Automatic Signals on the Northern Pacific

A Description of the Double-Track Block Signaling Recently Completed and Put in Service in the Northwest

BY ALF. MUNTHE*

In addition to the single-track signaling described in *The Signal Engineer* for February, 1911 (page 41), the Northern Pacific has also recently placed in service various stretches of automatic block signaling in the states of Minnesota, Montana, Washington and Oregon, aggregating about 350 miles of double-track road which has been thus equipped during the last fiscal year.

On account of the great difference in climate as well as in other conditions, at the various points, it was found necessary to modify and adjust the general specifications and methods of construction to fit each case. These modifications, however, were not of a nature to disturb the uniformity of the general signal arrangement. The main features and standards are not changed, but, by close study of local requirements in each instance, and by adapting the apparatus and arrangement to suit them, it was found possible greatly to reduce the expense, while the efficiency of the system was actually increased.

With the exception of a few miles near St. Paul, which were installed by the railway company's forces, all of this work was done by contract under the direction of C. A. Christofferson, signal engineer. The Hall Signal Co. was awarded the contract for a stretch of about 40 miles between Tacoma and Seattle, while the other installations were made by the General Railway Signal Co.

There are 49 signals and 82 switch indicators on the line between Tacoma and Seattle. Hall style "H" top-post mechanisms were used.

On the installations made by the General Railway Signal Co. the signals are model 2-A. There are 377 signals and 341 switch indicators on the entire territory of 285 miles, for which this company had the contract.

Fig. 1 shows a circuit which is typical of the method of control employed for all signals and switch indicators where no special features are involved. The 45-deg. control of all signals is taken through front contacts of the track relay, thus insuring one clear block ahead before a signal can assume the "caution" position, while the 90-deg. control is taken through the front contacts, both of the track relay and of the line relay, thereby insuring two "clear" blocks and the next signal at "clear" or "caution" before the signal can assume the clear position. The energy for the line relays is taken from the battery of the next signal beyond for the same direction. Thus, for the line relay of signal "C," Fig. 1, the current is taken from the battery of signal "A," the circuit being carried through front contacts of the track relay X, through a contact of a circuit controller operated with the mechanism of signal "A," over the line wires, through the front contacts of track relay Y, through the coils of the line relay for signal C, and to common. The contact of the circuit controller on the signal, through which this line wire is taken, is so adjusted that it does not close until the signal has assumed the 45-deg. position, but remains closed at all points between the 45-deg. (caution) position and the 90-deg. (clear) position. By this arrangement the line relay is controlled, not only by the indication of the signal ahead, but also by the track circuits of two blocks. The control of each switch indicator, as will be seen at A^1, D^1, E^1 and F^1, Fig. 1, is taken far enough back to give an approaching train both a caution and a stop signal in case the switch should be thrown. All indicators located in the same block are connected in multiple. The common is cut at points approximately ten miles apart, and, where possible, the cuts are made at double-signal locations, or at points where the shortest possible overlap is required.

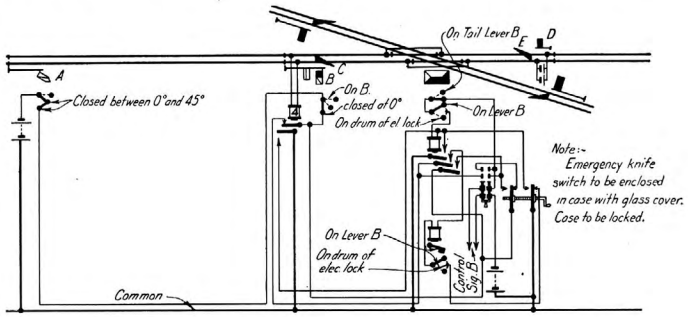

Fig. 2. Circuits for Back Locking and Route Locking.

