particularly if they are in a locality where there is not much signal apparatus.

Experience has shown that wire carrier wheels will rust and a great many times drop out of the carrier, wire stakes will get out of line, chain wheels will rust fast, the pulling and back wires will stretch, the pole fittings will rust and the roundels will be cracked or shot out by some malicious person. The above mentioned inspection also applies to manual controlled block stations operated mechanically or electrically. In some stations where manual block signals are used and operated electrically, traffic circuit controllers are used to repeat the position of the arm, control the circuits for clearing the arm and giving an indication of the stop or most restrictive position. These controllers require attention as the indicating and repeater mechanism is delicate and wears very rapidly, necessitating the replacement of parts if the proper efficiency is to be maintained.

Economy in Automatic Signal Operation as Effected by Design

Avoidable Waste in D. C. Apparatus Eliminated by Improved Design of Mechanism and Local Control Circuits

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SINCE the invention of the first motor operated, direct current, semaphore signal by Lattig in the early seventies, there has been a steady and rapid development of this type of signal along the lines of safety, efficiency and economy in operation. Consideration has also been given to the high speed traffic requirements and ready convertibility from one to another of the many and varied service requirements of present day railway signaling. As a result of this development, there are now several different signals of this type on the market which will, if properly maintained, make several thousand operations without a mechanism failure and with a comparatively low consumption of electrical energy. When one considers the different kinds of weather and climatic conditions, and other unfavorable circumstances under which the signals operate, the record is remarkable. Comparing the service performance of the electric semaphore signal with that of other power operated equipment in general use in industrial, commercial and railroad plants, one cannot but reach the conclusion that the signal is a very efficient and reliable piece of apparatus.

Ofttimes when a mechanism or machine is made that is intended for several different purposes, simplicity and efficiency are sacrificed and a number of complicated, interchangeable parts result in unsatisfactory service for several or all of the different uses for which it was intended. Such a machine may be considerably more expensive to maintain and operate than if a different design had been produced for each of the several classes of service. In some cases unnecessary parts are built into the mechanism which may never be used. The investment for the necessary stock which has to be carried, instead of being decreased, has actually been increased.

These conditions, however, do not exist in the case of the present general utility or all-purpose signal which has been in quite general use for a number of years. This type of signal may be used equally well for interlocking work, automatic or controlled manual block signaling, switch and station protection, and for many other purposes. The mechanism may be used to operate either high or dwarf signals, and by making minor adjustments or by interchange of parts it can be made to operate in two or three positions, in the upper or lower, right or left hand quadrant, with any movement of arm up to 90 degrees, on high or low voltage, alternating or direct current, and can be used in an automatic, semi-automatic or non-automatic capacity. There is no sacrifice in simplicity of design nor of safety, reliability or efficiency in using the mechanism for any of these different purposes.

One of the great problems of transportation is to get more power so that heavy tonnage can be moved over the road. In order to get this greater power the practice in the past has been to build larger and heavier engines that could operate over the ruling grade. While such engines develop maximum power when needed, there is necessarily a large waste of energy at other times. To avoid this waste the present day tendency seems to be to equip lighter engines with boosters. These boosters are applied to the trailers and are equivalent to additional drivers on the engine. They are used only in starting and at critical points when maximum power is needed and at other times are cut out.

Power Consumption Dependent on Signal Mechanism Design

This same principle is being applied today in the operation of automatic block signal systems. The present automatic signal has sufficient power to perform the work required of it, and the problem is to see that all the energy furnished is made to perform useful work, that it is used only when needed and that it is cut down at other times. In order to avoid waste in signal operation it is necessary to design the operating mechanism so that it will fulfill the efficiency requirements of:

(1) Operate the signal to clear position in a minimum amount of time with a minimum energy consumption.
(2) Hold the signal in the clear position with a minimum current consumption consistent with safety.

