Absolute Permissive Block Signal System*

A Study of Single Track Signaling Showing Track Layout and Circuit Diagram and Explaining the Operation of Trains Between Sidings

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IN automatic signaling we rely, for the most part, upon the principle that the opening of a controlling circuit or the interruption of the energy supply will cause the signal to assume the most restrictive indication. We have become accustomed to the assumption that our further checks as to the integrity of the system must depend on careful, consistent inspection. However, it must be admitted and should be stated in this connection that the *closed circuit* principle has been so well carried out that automatic signaling has reached a very high degree of perfection. I believe that many would welcome any suggestion whereby we could check each device as frequently and fully as possible without undue complication.

Duplicate protection as far as possible is demanded at interlocking, so that at least two things will have to improperly function simultaneously in order to cause an unsafe condition. We consider with favor a system of interlocking, which to the fullest extent renders the portion of the plant inoperative in case of an improper application of energy to a function. I am not unmindful of the difficulty and impracticability of carrying out these protective features to the same extent in automatic signaling as in interlocking. However, I wish to place emphasis upon some of the strong features of the A. P. B. system. I shall attempt to explain how the system to a large extent checks itself. I am so convinced that we have not always fully realized the merits of the signal system.

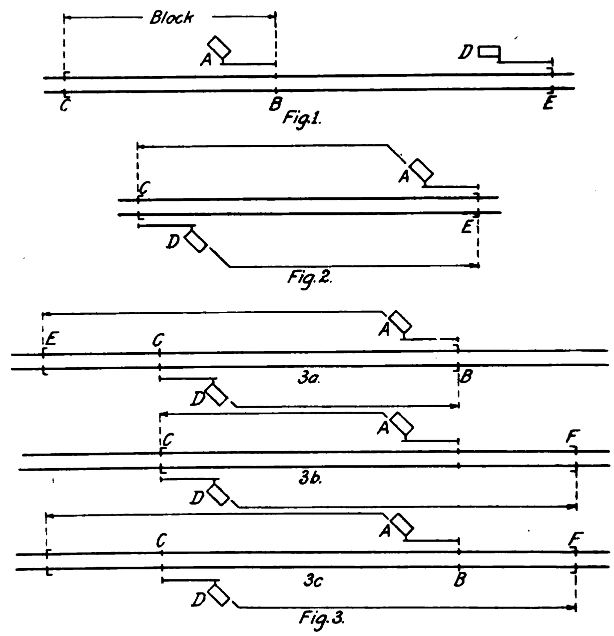
Principles of the A. P. B. System

Single-track signaling differs essentially from double track in that it must afford protection for train movements in either direction, whereas double-track signaling pre-supposes that all train movements are to take place only in a pre-determined direction on a given section of track. For instance, a train after accepting signal *A* (see Fig. 1) at clear, may expect to find block *B-C* clear, if on double track. However, if trains were operated in both directions, as on single track, another train moving from left to right might pass *C* after the first mentioned train had accepted signal *A*.

Suppose that another signal *D* is located at *C* to govern movements from left to right (see Fig. 2), and that signal *A* controls only to *C* and *D* to *E*. This will afford certain protection for following movements, but is of little value to protect against opposing movements, as two opposing trains may pass signals *A* and *D*, respectively, at the same moment, both being clear, and meet in the block.

Let us go a little farther by providing an additional track circuit *C-E* and extend the control of signal *A* to *E* (see Fig. 3a). It will now be seen that complete protection is afforded for opposing trains between *B* and *C*, as a train moving from left to right will have caused signal *A* to assume the *stop* position before it reaches signal *D*. It should be noted, however, that the extending of the control of signal *A* may reduce facility as far as following movements are concerned, as the arrangement of signals may be such that a train moving from right to left need not have the protection of signal *A* after it has passed *C*. This extension of the control of signal *A* from *C* to *E* is called an *opposing overlap*.

It need hardly be added that the same degree of protection for opposing movements could be accomplished quite as well by extending the control of signal *D* to *F* (see Fig. 3b). The only difference is that preference would then be given to movements from right to left, while the arrangement shown in Fig. 3a favors movements from left to right. Likewise protection is afforded



Track and Signal Diagram of Various Overlaps

by providing overlaps at both ends as shown in Fig. 3c. Earlier forms of single-track signaling are based upon the principles just set forth.

Fig. 4 shows, as far as essential principles are concerned, the arrangement of signals and limits of control of the earlier forms of single-track signaling.