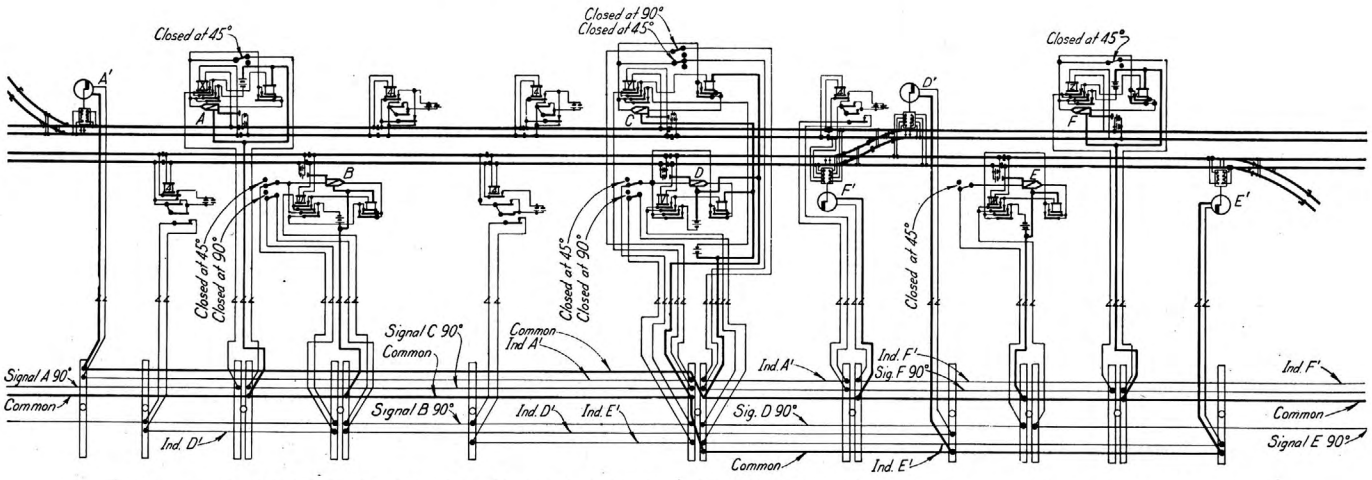

Fig. 1. Typical Circuit, Showing Method of Control for Signals and Switch Indicators on Double Track.

Where the view is obscured in the approach to a station, the 90-deg. control wire of the first block signal in each direction is cut through a contact of a circuit controller operated with the train order signal. As the latter signal is normally in the stop position, this contact is, therefore, normally open, as shown in Fig. 3.

There are 10 interlocking plants within the block signaled

*Of the Signal Department of the Northern Pacific. Mr. Munthe Described the Single-Track Signaling between Billings and Livingston, Mont., in *The Signal Engineer* for February, 1911, page 41.

territory. Three of these are new, having been installed by the General Railway Signal Co. concurrently with the block signals. The old plants had to be remodeled to conform to the general

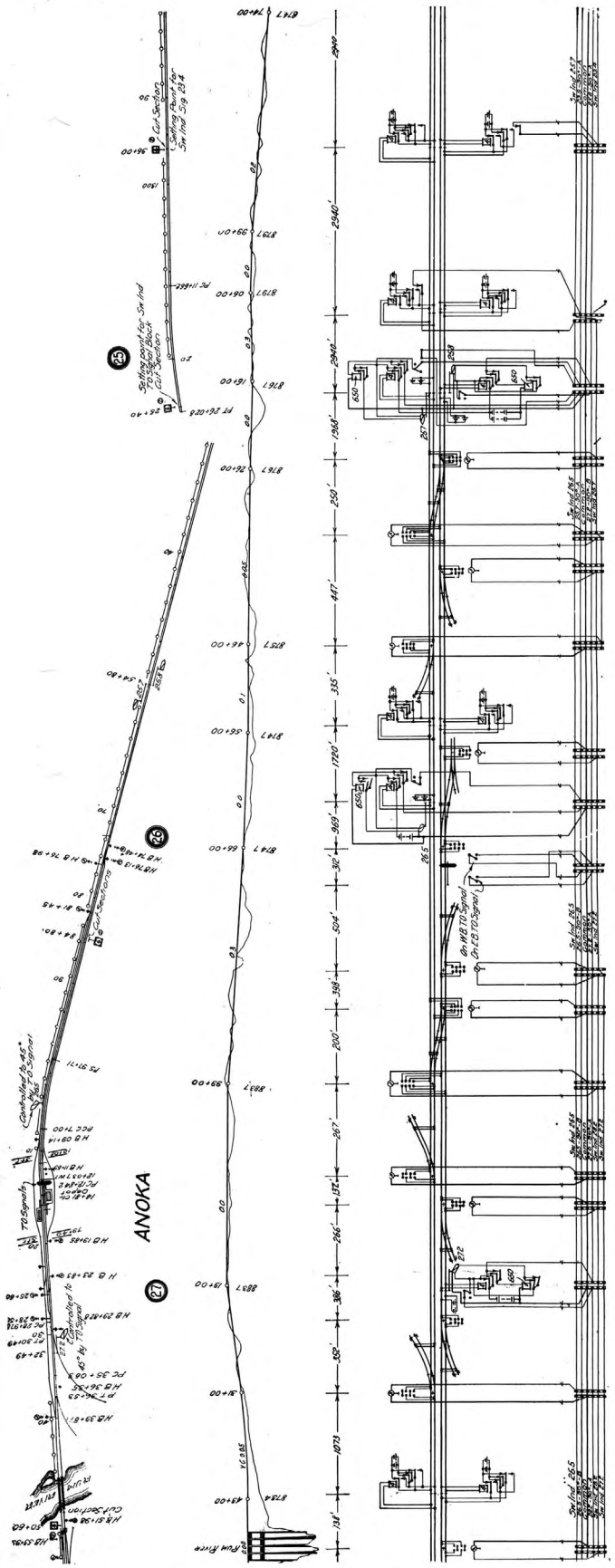

Fig. 3. Circuit and Track Plan near Anoka, Minn., Showing Method of Connecting Control Wires through Station Signal, where View Is Obstructed.

block arrangement. Two of the new plants are electrically operated, the General Railway Signal Co.'s model 2 machines being used. The third of the new plants, as well as the seven old plants, are all mechanically operated, using machines of various types and manufacture. The general arrangement, both of the new and of the remodeled plants, is such that continuous block operation is secured through them. To this end all main line signals have been made semi-automatic, operating in three positions, and are so controlled that when a route is set up and the signal lever is reversed, the signal is subject to the same control as an ordinary block signal. Back-locking for distant signals, electric route locking between home signals, tower indicators, and