Practically all low voltage direct current semaphore signals are equipped with the series wound type of operating motor; either 8 or 10-volt motors are used, but the greater proportion of those now in service are wound to operate on 10 volts. In the past it has been necessary to use a motor that would operate on a comparatively low current, due to the quite general use of different types of batteries having high internal resistance and limited capacity. With the gradual development of a caustic soda signal cell of as large capacity and low internal resistance and with the increased use of the storage battery for signal operation, it should now be possible to use a lower wound motor, preferably one that would operate efficiently on 6 volts. This would be desirable, for with the lower wound motor the current flow would be somewhat higher, but this could undoubtedly in many cases be compensated for with little additional cost and it would be possible to secure satisfactory signal operation with several less cells of battery than are now used.

Greater care would be required to see that the resistance of the operating circuit was reduced to a minimum. Where signals are located opposite each other, separate batteries are used usually. These batteries can in many cases be connected in multiple and the leads connected together between the battery housing and the instrument case. This gives double capacity except when both signals happen to be clearing at the same time, which probably happens very infrequently. By connecting the batteries in multiple the work of renewing them is simplified. As each one performs the same amount of work, they are both due for renewal at the same time. Increased life is obtained and the chances of signal failure are reduced. It will also be found to be a considerable advantage to connect all the spare relay contacts in the operating circuit in multiple. Any unnecessary duplication of circuit breaks should be avoided, and large size wires should be used for all local circuits.

By providing a working pressure at the signal motor terminals lightly above its normal requirements, faster signal operation is obtained and the energy consumption is reduced. This faster signal operation has other benefits, especially on divisions where traffic is dense. The clearing time of the signal is a factor in determining the length of the block to be used, and if possible to reduce this time a closer spacing of trains is permissible, which is often desirable.

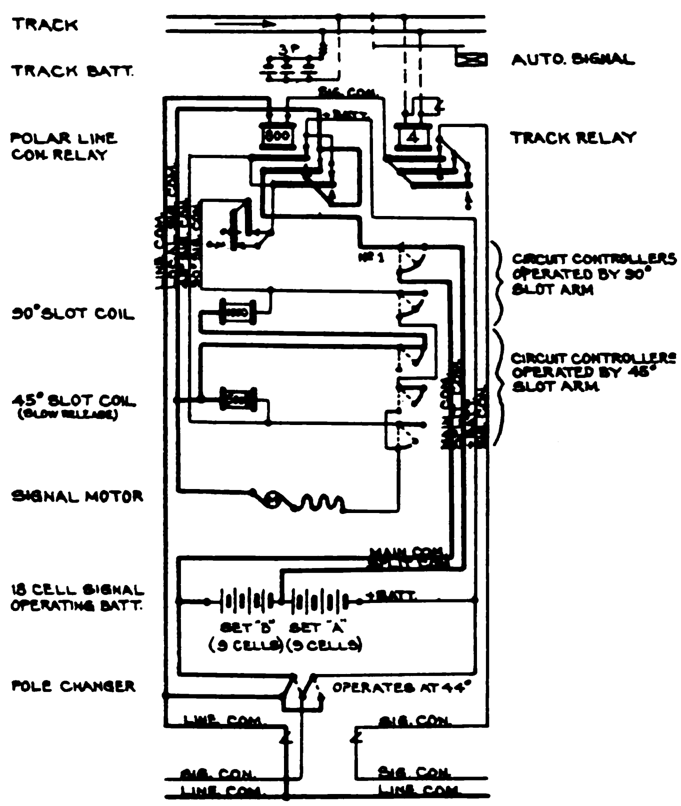
Large Energy Consumption in Holding Signal at Clear

The greater part of the cost for energy for the operation of a normal clear signal is the cost of holding the signal at the proceed indication rather than the cost of clearing the signal. It is necessary for the slot or hold clear magnets to exert a greater tractive effort during the time that the signal is being cleared than after it has come to rest in the normal or clear position. This extra magnetizing force required of the slot magnets while the signal is clearing has been provided by different means—principally by the use of a compound wound slot coil, the low resistance winding of which would be cut out as soon as the signal had cleared. In the past, considerably more current than actually required has been allowed to continue to flow through the hold clear magnets continuously after the signal had reached the clear position, which has resulted in a large waste of energy. The flow of this unnecessary current has also tended to reduce the safety factor due to over-energization of slot magnets.