X and *Y* are adjacent passing sidings.
Signals *2* and *3* are starting (or leaving) signals.
Signals *1* and *4* are intermediate signals.
Signals *6* and *5* are siding signals.

It will be seen that the arrangement affords complete protection in so far as it prevents one train from colliding with another (either opposing or moving in same direction) so long as the signal indications are obeyed. There are, however, undesirable features as follows:

(a) Following trains are held apart farther than necessary. For instance, signal *2* must control to some point beyond signal *1*, whereas from a standpoint of following protection this control need not go beyond signal *4*.

(b) With the controls as shown, after a train accepts signal *2* it will move to point *B* before placing signal *3* to the stop position. Meanwhile an opposing train can accept signal *3*. Of course these trains will be held apart by signals *1* and *4*, but delay and inconvenience will result. It is to be admitted that this condition can only exist as a result of error in or disobedience to orders, but it is also good practice to make the signals prevent such a condition so far as it can be done without sacrificing other facility or protection.

*Abstract of paper presented before the Kansas City Sectional Committee Meeting.

(c) Distant signals become of questionable value as a train may get a clear distant indication and find the home signal at stop due to an opposing train having in the interim entered the block of the home signal. As, for example, if a distant signal is provided for signal *6*, a train may find this signal clear and find signal *6* at stop due to an opposing train having entered the block of signal *6*. Furthermore, it will be seen that this is not an unusual condition, but on the contrary it is entirely regular when two opposing trains are approaching a siding for a meet and both are on time.

Stated another way, a distant signal for a siding signal must be regarded as a caution signal regardless of the indication given. If at caution it would mean nothing less than that the siding block is obstructed; if at clear that it might be on approach. The question naturally arises—why not use a fixed caution signal merely as a marker, which would mean to approach the home signal prepared to stop.

This subject, which could be truly called a problem, was given a great deal of study by many signal engineers.

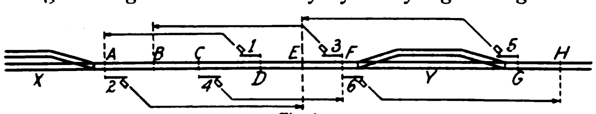


Fig. 4.

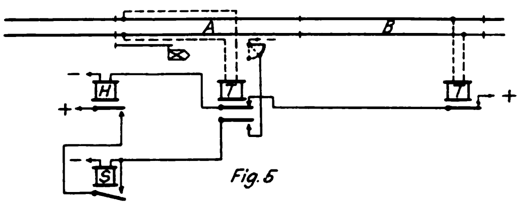


Fig. 5

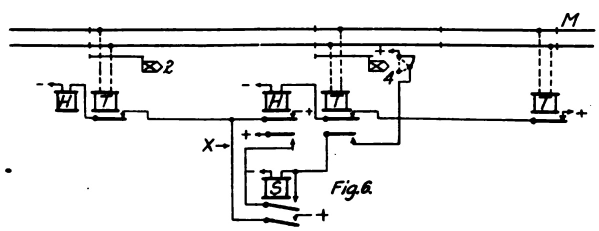


Fig. 6.

Overlap Control Circuits

The inventors and engineers who later developed the A. P. B. system at length went so far as to formulate a statement of the requirement of the problem, namely:

1. Afford full overlap protection for opposing movements.
2. Afford protection same as on double track for following movements.
3. Afford reliable distant signal protection.

This meant that the extent of control of a signal must be variable and depend upon the direction of traffic. For instance (see Fig. 4), signal *2* must control at least to some point *E* for opposing movement and, better yet, to signal *3*, as the chances of opposing trains entering the single track between sidings *X* and *Y* are thereby greatly reduced. Signal *2*, however, for following movements needs only control to signal *4*.

The means for providing this variable control is an ingeniously arranged stick relay, as shown on Fig. 5. In this diagram *H* is the control relay for the signal and is controlled by two track relays *A* and *B*. The stick relay is marked *S*. It will be noted that the pick-up of the stick relay is through a back contact of the relay of the track circuit *A* and a contact operated by the signal, which is closed, we will say, from 45 degrees to 90 degrees. The holding circuit for the stick relay is through a front contact of the stick relay itself, and a back contact of the signal control relay.

