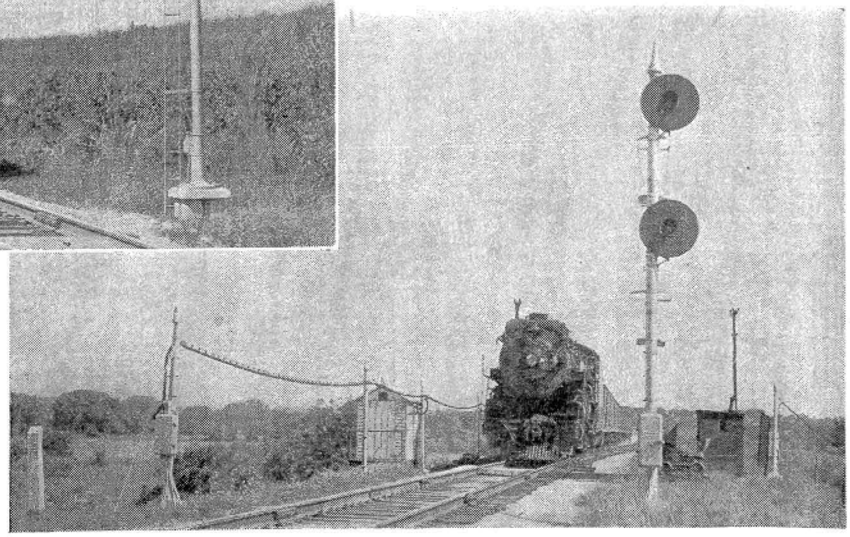


Continuously



Above — An intermediate automatic block location
Right—Power switch and signal layout at siding

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In 1930, the Chicago, Burlington & Quincy installed centralized traffic control on 24 miles of single track between Red Oak, Iowa, and Balfour, including about a mile of double track at each end. The arrangement of tracks, power switches, and signals installed at that time is shown in a diagram herewith. This 1930 project included lower-quadrant, two-position semaphore signals. The station-entering signal at the end of each passing track had three arms. The top arm displayed either of two night aspects, red for Stop, or green for Clear. The second arm was the distant signal for the main-line station-departure signal at the far end of the siding, the night aspect being yellow for Approach, or green for Clear. The bottom arm was a short red blade, the night aspect being red normally, or yellow for a move into the siding. Each station-departure, main-line signal governing moves in the trailing direction over a switch had one arm only, which was a red blade, the night aspect being red for Stop or green for Clear. The leave-siding signals were color-light dwarfs, which displayed two aspects, red for Stop or green for Clear.

Each intermediate automatic block home signal had one red blade, the night aspect being red, or green. In approach to each of these intermediate automatic block home signals, as well as in approach to each station-entering signal, there was a one-arm yellow blade distant signal, the night indication of which was green for Clear or yellow for Approach when the home signal ahead was displaying the red aspect. The distance from each home signal to its corresponding distant signal ranged from a minimum of about 3,000 ft. to a maximum of about 4,000 ft.

In the years following 1930, the weights and speeds of trains increased rapidly so that train stopping distances increased to more than the 4,000 ft. maximum signal spacing on the Red Oak-Balfour territory. As a part of a program, to provide proper train stopping signal distances, it was decided that on the Red Oak-Balfour section the lower-quadrant two-position signals, arranged on the home and distant principle, should be replaced with light signals, each of which display three aspects so that the yellow aspect of one signal would serve as the Approach aspect for the next signal, in the conventional manner. Searchlight type signals were installed for the semi-automatic C.T.C. controlled signals at switches, and three-aspect color-light signals were installed as intermediate signals. The signals were spaced a minimum of 9,000 ft. This change in signaling was completed September 30, 1942.

When installing the new signals, no changes were made in the centralized traffic control system as such, the power switch machines and the semi-automatic signals being controlled by the time code line system using two line wires, the same as before, and the C.T.C. control machine remained in the office at Red Oak.

Changes In Local Controls

In the arrangement as installed in 1930, each of the home automatic, as well as distant signals, was controlled by a neutral d-c. relay, which in turn was controlled by a neutral line circuit taken through contacts of the track relays involved, as well as certain signal controller contacts. Each line circuit consisted of a separate wire with connection to a common wire for return.