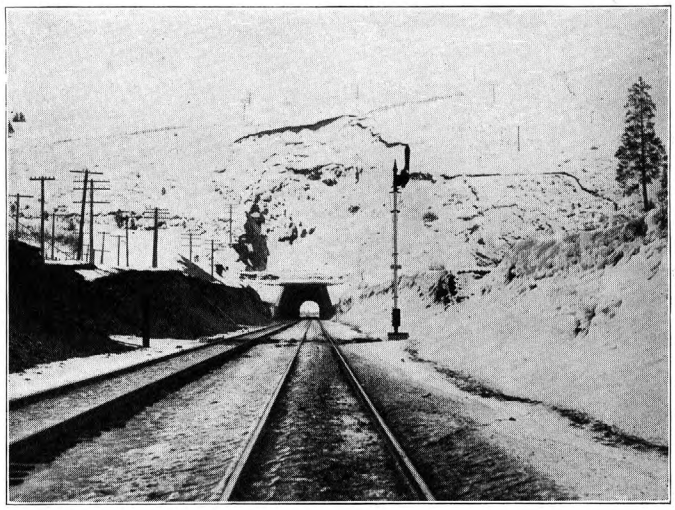

Fig. 4.

bell annunciators are, also, features entering into the general arrangement at each interlocking plant. Fig. 8, showing a mechanical interlocking plant located at Wadena, Minn., is an illustration of the general arrangement and the circuits employed. The distant signals are straight automatic, controlled through a front contact on the track relay for movements from 0 deg. to 45 deg., and through front contacts on both the track and the line relays for movements from 45 deg. to 90 deg. The energy for this line relay is taken from the battery of the home signal through front contacts on the relays of the track circuits for both the home

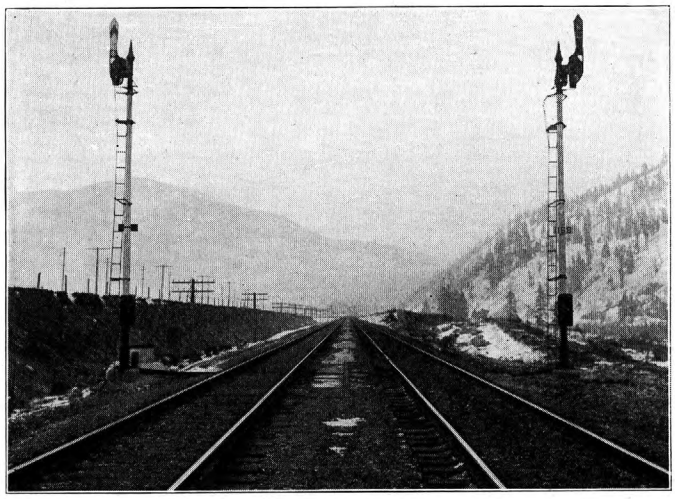

Fig. 5.

and distant signals, and through normally-open contacts on circuit controllers operated by the derail and by the home signal. By this arrangement the distant signal cannot go to the caution position unless the block is clear up to the home signal, and it cannot assume the 90-deg. position unless the next block is also clear, with the derail reversed and the home signal in the caution or clear position.

The main-line home signals are semi-automatic. The current from the signal battery to the motor is taken through a front contact on the track relay, through contacts of a circuit con-

troller operated by the derail (the contacts being closed only when the derail is reversed), and through contacts on a polarized line relay, the 45-deg. control being taken through the neutral contacts only, while the 90-deg. control is taken through both the neutral and the polarized contacts. The energy for this polarized relay is taken from the battery of the next signal ahead, the current being carried through a pole changer operated with the mechanism of this signal, through front contacts on relays of all track circuits in the territory intervening between the two signals, through a normally-open contact on a circuit controller operated

Fig. 6. Cut Section in the Town of Bonner, Mont., Six Miles West of Missoula.

by the home signal lever in the interlocking machine, and through normally-closed contacts on the emergency switch. In order to get a home signal in the 45-deg. position, it is, therefore, necessary that its lever in the interlocking machine be reversed, the derail reversed, the emergency switch normal, and the block clear up to the next signal ahead; and in order to get it in the 90-deg. position, it is also necessary to have the next signal in the clear position. The home signal and derail levers in the machine, when reversed, will, of course, also prevent any conflicting movements, by means of the mechanical locking in the machine. The

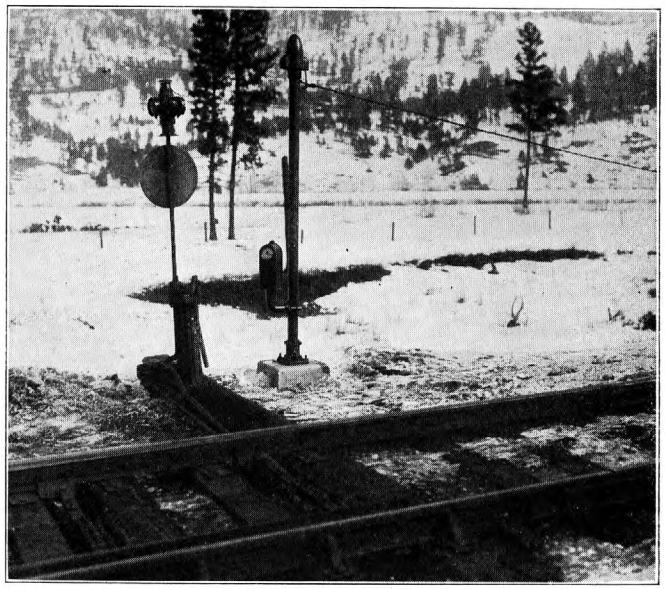

Fig. 7. Switch Indicator on Cable Post.