Within the last few years a number of different battery saving schemes have been used by various railroads having a considerable mileage of d.c. automatic signaling. These battery saving schemes are all based on the principle that less battery is necessary to hold the signal in its clear position than is required for motor operation and to energize the hold clear magnets during the time the signal is clearing. Under the schemes most generally used a number of cells of the operating battery are automatically cut out of the hold clear circuit when the signal is latched in the clear position only, a sufficient number of cells being left so that their minimum voltage will be slightly above the release value of the hold clear coils. Other schemes use a separate battery for the hold clear coils. With this latter arrangement the motor operating battery and the hold clear battery are connected in series during the time that the signal is clearing, but only the hold clear battery is left in the circuit for holding the signal at clear.

The Split Battery Saving Scheme

The Chicago, Milwaukee & St. Paul has adopted what has been termed the "split battery" scheme for the operation of its d.c. automatic block signals. Most of the signals on which it has been used are the U. S. & S. Co.'s Style B, 3 position, upper quadrant, 10 volt signals. The circuit arrangement used is indicated in Fig. 1. The operating battery of 18 cells is divided into two sets of 9 cells each, connected in series and designated *A* and *B* in the circuit diagram. The entire battery of 18 cells is used to clear the signal, but only 9 cells are used to hold it clear. An additional common is connected between the two sets of



Split Battery Saving Scheme Circuit Diagram

battery and runs to a special circuit controller, shown as No. 1. The main common from the negative side of the full 18 cell battery, instead of being connected directly to the signal mechanism through the control relay, is broken through circuit controller No. 1. When the signal is at "Stop" and while clearing from 0 to 90 degrees, the main common from the entire battery is connected to the slot coils and motor. Circuit controller No. 1 is operated just as the signal reaches the 90 degree position and this opens the circuit flowing through the main common and closes the circuit through the split common, which leaves both slot coils connected to only half of the battery.

It will be noted that the circuit is simple and that there are no special features to give trouble. A close adjustment of the special circuit controller is required to prevent the signal tripping off, but this adjustment when once made is not difficult to maintain. Battery sets *A* and *B* do not exhaust evenly, due to set *B* furnishing energy to hold the signal clear. At first it was thought that this uneven consumption of battery would be objectionable and it was planned to provide a means of interchanging the sets so that they would exhaust evenly. On account of the entire 18-cell battery being used to control outside circuits, the polarity of which could not be changed, it was found to be necessary to go into the use of a four pole switch in order to interchange the batteries, without moving the cells around on the shelves or to change the connections; either of which would be impracticable. This switch would introduce additional resistance into the operating circuits, and due to the fact that it would be necessary to operate it quite frequently, if the full life of the battery was to be obtained, it was decided to abandon this feature. From actual experience no real objections have developed to having the two sets of battery exhaust unevenly. The maintainer soon learns that the sets will have to be renewed at different times and consequently keeps a separate record for each.

The scheme has now been in service for several years, prior to and during which accurate records have been kept of the life of all operating batteries used. From these records it has been established that the life of the average signal operating battery is increased approximately 33⅓ per cent. A nominal expense is involved at each signal in connection with providing the additional wire, circuit controller, and for rearranging the circuits, but this is offset by the large saving that results from the use of the scheme.

It is now planned to make a further saving in energy consumption by applying push buttons to all switch indicators. These indicators at present are normally energized and stand at clear except when a train is approaching. Through the use of the push buttons the indicators will be de-energized at all times except when the push buttons are operated by the trainmen. It is calculated that on approximately 1,100 indicators in service the saving in current consumption will amount to about $2,500 annually.