These wires, as well as C.T.C. code line control circuit, were in an aerial cable which had been well taken care of during the years so that, in 1941, when the resignaling was proposed, the continued use of this cable was most logical.

Having adopted the policy of installing new three-aspect signals, a problem was to determine the necessary changes in local line control circuits. Whereas a neutral relay and one neutral line circuit had been adequate for the control of a two-aspect semaphore, some other arrangement, such as two neutral line circuits or the more conventional polar line circuit, would be required to control each of the new three aspect light signals. The existing cable did not contain

Coded Local Line Wire Signal Control Circuits

Respacing program leads to development of scheme to use two line wires to carry various continous codes, such as 75, 120 or 180 per minute, in one direction or in both directions simultaneously to control signals to display different aspects

enough wires to provide two neutral circuits for each signal, nor did it include enough wires for a two-wire polar line circuit for each signal. The use of polar line circuits using one wire and common was considered to be objectionable on account of the possibility of failures which might be caused by grounds and crosses.

Prior to that time, considerable research work had been done to develop the use of line circuits using continuously operating codes at rates such as 75, 120 or 180 pulses each minute, these particular rates of code being used because code transmitter instruments and de-coding units of the type used for coded track circuits were available to produce continuous code at these rates.

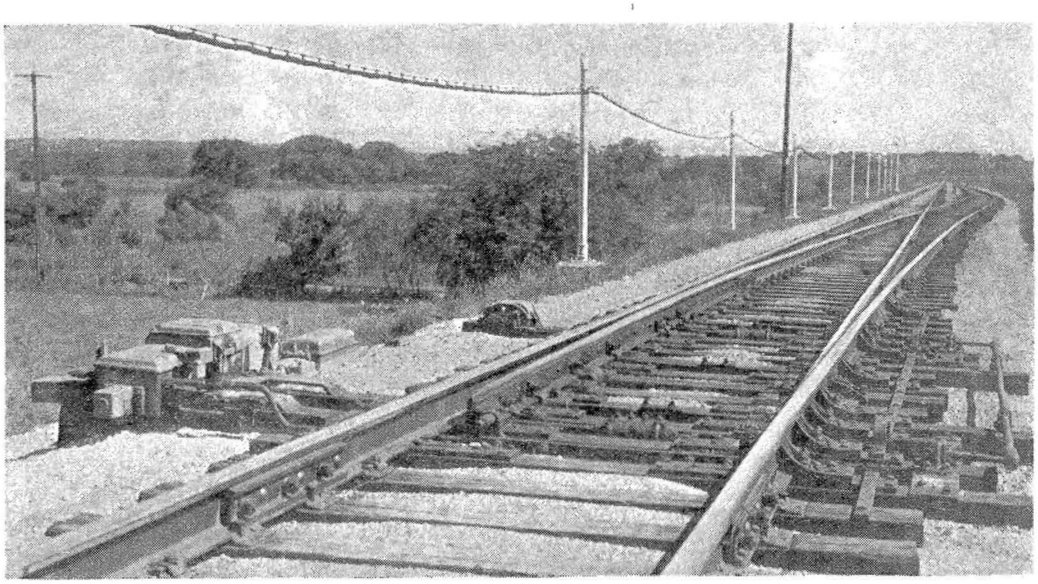
An advantage is that a coded line circuit offers a higher degree of protection against false proceed aspects which might be caused on neutral or polar line circuits by crosses or grounds. Foreign current, either intermittent or steady, of any sort, as for example, from a cross or ground, as applied to a coded line circuit, will not operate the relay in conformance with the code, and, therefore, the signals will be controlled to the most restrictive aspect. Thus, with a coded circuit, the signals can be controlled to the yellow or the green aspect only when the correct code is fed to the circuit and received by the code detector devices.

Both Directions Simultaneously

An important phase of this development is the use of the same two line wires to transmit two different codes in opposite directions simultaneously. Codes at different numbers of pulses per minute, such as 75 and 120, are fed at opposite ends of the two line wires, so that it is impossible for the two codes to become synchronized, i.e., to get in step and thereby oppose each other for more than perhaps a part of any one pulse in either direction. Thus it is obvious that there are regularly recurring intervals when the "on" impulse of one code occurs at the same time as part of the "off" period of the opposing code. During each of these intervals, the energy from the "on" impulse of the incoming code is transmitted to a relay during the "off" of the outgoing code. In other words, the "on" pulses in one direction feed through to the other end during the "off" pulses of the code feeding the opposite direction.