circuits employed to take care of the back-locking for the distant signals, as well as the locking of the route, are shown in Fig. 2. One lock for each track is made to take care of both these features. The energy for the lock is taken in all cases from the battery of the distant signal, through a contact on a circuit controller operated with the mechanism of that signal and so adjusted as to be closed at all points between the 0-deg. and 45-deg. positions, and open between the 45-deg. and the 90-deg. positions. If the distant signal should stick in the clear position, therefore, no energy is obtained. Similarly, the circuit is also taken in all cases through a contact of a circuit controller operated with the mechanism of the home signal and closed only when that signal

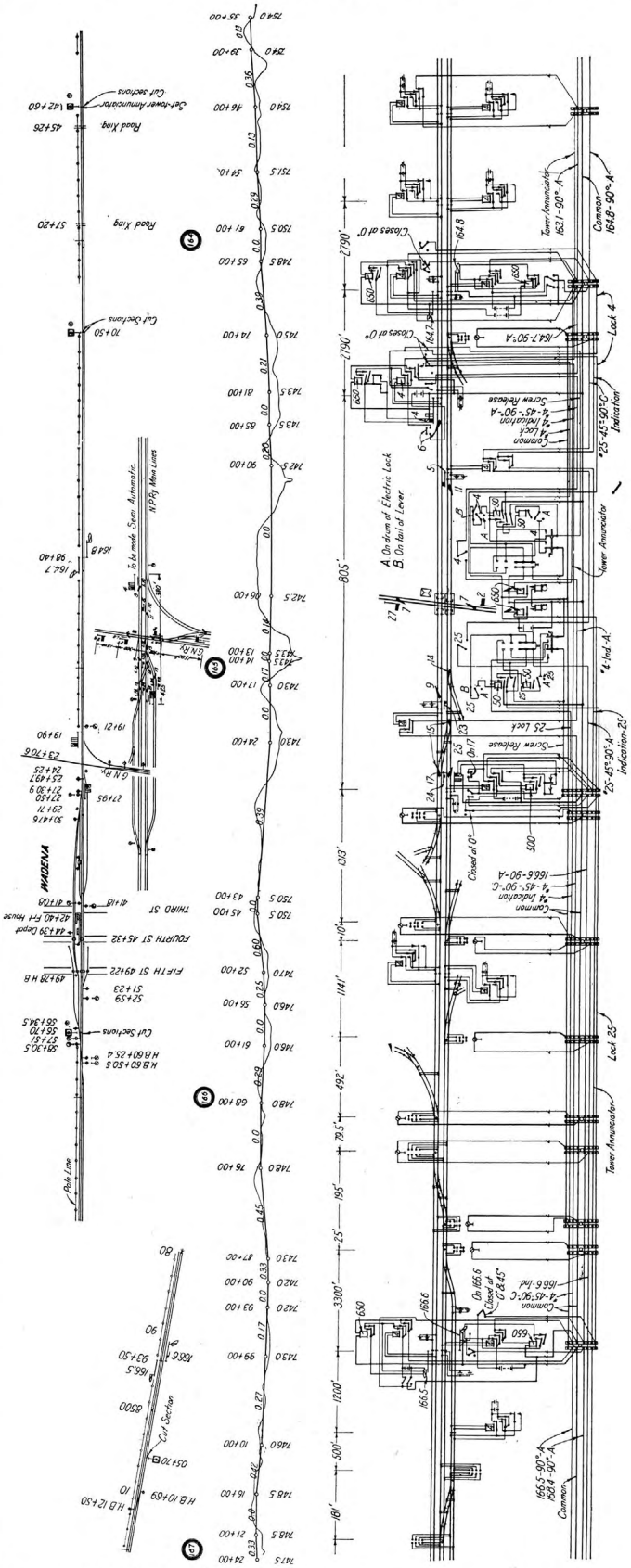

Fig. 8. Circuits and General Arrangement at Wadena Interlocking Plant.

is in the stop position. This in turn compels the home signal to be in the normal position before the lock can be energized. The wiring is so arranged that unless the latch of this lever is raised and on the quadrant before the train leaves the track circuit, it

