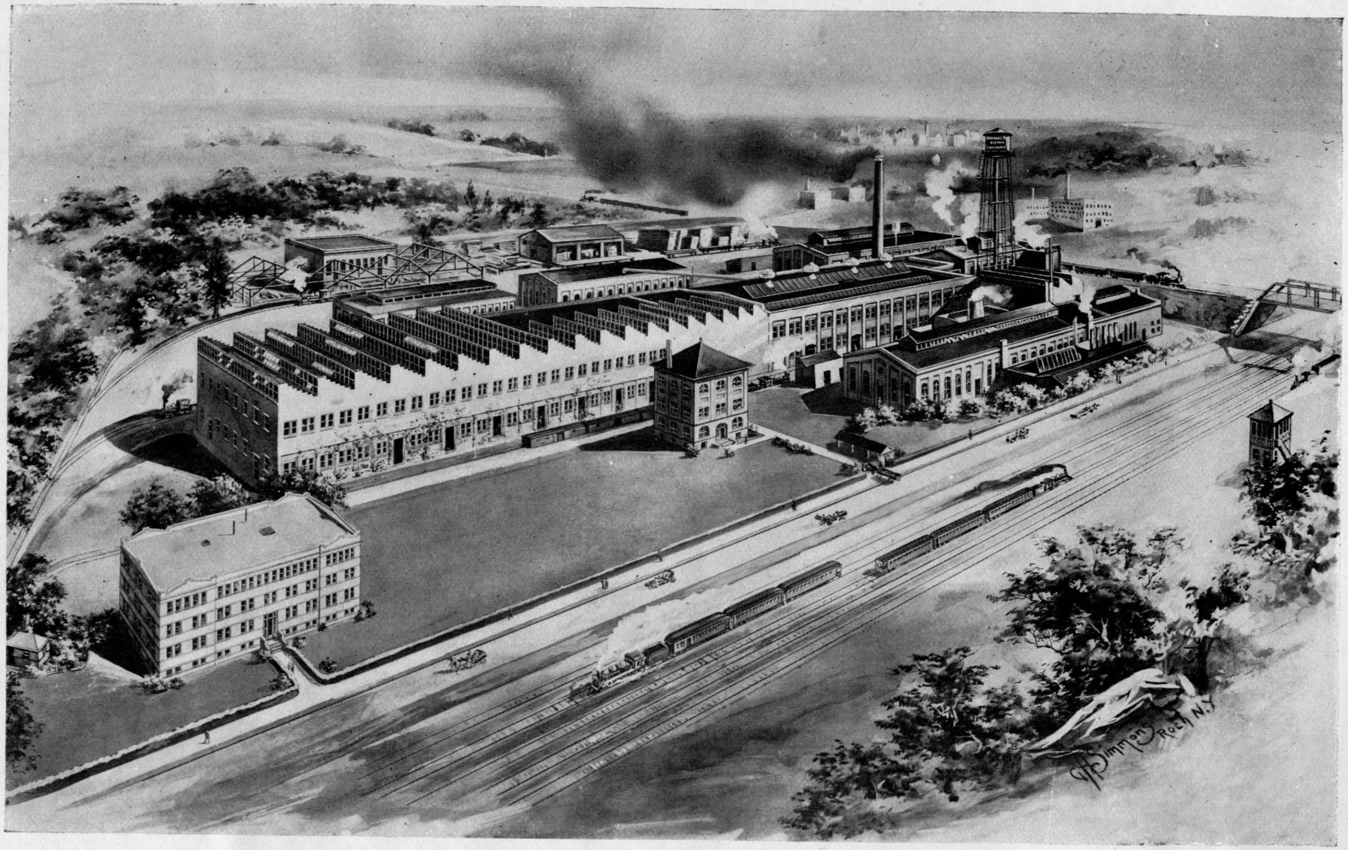
A.P. BLOCK SYSTEM

for

SINGLE TRACK STEAM RAILROADS

GENERAL RAILWAY SIGNAL COMPANY

ROCHESTER, N.Y.