A further fact is that the two codes being fed from separate batteries have no relation with respect to polarity; therefore, the polarity of either one or both of the codes can be changed irrespective of the opposing code, thus accomplishing selections for two different controls, such as the Approach or Clear aspects of a signal.

A review of the discussion above is that two line wires or two wires in a line cable can be used to transmit two controls in each direction, and that a control in each direction can be transmitted simultaneously. By applying these coded line circuits when changing from semaphores to light signals on the Red Oak-Balfour territory, the local signal line controls and the approach indication circuits are all handled on only two wires in the cable. Thus the old cable was used throughout with conductors to spare. In addition to the two wires for these coded circuits, two other wires in the cable are used, as before, for the centralized



Power switch at a long turnout with a second operating connection at middle of the points traffic control time code controls between the office and the field stations. Other wires as required are used, the same as before where line circuits are required for highway-railroad grade crossing signals.

Special Equipment Required

When installing this new scheme of continuously coded line control signal circuits on the Red Oak-Balfour territory, new code equipment was required. The code transmitters are of the same type as used in coded track circuits. In the accompanying circuit diagrams, the letters "CT" stand for "code transmitter." The 75CT pulses its contacts 75 times each minute, and the 120CT and the 180CT pulse their contacts 120 or 180 times each minute, respectively. These code transmitters operate continuously from a 10-volt d-c. supply.

The PCSR relays are the polar code stick relays which are designed to operate the contacts to one position when the coil is energized by one polarity, or to operate the contacts to the other position when the coil is energized by the opposite polarity; furthermore, when the contacts have been operated to either position, they stay there regardless of the fact that the incoming feed may be pulsating or discontinued. Therefore, having once positioned the contacts they stay closed in that position until current of the opposite polarity is applied to the coil to cause the contacts to be operated to the opposite position. Each of these PCSR relays is equipped with four normal and four reverse contacts.

The CFR relays are polar biased, code-following, quick-acting relays designed to respond to coded d-c. energy. It is quick enough to be energized during the "on" period, and de-energized during the "off" period of the code. The design of the magnetic circuit, together with the use of a permanent magnet, is such that the relay will be actuated by direct current of one polarity only (in the direction of the arrow as shown on the drawings). Energy of the opposite polarity merely increases the pressure of the armature against the back stop and holds it in its de-energized position. Two front and two back dependent contacts are required on this relay.

Decoding Equipment

The DUT decoding transformers are transformers of standard type designed to operate on current of a low frequency, such as 75 to 180 per minute. Two types of these transformers are used in this circuit. Where the incoming code is always of the same rate and no tuning is required, a small transformer of the W5A type is used. A W7 type of a larger size is used where the incoming code may be at one rate part of the time, and of a different rate at other times. This condition requires a system of tuning which in turn necessitates the use of the larger transformer.

The 180 DU tuned decoding unit is used in connection with the W7 decoding transformer to receive low frequency alternating current from the transformer and performs a two-fold purpose. First it is tuned to function only when the incoming alternating current from the transformer is of a frequency of three cycles per second. This is the frequency supplied by the 180 per minute code. The 120 code (two cycles per second) and the 75 code (1½ cycles per second) will not actuate this tuned decoding unit. This feature is accomplished by the use of condensers which are electrically tuned to the reactance of the transformer. The second function of the 180 DU is to rectify the three-cycle alternating current and feed the resultant direct current to a d-c. line relay. This is done through copper-oxide rectifiers which are an integral part of the unit.

The HR relay (or AR relay at certain locations) is a slow pick-up and slow-release line relay, which is energized by the untuned output of the decoding transformer. The slow pick-up characteristic is to prevent the immediate pick-up of the relay in case of a single code impulse due to possible momentary loss of train shunt. The slow-release characteristic keeps the relay energized during the momentary periods when no output energy is received from the decoding transformer.