It will, therefore, be seen that when a train passes the signal moving from left to right it first drops the relay for track circuit *A*, and, the signal being clear, the pick-up circuit is thus made. That is to say, the signal will remain clear for a sufficient length of time to pick up the stick relay and the stick relay will remain picked up as long as the signal control relay remains de-energized. It will furthermore be seen that a train moving from right to left will not pick up the stick relay as the de-energization of track circuit *B* will have caused the signal to assume the stop position before the train has reached track circuit *A*. Therefore, the pick-up circuit will not have been made at any time. Thus we have a means of detecting the direction of traffic—a relay energized during the time a train is moving through a block in one direction and de-energized during the same period if moving in the other direction. An essential way, in which this means of detecting traffic direction has been extensively applied to single-track signaling is shown on Fig. 6, on which signal *4* controls to *M*. Also, if we disregard wire *X*, signal *2* will control to *M*, as the control for signal *2* is broken through the control relay for signal *4*. It will be seen that wire *X* feeds energy to the control wire for signal *2* when the stick relay is picked up, even though the control relay for signal *4* is de-energized. Therefore, a train moving from left to right will allow signal *2* to clear as soon as it passes signal *4*, as the stick relay will be picked up as long as the train is in the block of signal *4*. However, in the case of a train moving from right to left both signals *2* and *4* will be caused to assume the *stop* position as soon as the train passes *M*, as the stick relay will not pick up for this movement. In other words, signal *2* has an overlap for opposing movements, but not for following.

Now, we come to the application of these principles to actual single-track conditions. Fig. 7 shows the arrangement of the signals and circuits as usually employed, it being understood that in practice general modifications are made due to local conditions and general standards. For instance, siding arrangements and their relative positions vary; some roads want polar line circuits while others insist upon neutral; some employ 3-position signaling, others 2-position; some use one battery for line and motor control, others use separate batteries. While the system as illustrated on Fig. 7 is essentially the same as first conceived, the flexibility and adaptability of the system has proved to be very satisfactory. It has met the variable conditions in a most exacting manner and affords a signal system of unbroken continuity. In Fig. 7 is shown two simple sidings, *X* and *Y*, with the usual two signals at each end and with two pairs of intermediate signals. In this case both pairs of intermediate signals are shown opposite. However, the general scheme is not affected in the case of staggered intermediate signals. It will be seen that the control wire for signal *2* is carried forward and broken through the front contacts of the control and stick relays at signal *4*. Likewise the control of signal *4* is carried forward to signal *6*. Signal *6*, however, only controls to signal *8*, or the end of the single track block. Signals *7*, *5* and *3* are controlled exactly the same as *2*, *4* and *6*. Therefore, a train moving from right to left upon passing signal *7* will cause signals *6*, *4* and *2* to assume the stop position, as the stick relays at signals *4* and *6* will be de-energized. Thus, a long overlap is provided for opposing movements (to the next siding in each instance), and this is not objectionable in the case of following movements, as these overlaps are then cut off by the stick relays in a manner already explained. The net result is that we have: Complete overlap protection from siding to siding for opposing movements, and signal to signal protection for following movements.

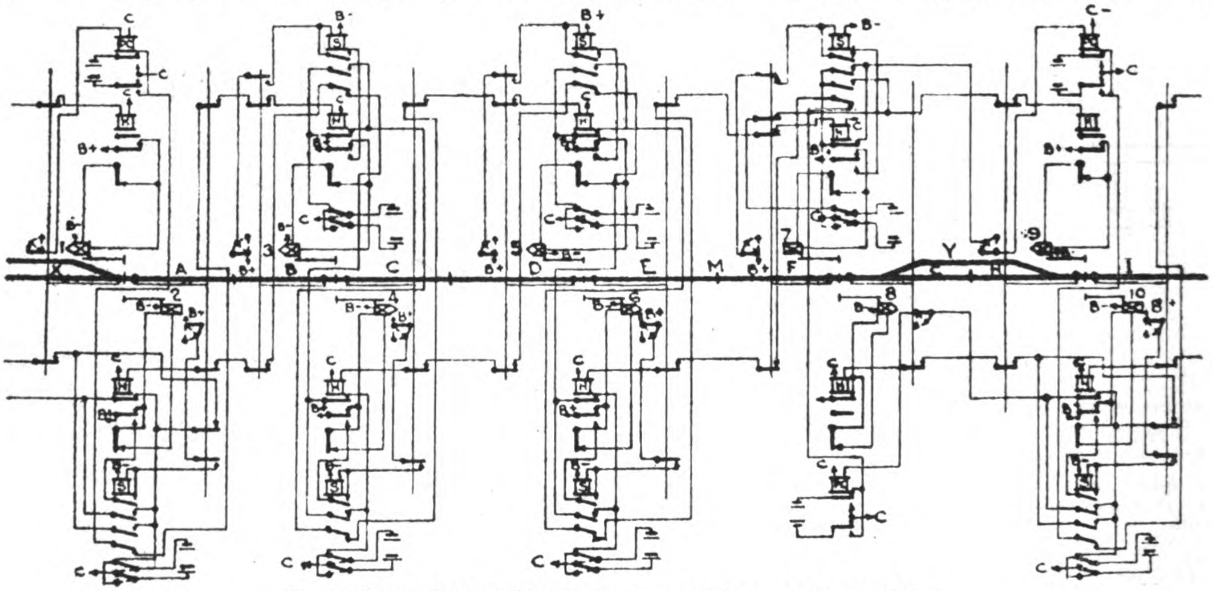
Little emphasis need be placed at this time upon the very great value of these net results. Opposing protection has suffered no loss—in fact, has been strengthened.