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The
A. P. Block System
for
Single Track Steam Railroads

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MODEL 2A SIGNAL

A. P. Block System
for
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IMPORTANT NOTICE

To every executive, operating and engineering officer upon whom rests in any degree responsibility for the safe, expeditious and economical movement of trains over single track lines of railway, we strongly recommend the careful reading of the following pages which contain a simple, non-technical description of a system of automatic block signals by means of which such train movement may be conducted with greater safety, more expedition and at lower cost than has ever been known or possible heretofore.

Though it is generally recognized that great advantages are obtained by the use of automatic block on single track lines, there has been and is a feeling on the part of many railway men who strongly favor and largely employ automatic block signals on double track lines that they cannot be used with equal advantage on single track lines, or be so installed thereon as to afford complete head-on protection and at the same time provide such increase in facility of train movement as is obtainable by their use on double track lines. This view is strongly indicated by the fact that though, from the stand point of safety alone, there is even greater need of automatic block signals on single than on double track lines, and though single track mileage enormously exceeds double track,—on January 1st, 1911, out of a total of 29,202 miles of track in the United States then equipped with automatic block, only 8,312 miles of this was single track. That this feeling has been in a measure warranted will not be denied by those who have intimate knowledge of the subject and who have taken the trouble to carefully analyze it, as will appear from a consideration of the following brief statement.

In the ordinary systems of automatic block signaling, each and every block signal indicates the occupancy or non-occupancy by a train of a certain section of track called the block, without distinction as to whether such train is moving toward or away from such signal; but it is self evident that safety requires the establishment and maintenance of a much longer space interval between opposed signals designed to prevent trains moving at high speeds toward each other, from colliding, than is required for the protection of trains moving in the same direction. Hence it inevitably follows that in these ordinary systems of single track automatic block, it is necessary, in order to secure the same facility for following train movements that is obtainable on double track, to greatly curtail the desired head-on protection; and, conversely, in order to obtain complete head-on protection, it is equally necessary to correspondingly lessen the facilities for controlling following train movements. Thus, with the means heretofore at their command, the railways have been between the two horns of a dilemma and have accordingly done what is generally done in a like situation,—namely, have effected what seemed to them the best possible compromise. What they want is head-on protection from passing siding to passing siding, with blocks for following train moves just as short as traffic conditions require. The best they have obtained is head-on protection which does not extend from passing siding to passing siding and blocks for following train moves which are frequently not as short as are required.

After many years of study of this difficult and important problem, we have discovered and incorporated in what is called the A. P. Block, means for automatically, simply and reliably blocking the entire section of single track between adjacent passing sidings, as against a train moving toward that block in a direction opposed to that of a train already occupying it,—and whereby such section of track may also be sub-divided into two or more blocks, thus permitting two or more trains, moving in a like direction to as closely follow each other at speed and with entire safety into and through such section, as though it were one track of a double track line.

For the ease of mind of those readers who have found that such marked improvements are usually obtainable only by the employment of additional or more complicated apparatus, we will state that the apparatus used in the A. P. Block is identical in character with that which has been long and successfully used heretofore; that no more of it is required than in existing systems; that its circuits are extremely simple, involving not a single feature that is not known to be absolutely safe and reliable; and that it will cost no more to install or maintain than do the systems now in common use.

It is our belief that since the discovery by Robinson of the track circuit, no development has been made in single track automatic block signaling that has benefited the railways as this A. P. Block will do and we, therefore, earnestly urge upon all who have an interest in the safe, expeditious and economical operation of single track railway lines, that they carefully read the following simple description of this system.

Respectfully submitted,

GENERAL RAILWAY SIGNAL COMPANY.

Object of This Bulletin

At the meeting of the American Railway Engineering Association in Chicago in 1911, this Company exhibited a working model which demonstrated a system of automatic block for single track signaling which it called the "Absolute-Permissive." The particular system exhibited at that time was designed especially with a view to its use upon certain Interurban Electric Railways, where head-on protection was the principal object sought and rear protection or spacing of trains moving in the same direction was only a secondary consideration. It attracted considerable attention at that time and has been the subject of a great deal of discussion since, the consensus of opinion being that it disclosed means long sought for but never before shown for greatly improving single track automatic block.

Since the meeting referred to, this system has been further developed with particular reference to the requirements of single track steam railways and the object of this Bulletin is to describe this later development and to point out the advantage gained by its use and to compare this system with the present day practice.