The DR relay (or 180 CPR relay at certain locations) is a 55-ohm slow-release line relay, which received energy from the 180 DU. Thus it can only be energized through the functioning of the 180 DU, which occurs

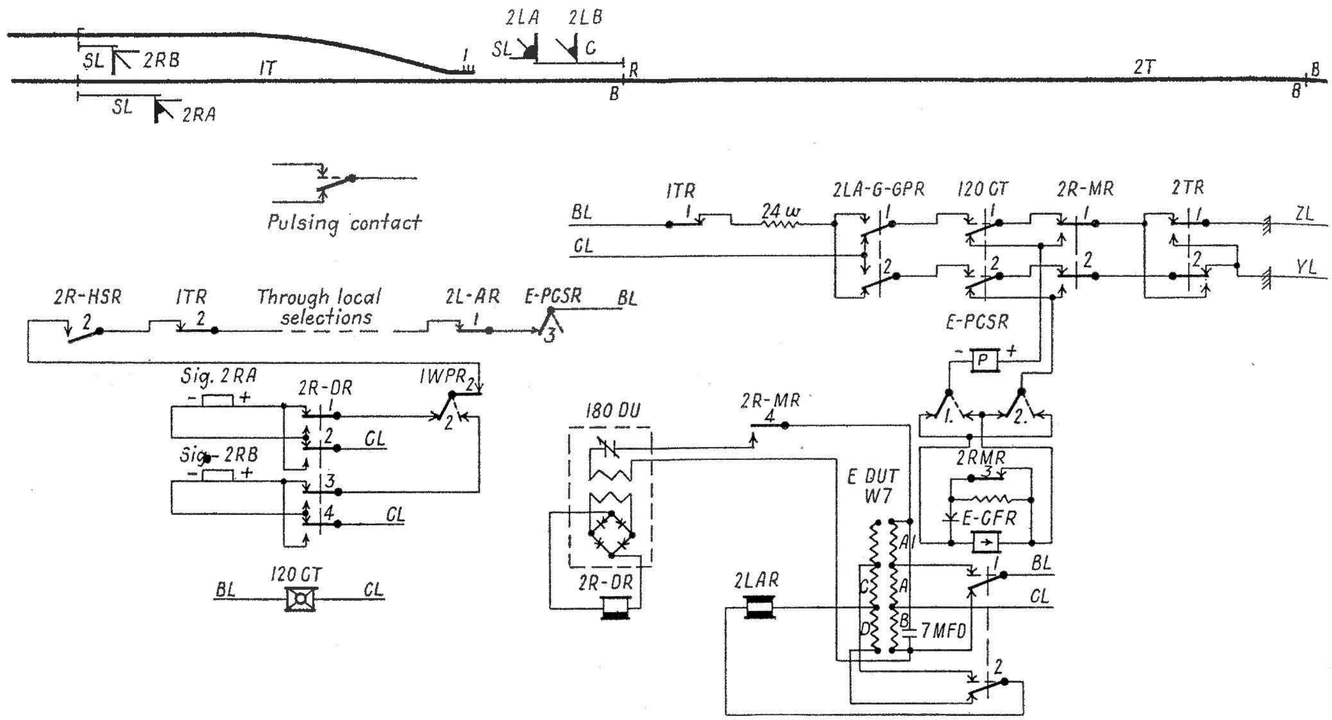
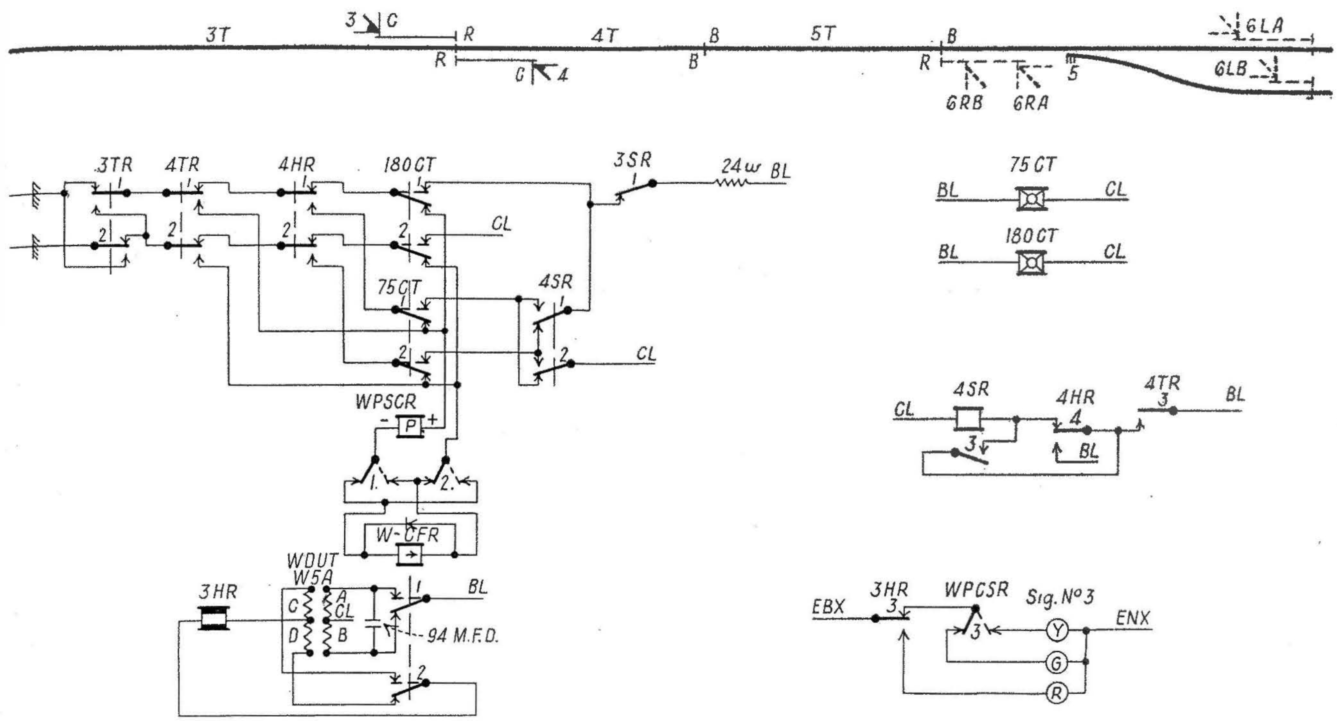