The utmost facility has been provided for following movements. It was truly a forward step.

Self Checking Feature of the Circuits

Early in the development of the A. P. B. system certain protective features not heretofore described were recognized as desirable and necessary. For instance, the engineer asked himself as to the result of a stick relay remaining to be picked up, as might be the case if the control relay failed to pick up after the train had cleared its block. For example, suppose the stick relay at signal *4* is improperly picked up for any cause. Signal *2* would then be at 45 degrees even with an opposing train between signals *4* and *7*. To protect against such a condition it will be noted that, for instance, the control for signal *5* is broken through a back contact of the stick relay for signal *4*. Therefore, after a train has passed signal *4* moving from left to right the stick relay for signal *4* must again drop before either signals *5* or *7* can clear for an opposing movement. A careful study of the whole arrangement will disclose the fact that after a train movement has established traffic in one direction, the signals will not permit a reversal of traffic until the stick relays have been restored to normal or de-energized position. Suppose, for instance, signal *4* should stick position (as will also signal *8*) as soon as train (moving from right to left) leaves the siding next to the right of siding *Y*. Furthermore, the distant indication for following movements is the same as on double track. The very great value of this feature can scarcely be questioned. It prevents a condition so common to the older systems, in which a train passes a full-clear signal and finds the next signal at stop and the block occupied by an opposing train. The A. P. B. provides a caution signal whenever it is necessary to approach the next signal prepared to stop, and in operation when a full-clear signal is passed it need not be expected that a stop will be necessary at the next signal.

An optional feature might be mentioned, which appeals to some. Suppose a train moving from right to left stops after passing signal *5* and for any reason must return to siding *Y*. Fig. *7* as drawn would permit signal *6* to clear, but it obviously is not safe for the train to return to siding *Y* relying upon the protection of signal *6*. Signal *7* would be at 45 degrees and another train might pass signal *7* at the same moment as the first mentioned train passed signal *6*. Some consider that the rules requiring flag protection for such a reverse movement are adequate. Others ask why not make signal *6* assume the stop position until the first



Detail Signal Control Circuits Between Sidings on Single Track

clear as a result of mechanical trouble or improper application of energy. A train moving from right to left would pick up the stick relay for signal *5* in the regular manner. It would also pick up the stick relay for signal *4* when passing onto the track circuit *C*. A locked-up condition is then set up, leaving both home relays open and both stick relays picked up, which condition cannot be removed without maintenance attention.

Suppose two opposing trains should pass the signals *2* and *7* simultaneously, both signals of course being at clear, a locked-up condition will again be setup, signals *2, 3, 4, 5, 6* and *7* all being held in the stop position even after all trains have cleared the territory. A telltale is left of an unauthorized train operation.

By applying the simple basic A. P. B. principles to the distant control at sidings, reliable distant indications have been provided. For instance, the 90 degree position of signal *6* depends always upon the position of signal *8* and upon signal *10* for opposing movements only. In other words, signal *6* will assume the 45 degree mentioned train has passed signal *3* and thus make signal *6* tend to enforce the flagging rule? This is easily done by controlling signal *6* through a back contact of the stick relay of signal *5*.

In conclusion, I am convinced that as railway signal employees and officers we have not fully succeeded in convincing our superior officers as to the operating results which can be obtained by the use of a proper signal system on our railways. The future is before us. The present condition of commercial depression will gradually be replaced by returning prosperity and in the not distant future I believe our railways will look with favor upon extending the use of the signaling system as the best means of quickly and safely securing increased transportation efficiency at a relatively small cost, thus deferring for some years the large expenditures which ultimately must be made for additional trackage facilities to handle the business which surely will be ours when we have all returned to our normal habits of industry and economy.