A Typical Present Day System

In order to make this comparison, it will be necessary to describe the operation of signals in automatic single track block signaling under various conditions, in present day use and in the A. P. Block System.

One of the most up-to-date examples of steam road automatic signaling, is the system now in use on the Northern Pacific Railway. This system employs three position signals and is considered by the majority of Signal Engineers to give the maximum protection heretofore obtainable for both head-on and following movements and at the same time to give that facility for train movement which, particularly at passing sidings, is so greatly desired.

The Meaning of Symbols on a Control Diagram

The "Typical Signal Location and Control" system of the Northern Pacific is shown in diagram 1. For the benefit of those who are not familiar with this branch of signaling it will perhaps be best to explain briefly the meaning of the symbols used on this diagram. It will be noted that a line is drawn from each signal parallel with the track and in the direction in which that signal governs. These lines are for the purpose of indicating diagrammatically the extent of the "Stop" control of the signals. For example: the line from signal 1 extends to the right as far as signal 5 and indicates that when a train occupies any portion of the track between signals 1 and 5, signal 1 will be placed and held in the stop position. It will be noted also that a dotted line starts from some of the signals and joins a full line which full line represents the control of another signal. This dotted line indicates that the "proceed or 90° position" of the signal to which it is joined is controlled by the next signal in advance as well as by that portion of the track covered by the full line to which it is connected. For example; the 90° or proceed position of signal 1 is controlled by the 45° position of signal 3. In other words, when a train occupies any portion of the track between signals 3 and 7, signal 3 will be in the stop position and signal 1 in the caution position.

Reasons for Control and Location of Signals Found in Present Day System

Following are the reasons for the particular system of signal location and control shown on diagram 1. The primary object is to prevent two trains from meeting head-on upon any portion of the single track, or, in other words, to provide what is generally termed "head-on protection." The reasons for these various controls can be best explained by referring directly to diagram 1. Suppose an east bound train is about to pass signal 1. In order that this train may proceed to the next signal, that is to signal 3, without meeting an opposing train, there must be no train between signal 1 and a west bound signal which would prevent such opposing train from entering this particular piece of track. In this case, this west bound signal is No. 4; therefore, it is quite plain that the stop control of signal 1 must extend at least as far as signal 4. Further, when the east bound train passes signal 1, it must place at *stop* the signal which is to give it head-on protection. In this case, that signal is No. 4, and consequently, the *stop* control of signal No. 4 must extend at least as far as signal No. 1. It will be noted on the diagram, that the control of signal 1 extends beyond signal 4, and that the control of signal 4 extends only to signal 1. The reason for this is as follows: Suppose there is an east bound train about to pass signal 1, and at the same time there is a west bound train about to pass signal 4, if the control of signal 1 extended only as far as signal 4, both signals 1 and 4 would be at *caution* and the two trains, accepting these signals, would meet somewhere between them. In order to prevent this, it is necessary to have the control of one of these signals extend farther than does the other, and, in this case, the control of signal 1 is carried beyond signal 4, so that in the event of two opposing trains attempting to pass these two signals at the same time, only one of them, that is signal 4, will be at *caution*, and the east bound train will, therefore, be held at signal 1, which will be at *stop*.

For identically the same reasons the controls for signals 3 and 6 are relatively the same as the controls for signals 1 and 4 which have just been described.

Let us now consider the control of signals 7 and 8 which may be termed "the siding entrance signals." In order that a train which has passed signal 7 may not find another train between that signal and signal 9, which is the next signal in advance, the stop control of signal 7 must necessarily extend as far as signal 8, which is the signal that prevents an opposing train from entering this piece of track. For the same reason, the stop control of signal 8 must extend at least as far as signal 7 and further, in order to prevent two trains passing 7 and 8 at the same instant, the stop control of one of these signals must be carried one section beyond the other. It will be noted, therefore, on diagram 1 that the stop control of signal 7 extends to signal 10 and that the stop control of signal 8 extends to signal 5. As has been explained it is not absolutely necessary to have the stop control of such a signal as number 8 extend beyond its opposed signal 7; but owing principally to the fact that the block between signals 7 and 9 is usually shorter than the other blocks, it has been customary to give to both of these signals this extra overlap.