will be necessary to operate the screw hand release before the home signal can be latched in the normal position and the route changed. This is accomplished by carrying the circuit for the stick relay through a back contact on the track relay, so that the former relay will not pick up unless the latter relay is de-energized. The circuit for the stick relay is also carried through contacts on two circuit controllers, one operated by the home signal tail lever, and the other on the drum of the electric lock. As the former is closed only when the lever is in the normal position, and the latter is closed only when the latch is on the quadrant, it is, therefore, necessary to raise the latch and put the lever normal, while the track relay is still de-energized, in order to pick up the stick relay. The lever cannot be latched in the normal position, however, until the electric lock is energized, which does not take place until the train has left the track circuit and the track relay has picked up. As soon as the train is off the track circuit, the track relay having picked up—the stick relay being up, the circuit-controller contact on the drum of the electric lock being closed while the lever latch is on the quadrant, and the screw hand release being normal—the circuit for the electric lock is thus completed and the lock will pick up, allowing the home signal lever to be latched in the normal position. This movement of the latch, by revolving the drum of the electric lock, again cuts off the energy for the lock magnets, by opening the contact on the drum of the lock, but the latch is not locked thereby and the lever may be reversed at any time. If, however, the towerman should neglect to throw the lever normal until the train has left the track circuit, or if he wishes to change the route before the train arrives, it becomes necessary to operate the screw hand release. With the release full reversed, the circuit for the stick relay is then completed through a back contact on the release in place of through a back contact on the track relay. The release must be returned to normal, however, before the electric lock becomes energized. The emergency switch, which is enclosed in a locked case with glass cover and placed downstairs in the tower, is introduced to take care of any failures of the track circuit or local battery. In case the track relay remains down or the local battery fails, the towerman must go downstairs, break the glass of the box and throw this switch, after which he must operate his screw release to the reverse position. With the lever normal and the latch up, this completes the circuit to the stick relay through the back contacts on the screw release and on the emergency switch, the energy in this case being taken from the battery of the distant signal for both the stick relay and the lock. In order to energize the lock, it again becomes necessary to return the screw release to its normal position. Meanwhile the stick relay is held up through two of its own front contacts and through back contacts on the emergency switch. As the control wire to the line relay for the home signal is carried through front contacts on the emergency switch, the home signal will remain at danger until the emergency switch is returned to the normal position.

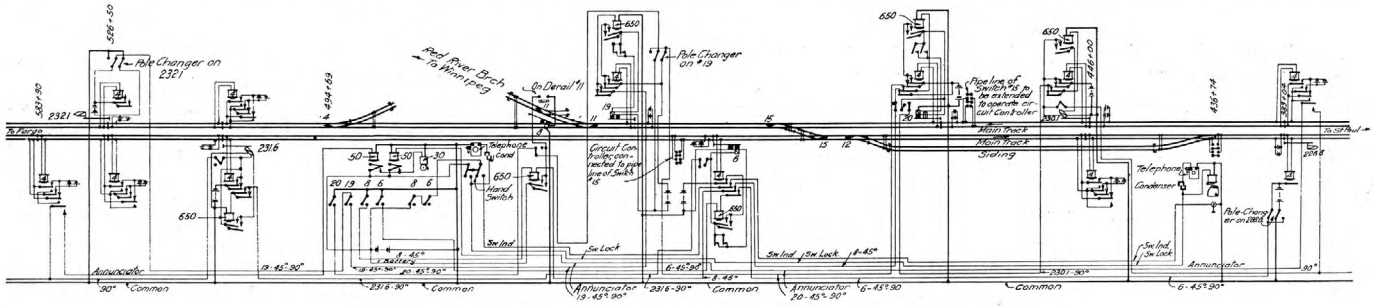

Fig. 9. Circuit Plan of the Interlocking at Manitoba Jct., Minn.

Fig. 10. In the Hell Gate Canyon, Rocky Mountains.

The tower annunciators, which are equipped with indicators and bells, take energy from the 90-deg. control wire of the signal

beyond the distant signal, through a front contact of the relay of a track circuit, located a suitable distance away, to give timely warnings. At Manitoba Jct., Minn., which is the connecting point between the Northern Pacific main line to the coast and its Winnipeg line, the arrangement is somewhat different (see Fig. 9). The distant signals here are also straight automatic signals with 45-deg. control through the track relay and 90-deg. control through the line relay. Here signal 231.6 compels a clear block up to home signal 6, before it can assume the 45-deg. position, and compels two blocks clear and signal 6 in the 45-deg. position or 90-deg. position, with its lever reversed, before it can assume the 90-deg. position. Signal 231.0, however, while it will go to 45 deg. with only one block clear up to home signal 20, cannot go to the 90-deg. position, even with two blocks and signal 20 clear and lever 20 reversed, unless signal 8 is in the stop position. This control is effected by taking the circuit for the line relay of signal 20 through a contact on a circuit controller operated with the mechanism of signal 8 and so adjusted that it is closed only when that signal is in the stop position. It will be noticed that on account of the circuit controllers operated in connection with switch 15, which shunt the track circuits when switch 15 is reversed, neither of the distant signals can be operated unless switch 15 is normal.

The home signals are all semi-automatic, signals 6, 19, and 20 on the main line operating in three positions, while signal 8 on the branch lines operates only in two positions, from horizontal to the 45-deg. position. The local circuits for signals 6, 19, and 20 are subject to the same method of track and polarized line control that is used at the other interlockings. This means that in order to get signals 6 or 19 in the 45-deg. position, their proper lever in the interlocking machine must be reversed and the block must be clear up to the next signal; while to get any of them in the 90-deg. position, the next signal ahead must also be clear. The operation of signal 20 is similar to this, except that as its line relay control is taken through a normally-closed circuit controller on signal 8, it cannot operate, but remains in the stop position unless signal 8 is at stop. Signal 8 takes its battery from the tower through a front contact on a line relay and through a normally-open contact on a circuit controller operated by derail 11. The energy for this line relay is taken from the battery of signal 20, the flow of current being controlled through a normally-open circuit controller operated by lever 8 in the interlocking machine, through front contacts of track relays for signals 6 and 20, and through a circuit controller operated with signal 20 and closed only when that signal is in the stop position. In order, therefore, to operate signal 8, it is necessary that its lever in the interlocking machine be reversed, that signal 20 is in the stop position, and that the blocks between signals 19 and 20 and between signals 6 and 228.8 are clear. In regard to the distant switch lock arrangement shown in connection with this interlocking, this is a very effective and useful arrangement in controlling the movements of trains from the siding on to the main line, owing to the great distance from the station making the usual means of communication inconvenient. It will be noticed