Automatic Train Control in Use On American Railroads

THE notice of the Interstate Commerce Commission, calling upon prominent railroads to install automatic train stops, which was published in the *Railway Signal Engineer* of January, page 24, has revived interest in the general subject of automatic stops, and many inquirers are calling for information concerning it. Apparatus of this character is already in use on 11 railroads in this country, of which four run both passenger and freight trains, and it will be of interest at this time to note briefly the situation on these railroads. The list below, "List A," gives the names of these roads, with some data concerning the kinds of apparatus and the extent of the installations:

List A—Automatic Stops in Use

a Boston Elevated.—Stops in use over 20 years. Simple mechanical trip. Described in Signal Dictionary, pages 122-124.

b Interborough Rapid Transit Co., New York—Subway and elevated lines. Simple mechanical trip. Described in Signal Dictionary, page 117.

c Hudson & Manhattan (Subway).—New York and Jersey City. Same general type as above. Signal Dictionary, page 108.

d Pennsylvania, New York City Terminal. Tunnels; also in unprotected situations. The Hill mechanical trip. Described in Bulletin No. 63 of the Union Switch & Signal Co., and in the *Signal Engineer* of January, 1912.

e Brooklyn Rapid Transit Co. (N. Y.) Subway and elevated lines.

f Chicago & Eastern Illinois.—Used on both passenger and freight trains over about 100 miles of line. Miller Train Control Corporation; apparatus described in the *Railway Signal Engineer,* page 329, November, 1914; page 61, February, 1916.

g Chesapeake & Ohio.—American Train Control Company; in use on about 20 miles, single track. Apparatus described in *Railway Signal Engineer,* page 131, April, 1919. Ramp type.

h Chicago, Rock Island & Pacific.—Regan Safety Device Co. Described in *Railway Signal Engineer,* page 204, May, 1920. Ramp type, with speed control.

NOTE—The three last preceding installations have been under inspection during the past year by the Bureau of Safety of the Interstate Commerce Commission and the Train Stop Committee of the American Railway Association.

i Cincinnati, Indianapolis & Western.—The Shadle automatic train control—intermittent electric contact type. *Railway Signal Engineer,* page 405, October, 1920.

j Washington Water Power Company. This is a trolley road; Overhead automatic stops in use on 22 miles. Described in Signal Dictionary, page 112.

k San Francisco-Oakland. Double track line, overhead trip. Signal Dictionary, page 113.

The list begins with elevated and subway intramural railroads, the situations of which are so different from those of ordinary railroads that must students of the problem have paid little heed to the question of adapting the simple mechanical trips of these city railroads to the needs of heavy and mixed trunk-line service; but it is proper to include the city lines in this list, for two reasons: First, the main reason for classing the simple trip as available only on the city roads is that it is particularly susceptible to being interfered with by snow and frost; but the government now calls for installations where snow and frost do not make much trouble; and the adaptation of the principles of these trips to apparatus usable in cold climates has not as yet been thoroughly studied.

Second, the experience of the subways and the elevated lines should be availed of by all railroads in the matter of discipline of runners. One of the persistent arguments against the use of automatic train stops is that they will make, or tend to make, all enginemen careless. But officers of roads using the stops give strong testimony that the actual effect is exactly the other way; the stops make the men more careful. Testimony on this point on the Boston Elevated covers a period of over 20 years. The Chicago & Eastern Illinois, with its more varied traffic and different conditions, confirms the story of the Boston Elevated. An important element in the successful operation of automatic stops on a busy line is the success with which the enginemen maintain smooth and regular operation; and no road can afford to ignore the records of the years of successful operation on these city railroads, with their many hundreds of motormen.

In a second list, "List B," there are shown the names of roads in which experimental installations have been made. Of the 16 items in this list, five—Nos. 1, 6, 7, 13 and 15—have been the subject of recent published descriptions or news notes, as shown in the list. Item 12 refers to a recently reported contract, concerning which we have no detailed information. The other 10 refer to experiments which have been closed, or which have lain dormant for a considerable length of time.

List B—Automatic Train-Stop Experiments

1 Buffalo, Rochester & Pittsburgh—General Railway Signal