It will be noted that the signals between sidings, such as signals 3 and 4, are placed some distance apart. These are commonly termed "Staggered" signals and the reason for so placing these signals is entirely for the purpose of giving head-on protection. For example, suppose there is an east bound train at signal 1 and a west bound train at signal 6. By following out the control lines it will be found that with the trains so placed both signals 6 and 1 are in the proceed position and should these two trains proceed, the east bound train will be stopped at signal 3 and the west bound train at signal 4. It is the general practice to place staggered signals one track circuit section or about three thousand feet apart.

The signals on diagram 1, the control and location of which we have thus far described are all that are required for the purpose of giving adequate head-on protection; but owing to the necessity of staggering the intermediate signals, the distance between the entrance of a passing siding and the next signal leading to it is too great to give the proper distant signal protection for the siding by means of such intermediate signals. It is customary therefore to add two more signals for each siding and place them one track circuit section, usually about three thousand feet, from the entrance to the siding. These signals on diagram 1 are numbers 5 and 10 and their stop controls extend only to the next signal in advance; that is, the stop control of signal 5 extends to signal 7 and the stop control of signal 10 extends to signal 8, the 90° or proceed position of both of these signals being controlled by the next signal in advance.

One of the principal advantages of this particular location and control system is that a train may occupy that portion of the main track opposite the siding and be properly protected by signals while at the same time other trains may approach either end of the siding without passing any signals at stop; for example, when a train occupies the main track at siding B, signals 7 and 8 will be at stop and signals 5 and 10 will be at caution. Thus trains may approach the entrance to the siding without passing stop signals and yet the train at the siding will be amply protected by signals.

There is one peculiarity in this control and location system which it is well to mention here. It will be noted by referring to diagram 1 that the stop control of signal 3 extends to signal 7 and includes in its stop control the same piece of track that furnished stop control for signal 5. Signal 3, therefore, must remain at *stop* until signal 5 is at *caution* and following the regular rule of three position signaling, by making the *proceed* position of signal 3 depend upon the *caution* position of signal 5, signal 3 can have no 45° position. This is also true of signals 4, 11 and 12. In other words, the second signal out from the siding has only two operative positions. Again, owing to this peculiarity of the stop controls of signals 3 and 5, signal 5 will never be found in the *stop* position by a train if that train and all other trains shall have been governed strictly by signal indications. For example, when a train passes signal 3 in the *proceed* position there can be no train between that signal and signal 6, therefore signal 5 cannot be found in the stop position and further, before the train passes signal 3, signal 6 must be in the stop position, so that if no train passes signal 6 in the stop position trains which pass signal 3 in the proceed position must always find signal 5 either at proceed or at caution. The first signal from a passing siding, as well as the second signal, has only two operative positions.

In diagram 1, only one pair of staggered signals is shown between sidings. When the distance between sidings is so great as to require more signals, they are located as shown in diagram 2. To get the proper head-on protection it is only necessary to carry out the same general system of signal control as has already been described for diagram 1. It may be well to call attention to the fact that in this diagram signals 7 and 8 are the two position signals and that signals 6 and 9 are the signals which act only as distant signals for the siding.

Some Deficiencies in the Present Day System

It will be noted in the two diagrams which have just been described that the control of each of the signals extends a considerable distance beyond the next signal in advance. In most cases this distance, or over-lap must be at least two track circuit sections. It will be noted, furthermore, that these over-laps are required solely for head-on protection not being required at all for the protection of following trains. The distance between following trains is thus greatly increased beyond what is necessary for their protection from each other.

It will be noted further that in this particular system of signaling, in which intermediate signals are employed, two opposing trains may enter upon the same piece of single track; for example, a west bound train may leave siding B (diagram 1) with signal 6 in the proceed position and during the time that this train is moving between signals 6 and 5 an east bound train may leave siding A with signal 1 in the proceed position. In such event these trains would be stopped at signals 3 and 4 and therefore one or the other must return to the siding from which it came, thereby causing considerable delay.

These deficiencies in the present day system of single track block are known to those signal engineers who are familiar with this branch of signaling but unfortunately, until now, no way has been known to better either of these conditions without further sacrifice as to the other and therefore they have been universally accepted as detriments necessarily incident to obtaining the recognized great advantage of single track automatic block.