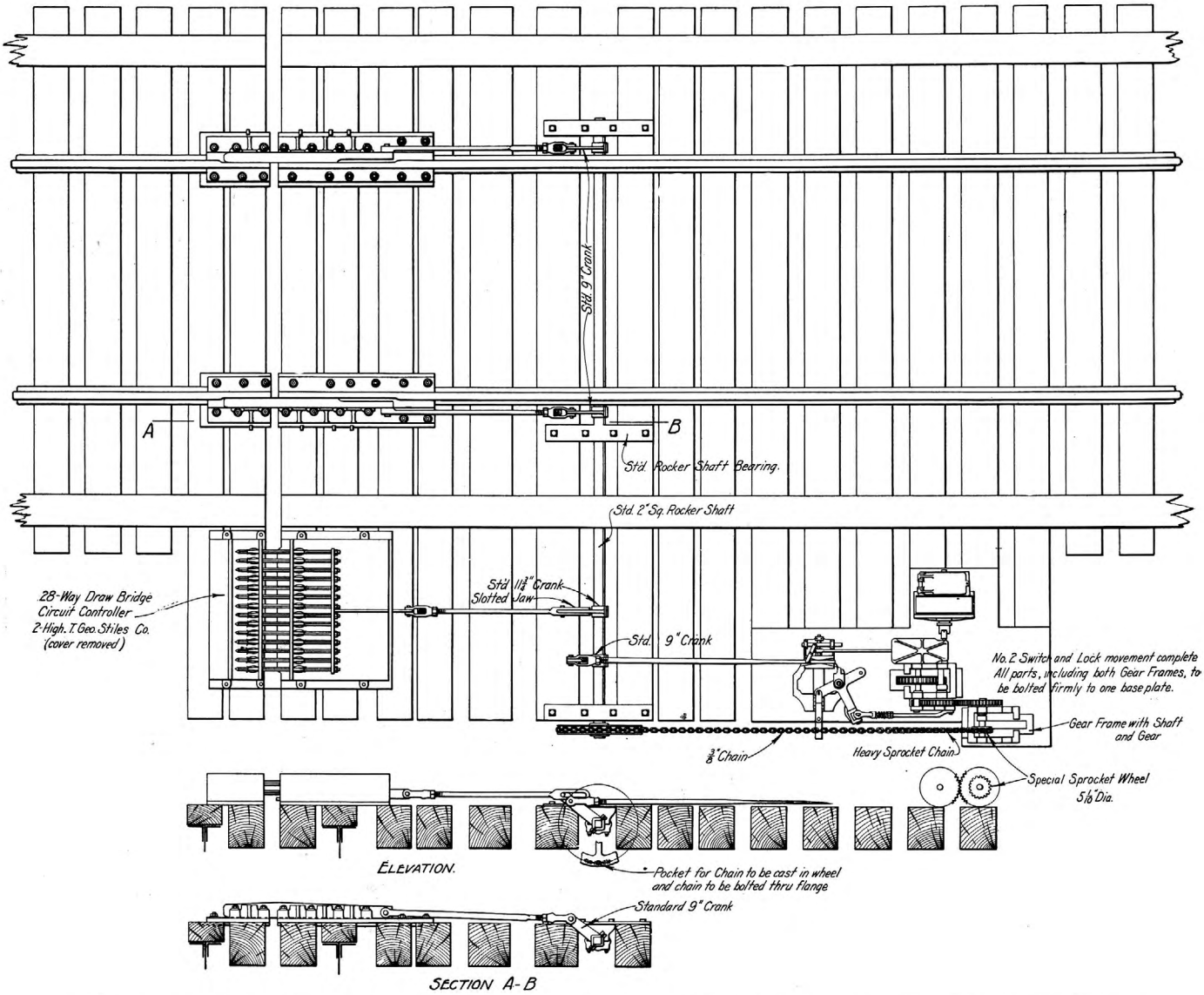

Fig. 11. Method of Operating Circuit Controller and Latches at Lewis River Drawbridge, near Kalama, Wash.

that this lock is not effective unless signal levers 8 and 6 are normal and a hand switch in the tower reversed. In order to get the indicator clear, the block between signals 6 and 228.8 must also be clear.

Of the special features in connection with the work may be mentioned the arrangement designed by Mr. Christofferson (shown in Fig. 11) for the operation of the Stiles circuit controler and the latches at Lewis River drawbridge, near Kalama, Wash. The electric interlocking plant at this place was installed at the same time as the block signals. It will be noticed that the operation is made through a No. 2 electric switch and lock movement, the motion being transmitted by means of a sprocket chain to a wheel applied to the end of and operating the rocking shaft. From cranks on this shaft connections are run to the bridge latches and the controllers, while the lock rod for the switch and lock movement is also operated from this shaft. This makes a very good arrangement, and is simple and easily applied.