Fig. 1—Diagram of typical circuits including

only when the incoming code is 180 cycles per minute (three cycles per second). The slow-release characteristics of this relay is to keep it energized during momentary periods when no output energy is received from the 180 DU.

Operation of Typical Circuits

Figure 1 illustrates a typical block in centralized traffic control territory with a controlled switch and its asso-



territory between two passing tracks

ciated signals at the left of the plan, and an intermediate location in the center. Assuming that west is to the left, then controlled signals 2RA govern eastward train movements into the block. Likewise, intermediate signal No. 3 governs westward movements into the same block. Intermediate signal No. 4 would govern eastward train movements into the adjoining block east, and signal 6LA and 6LB would govern westward movements into that block. The control circuits for these latter signals would be identical to the typical circuits shown for the other blocks in the remainder of the territory.

Assuming that no trains are present, and that controlled signals at both sidings shown on the plan, as well as at the next siding east, are at Stop due to the centralized traffic control controlled HSR relays being deenergized, then the following code action will take place.

Referring to circuit plan Fig. 1, positive battery BL originates at the controlled switch location. After passing through front contact No. 1 of ITR relay, through a 24-ohm resistance, then through back contact No. 1 of the 2LA-GPR (green repeater relay of signal 2LA) then through the front contact No. 2 of the 120CT and 2RMR relays, which checks signals 2RA and 2RB at stop, also checking the expiration of the time locking for these signals when required. The No. 2 front contacts of the 2TR, 3TR and 4TR are then checked before reaching the intermediate location. If the 4HR is energized, the circuit also checks its No. 2 contact.