The Absolute Permissive Block System

In the "Absolute Permissive" System, these two necessary detriments, together with several other minor ones, have been entirely eliminated. This has been accomplished by employing a very simple circuit which,

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like all other signaling circuits, is affected by the presence of a train upon a certain piece of track but *unlike* all such other circuits is affected also by the direction in which the train is moving on that piece of track. Taking advantage of this last named feature, the *stop* control of a signal is made to extend to a certain point when the train is running in the direction in which this signal governs and to another point when that train is running in the opposite direction. This peculiarity of the circuit makes it possible, therefore, to shorten the control of a signal for following trains and to lengthen it to any desired distance for opposing trains. In other words, for following trains the control of the signals can be exactly the same as in double track signaling, that is, signal to signal; and for opposing trains, the same as in a manual controlled system, which is, siding to siding. The advantage of this is at once apparent. Other advantages equally as important will also be apparent as the description of the system progresses.

Diagram 3 is a typical signal location and control diagram of the Absolute Permissive System. For sake of simplicity, this diagram shows only the control for trains running in the direction opposite to which the signal govern. Diagram 3a has the same signal locations and shows only the control when trains are running in the same direction in which the signals govern.

Referring now to diagram 3, it will be noted that the *stop* control for signal 1 extends to siding B, so that when a west bound train leaves siding B, signal 1, which is the leaving signal for east bound trains at siding A, is placed at *stop*. Likewise when a train passes signal 1 at siding A, signal 6, which is the leaving signal at siding B for west bound trains, is placed in the *stop* position. In other words the stop control for these two signals, when trains are running opposite to the direction which they control, is the entire piece of single track between sidings A and B.

Referring now to diagram 3a: The *stop* control of signal 1 for east bound trains the direction in which that signal governs, extends only to signal 3 and the similar control for signal 3 extends only to signal 5. For following trains, therefore, the control of the signals is exactly as it would be in a double track system, and for opposing trains, it is exactly as it would be if there were no intermediate signals and the block extended from siding to siding.

With this system of signaling, it is possible to differentiate not only in the control of the stop position as to the direction in which the trains are running but also to differentiate in the control of the 90° or *proceed* position. For example, in diagram 3a the 90° or proceed position of all signals depends upon the *caution* or 45° position of the next signal in advance, just the same as in double track signaling; but in diagram 3 some of the signals have a different control for the 90° position; for example, signal 5 will be placed in the *caution* position when a train leaves siding C; likewise, signal 10 will be placed in the *caution* position when a train leaves siding A. The reason for this will be explained later.

Operation of Signals in A. P. B. System Due to Normal Train Movements

In order to show clearly the operation of the signals caused by train movements a few simple diagrams are given. In diagram 4 it is assumed that a fast west bound train is passing a slower west bound train at siding B. When the two trains occupy the positions shown on the diagram the indications displayed by the signals will be as shown; that is, signals 7 and 8 will be at *stop* and signals 5 and 10 at *caution*, while all of the other signals will be at *proceed*. Assume that one of these trains moves into the block guarded by signal 6. Indications displayed by the signals will then be as shown in diagram 5, that is, the east bound signals 1, 3 and 4 which are between sidings A and B will be at *stop*, as well as west bound signal 6 which will be at *stop*, while signal 8 will be at *caution*. In diagram 6, the first train has been moved into the block guarded by signal 4. The only changes that have taken place in the indication of the signals are that signal 6 has moved to *caution* and signal 8 to *proceed*, thus allowing the second train to leave siding B. If the second train proceeded into the block guarded by signal 6 this signal would change to *stop* while signal 8 would remain at *caution* and signal 10 at *proceed*. If, however, the second train waited until the first train was beyond signal 2, then signal 6 would move to *proceed* as shown in diagram 7.

Next will be considered two trains which are approaching each other as shown in diagram 8. When these two trains are at sidings A and C, the indication displayed by the signals would be as shown in the diagram. Next let these two trains occupy the positions shown in diagram 9. It will be noted that under these conditions the leaving signals 6 and 9 at siding B are at *stop* and that signals 7 and 8 are at *caution* and also signals 5 and 10 are at *caution*. If these two trains should proceed at such relative speeds as would bring the east bound train to signal 7 at the same time that the west bound train arrived at signal 8, then the position of the signals would be as shown in diagram 10. It will be well to note here that the east bound train passed signal 5 in the *caution* position and also that the west bound train passed signal 10 in the *caution* position.