The signals used on all the installations are of three-position, upper-quadrant type, equipped with Loree-Patenall castings, carrying 8⅜-in. roundels. The automatic signals are also equipped with sheet-steel number plates, having block figures 6 in. high, with 1-in. bars on a white ground. As only "stop and proceed" (automatic) signals are equipped with such plates, these also serve as markers in the daytime to distinguish such signals from the "stop and stay" (interlocking) signals, which are not thus equipped. Another distinction is the second arm, which in all cases is used on interlocked home signals. At night the "stop and proceed" signals display one light only, while all "stop and stay" signals display two or more lights in a vertical line. The blades for all "stop and proceed" signals have pointed ends and are painted yellow, with a black stripe, while the "stop and stay" signals have square-ended blades painted red, with a white stripe. The night indications for both classes of signals are red for "stop," yellow for "caution," and green for "proceed." All automatic signals are equipped with Veeder counters to register all blade movements, so that a record may be had of the performance of each signal, as well as of the signal batteries.

The lamps used are of Mr. Christofferson's "Universal" design, equipped with two openings for lenses, which allows the transposition of the effective lens from one side to the other as may be desired, the unused opening being closed with a steel shield. Lamps of this type are thus adaptable to either train order signals, where two lenses are required, or to any other style of semaphore signal operating either in the upper or lower quadrant. They are equipped with a 42-oz. oil pot, which requires refilling but once a week, even with the largest size of a long-time burner.

The switch indicators are of the "normal-danger" type, with push-buttons outside of the case to close the circuit. The miniature blades are arranged to operate in the upper quadrant from horizontal to 45 deg. only. The coils, which have a resistance of

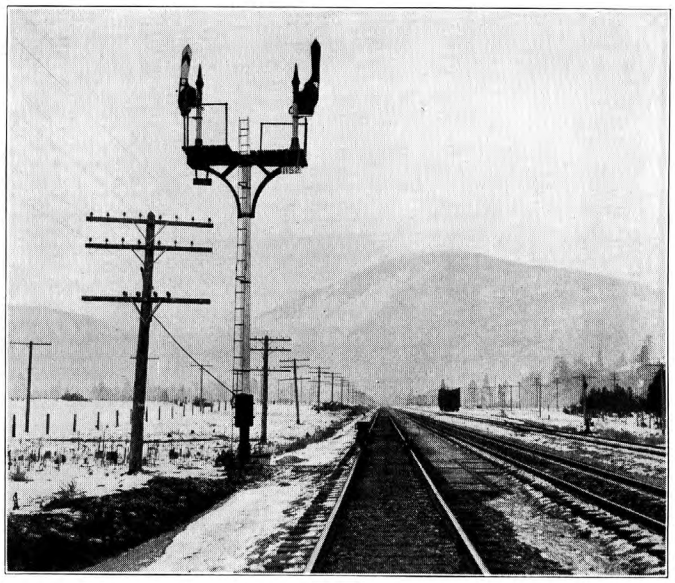

Fig. 12. Bracket Post Signal.

650 ohms, are form-wound and are interchangeable with those of the line relays. The glass front is circular and of convex construction.

Where signals are on the pole-line side the wires are run direct from the telegraph poles to the signals; and relay boxes or indicators, when so located, are placed on iron cable posts, and the wires run direct to these posts. Where the apparatus is located across the track from the pole line, wires are run to a terminal box located on a wooden cable post and are carried across the track in trunking. In all cases, except on the coast territory, where lightning arresters are not used owing to the absence of electric storms, the arresters, of the carborundum type, are made to serve the purpose of terminals.

Fig. 13. Cut Section With Relay Controlling Line Circuit.

The various views of the installations give a very good idea of how this wiring arrangement is taken care of. The line wire is all No. 10 B. & S. gauge Copper Clad, manufactured by the Duplex Metals Co. All wiring between the overhead line and the instrument is made with single conductors of No. 14 B. & S. gauge copper, taped together and supported by 3/8-in. galvanized stranded messenger wire. Local wiring for signals and other apparatus is also made with No. 14 B. & S. gauge wire, except in cases of unusually long leads between battery and signal mechanisms, such as at some of the interlocking plants where the batteries are located in the tower, in which case either No. 4 or No. 6 B. & S. gauge copper wire is used the entire distance.

Fig. 14. Going to Work—20 Degrees Below Zero.

No. 10 B. &. S. gauge copper wire is used for all track connections. All rubber-covered wire has a 5/64-in. rubber wall, and is manufactured in accordance with the railway's specifications.

There are 1,050 track circuits on this work, their average length being about 3,000 ft., although there are several circuits considerably longer. The energy for each track circuit is furnished by two cells of potash battery with high internal resistance, connected in multiple, except through station grounds, where gravity battery is used. The track batteries, where not housed in the wells or otherwise taken care of, are placed in cast-iron chutes.