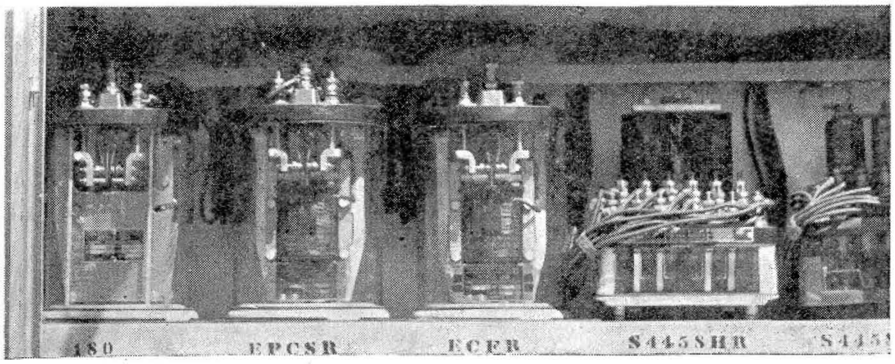
At the intermediate location, the circuit checks the No. 2 back contact of 180CT code relay, passes to the No. 2 polar contact of the W-PSCR relay. If the W-PCSR is normal, the current then flows over its No. 2 normal contact through the coils of the W-CFR (in a reverse direction), then back over the No. 1 normal contact of the W-PCSR through its coils from the minus to the plus terminals. From here, the return circuit is over back contact No. 1 of the 180 CT code relay, front contacts No. 1 of the 4HR, 4TR and 3TR; then over line ZL and over front contacts No. 1 of the 2TR and 2R-MR; then through front contacts No. 1 of the 120CT code relay, back contact No. 1 of the 2LA-G-GPR, thus completing the circuit back to negative battery CL.

Under the above conditions, the current flowed in a reverse direction through both the W-CFR and the W-PCSR, thus the W-CFR will remain de-energized when current is applied to its coils in this reverse direction. However, the reverse direction of the current through the coils of the W-PCSR will cause it to reverse its contacts, and, when this occurs, the positive energy which was being fed to its No. 2 contact will then flow over the No. 2 reverse contact instead of the normal. From this reverse contact, it goes through the coils of the W-CFR in the proper direction, then back over the No. 1 reverse contact of the W-PCSR, and so on through its coils previously described. This change in polarity permits the W-CFR to be energized each time current is applied to its coils. In tracing back over this circuit, it will be noted that the current for energizing the W-CFR is being constantly interrupted (or coded) at two points. First over the front contacts of the 120 CT at the controlled switch location, and second over the back contacts of the 180 CT at the intermediate location. Thus, to energize the W-CFR relay requires the front contacts of the 120 CT to be closed at the same time as the back contacts of the 180 CT. As these two code transmitters are operating at different frequencies, the above condition will be continually occurring at intervals of an uneven frequency, which provides energy to the W-CFR over approximately 25 per cent of any given period of time. This uneven energization is partially compensated for by the rectifier snub across the coils of the W-CFR, thus giving it slow release characteristics so that its pulsing in response to the incoming code will be reasonably uniform. The

No. 2 front contacts of 2TR, 2R-MR, 120CT, 2LA-G-CPR and back to negative battery. This would result in continued pulsing of the W-CFR relay which would keep 3HR relay energized. Thus W-PCSR relay has moved its contacts from reverse to normal and signal No. 3 will display its proceed indication. When signal No. 2LA displays its green aspect, the outgoing code changes polarity and thus causes signal No. 3 to also display the green aspect also, providing the track is unoccupied. When positive energy of a code in this direction is fed to line ZL and causes signal No. 3 to display the green aspect, it is known as a positive code, and when negative energy is fed to line ZL and causes signal No. 3 to display its yellow indication, it is known as a negative code.

It has been assumed that to clear signal No. 3, the 4HR relay was energized. However, the reception of incoming code when the 4HR relay is de-energized is identical, as previously described, except it reaches the coils of the W-PCSR and W-CFR relays over back contacts No. 1 and 2 of the 4HR and 75CT instead of front contacts No. 1 and 2 of 4HR and back contacts No. 1 and 2 of 180CT. Thus the indications of No. 3 signal are not affected by the position of 4HR relay, the contacts of which are in the circuit for selection of outgoing code only.