Now should it happen that the east bound train traveled considerably faster than the west bound train so that it arrived at signal 9 just before the west bound train arrived at signal 10, then the indication displayed by the signals would be as shown in diagram 11. The west bound train would pass signal 10 in the *caution* position, proceeding to signal 8, which it would find in the *stop* position and there take the siding. When the west bound train has entered the siding so as to clear the main line, signal 9 would go to *proceed* and the east bound train would be free to go on.

Operation of Signals in the A. P. B. System Due to Abnormal Train Movements

It is believed that these diagrams are sufficient to show the operation of the signals under normal condition of train movements. It is perhaps very pertinent to inquire what would happen if there was an abnormal train movement such as a train leaving a siding and after going some distance, returning to that siding. Supposing, for example, a west bound train left siding B diagram 5 but went only as far as signal 4, the east bound signals 1, 3 and 5 would be placed at *stop* as well as the west bound signal 6. If the train did not clear the block of signal 6 before it started on its return journey the condition of the signals would not be changed until the train was all the way back to siding B and into clear, when the signals would all return to their normal positions and the circuits would be exactly the same condition as they were before the train started from siding B. Now suppose that the train had passed signal 4 before it started on its return journey. See diagram 6. Signal 6 would then be in the caution position and, if there was no east bound train between siding C and signal 5, signal 5 would be in the *proceed* position. As soon as the train passed signal 5 on its return journey that signal as well as signal 6 would go to *stop* and signals 3 and 5 which were in the *stop* position would remain there. Now, when the train had cleared the block of signal 4, on its return journey, signal 3 would go to *caution* and signal 1 to *proceed*. In other words, as soon as the train passes a signal at clear it establishes its direction of movement as far as the circuits are concerned and is then under the same signal protection as it would have been had it not changed its direction of movement but had come from the siding in its rear.

It will be evident from what has been said that no abnormal train movement can place the system in an abnormal condition. It is not necessary for a train to make a complete journey from siding to siding before the circuits are restored to their normal condition, nor is it necessary for the signals to be operated in any predetermined sequence in order that the circuits may operate correctly and finally be restored to their normal condition.

Having described the control and operation of the signals, in the *Absolute Permissive System,* let us now compare it with the present day practice of single track signaling and see what advantages have been gained.

Comparison of the Spacing of Following Trains

First, compare the spacing of following trains. In order to do this it will be necessary to make some assumptions which must govern irrespective of the system that is being used. It is the opinion of a great many Signal Engineers that where three position signals are used the distance between signals should not be greater than six thousand feet, for the reason that with the class of traffic usually found on single track roads, this distance is as far as an engineer should be required to remember the position of the last signal he passed. For the purpose of this comparison, therefore, let us assume that six thousand feet is the maximum spacing of signals. The length of track circuit section is also a factor in determining the spacing of trains and, taking into account the average track conditions, it is believed that a fair assumption for track circuit lengths would be three thousand feet.

There is another assumption which must be made before comparing the spacing of trains and that is the distance which a train must be from a signal, when that signal goes to a clear position, in order that the train will not have to slacken speed on account of first seeing the signal in the danger position. Without making any assertion as to what this distance should be let it be assumed for purposes of this comparison, to be one thousand feet.

Applying these assumptions to diagram 1, it will be found that the distance between ends of siding is fifteen thousand feet, that is, six thousand feet between signals 1 and 3, six thousand feet between signals 3 and 5 and three thousand feet between signals 5 and 7.

Now when a train is one thousand feet from signal 1 in order that the signal may be in the *caution* position, any preceding train must have passed signal 5. The distance between these two trains is therefore thirteen thousand feet, which is the minimum spacing of trains running under caution signals in this system.