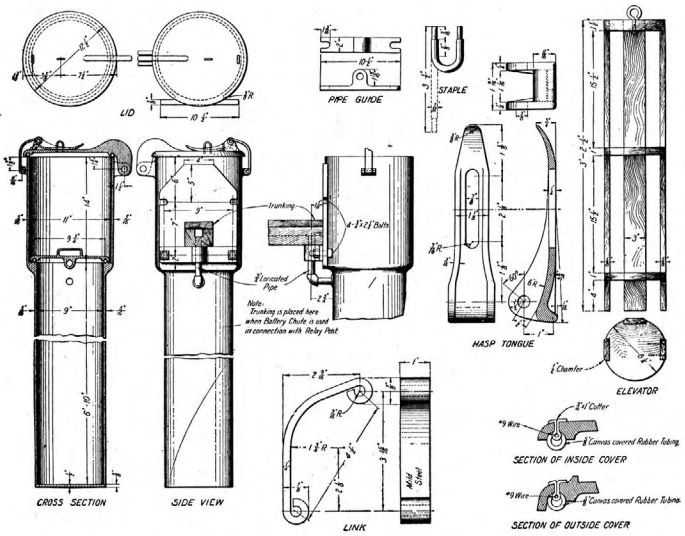

Fig. 15. Details of Special Battery Chute.

On the coast, where the temperature is never very low, six-foot chutes of the usual type are used, but where very low temperatures may occur, the type of chute shown in Fig. 15 is used. This chute, which was specially designed, has proved very effective, no failures from frozen track battery having developed on any of the installations, although the temperature has been extremely low at times. The wells used for housing the signal batteries in extreme climates have also proved a success. The minimum temperature in these wells has been about 40 deg. F. in the coldest weather. They are of reinforced concrete construction, and are a development of the concrete wells previously on the market. The improvements, which were suggestions of Mr. Christofferson's to meet the requirements of the most extreme climates on the Northern Pacific, were embodied in their construction, and wells of this type have been placed on the market, and are now known as the Potter-Winslow Co.'s type 72 special, and the C. F. Massey Co.'s type "A" special.

The signal batteries on all the installations are of 400 a. h. capacity. The jars for both track and signal batteries are of heat-resisting glass made by the Corning Glass Mfg. Co. This glass has proved to be as strong as porcelain, and the jars, being transparent, possess the advantage over porcelain jars that the elements may be easily inspected. Bonding is done with galvanized-iron bond wire, except through street or highway crossings or at other points where the wires are greatly exposed to corrosion, in which cases Copper Clad wires are used. Copper Clad wires are also used for bonding at switches and frogs.

The circuit controllers for the switches are all connected to the normally-closed point of the switch. All track relays are of four ohms resistance, while the line relays have a resistance of 650 ohms. The coils of all relays are form-wound. All relay boxes used on this installation are constructed to hold two relays. They are of cast-iron with a wood lining, and are provided with an inside wood door which is hinged and has beveled edges, so that it can be easily opened in case of swelling. The boxes are

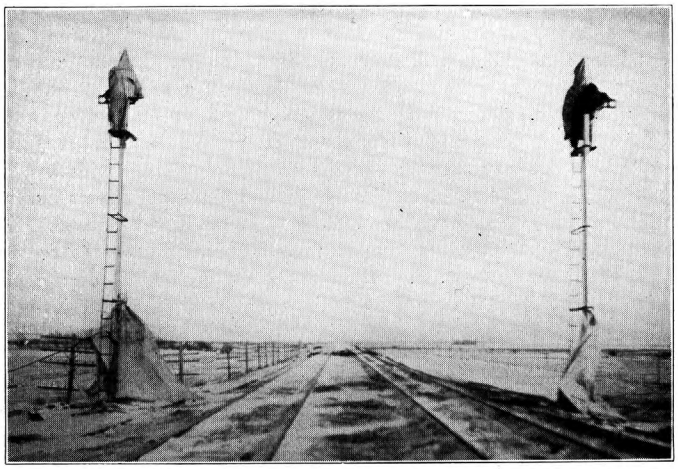

Fig. 16. Wiring Signals—30 Degrees Below Zero.

either clamped to the signal poles with "U" bolts, or are placed on separate iron posts, according to requirements. A separate compartment is furnished in each relay box for terminals or lightning arresters when such are used. The trunking and capping are of Washington cedar, which has been found to be an economical as well as a durable material for this purpose.

During the construction period, very rigid inspection was maintained, experienced inspectors whose duty it was to see that the specifications, both in regard to labor and material, were strictly lived up to, being assigned to each territory. As a result, the railway has secured a satisfactory and durable installation, and this in spite of the fact that during part of the time on some of the installations the severest kind of weather conditions prevailed, as may be surmised from Figs. 14 and 16. These two views were taken by one of the foremen, and are from the western part of Minnesota. The other views, Figs. 4, 6, 7, 10, 12, and 13, were taken from the installation between Garrison and Missoula, Mont., along the banks of the Hell Gate river, the region of the grandest scenery in Montana, outside of Yellowstone Park.

For maintenance purposes, the territory has been divided as evenly as possible into maintainers' districts, each averaging 20 miles of double track, with about 27 signals and about an equal number of indicators. Each maintainer is furnished a helper and has a motor car to facilitate his work, which includes the care of all signal lamps on his territory. Part of this work has now been in service for some months, during which the arrangement has been tested, and proved very satisfactory.