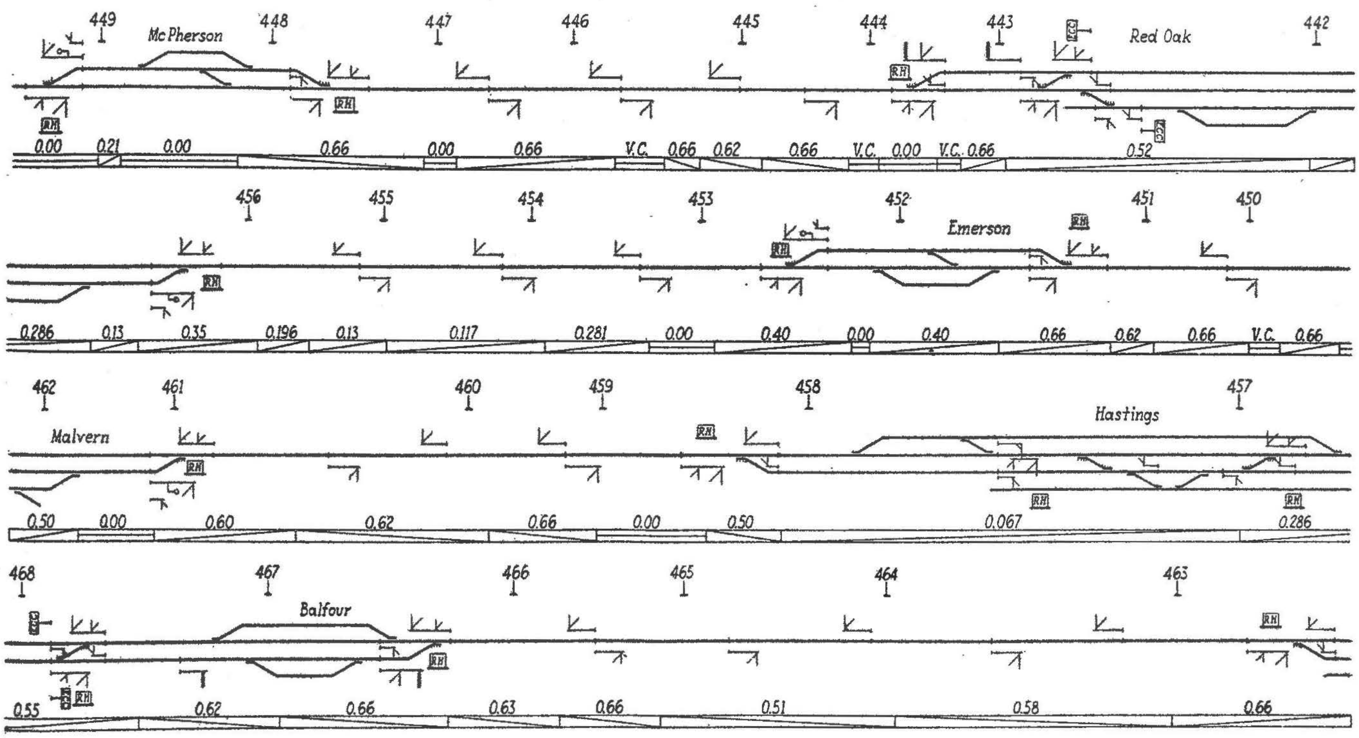
The red aspect of signal No. 3 will be displayed at any time when no code is being received by W-CFR relay. This condition prevails at any time the track relays 1TR, 2TR or 3TR are de-energized, thus providing track-occupancy protection between signal No. 3 and signals No. 2RA and 2RB. As protection for opposing movements, the outgoing code from the controlled switch location is broken over front contacts No. 1 and 2 of 2R-MR relay. This relay becomes de-energized when either signal 2RA or 2RB is cleared. Thus, the clearing of either of these eastward signals causes the intermediate signal No. 3 to display its red aspect. Inasmuch as the 2R-MR also checks the expiration of the time locking when required, it, therefore, renders it impossible to set one of these signals to "stop" in front of an eastward train, and then immediately clear the opposing signal. Such a move cannot be made until after the expiration of the pre-determined time interval.



A code transmitter, a polar code stick, a polar biased, and a home relay.

In order to study the possibility of a false proceed aspect, it should be kept in mind that a constantly coded energy must be present in order to receive a clear signal. In order further to study the possibility of a false proceed aspect, we will use signal No. 3 as an example. An open circuit results in de-energization of W-CFR relay, thus causing the restrictive aspect of the signal. Also it has been shown that correct code is necessary for each aspect. Thus short circuits, grounds, etc., would cause a more restrictive aspect.

These examples are a few of the safeguards of continuous coded circuits and show that it is the most foolproof circuit for centralized traffic control, automatic signals and other signal circuits that has been developed to date. It is used for all circuits other than the centralized traffic control code circuit, which was not changed from its original installation. The centralized traffic control code and the signal circuits continuous code cannot be combined in the same conductors, consequently it requires four line conductors for a complete installation, which is much less than when neutral signal circuits are used.



Arrangement of signals as originally installed in 1930