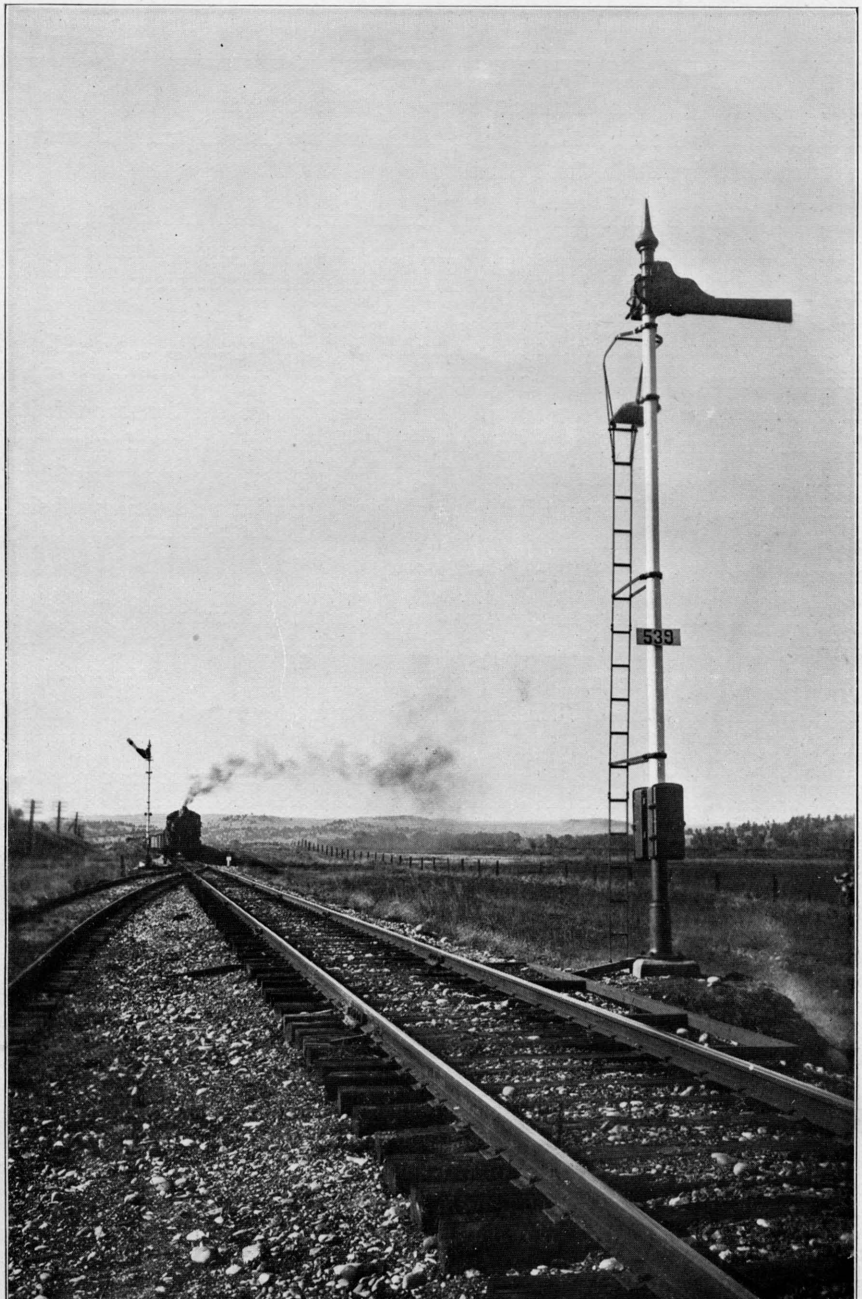
Applying the same assumptions to diagram 3, and taking the same distance between sidings, that is, fifteen thousand feet and the same number of signals between sidings, that is, six, the distance between signals 1 and 3, 3 and 5, and 5 and 7 would in each case be five thousand feet. Now, as before, when a train is one thousand feet from signal 1, a preceding train must have passed signal 3, before signal 1 would go to *caution*. The distance between these two trains would therefore be six thousand feet. The result, therefore, is a minimum spacing for trains running under *caution* signals of thirteen thousand feet in the present day system and for the same number of signals between sidings a minimum spacing of six thousand feet with the Absolute Permissive System, a saving of seven thousand feet or over a mile and one-third.

When trains are running under *proceed* signals, there will be the following conditions; on diagram 1, with a train one thousand feet from signal 1, a preceding train must have passed signal 7 before signal 1 would indicate *proceed*. The distance between these two trains would under these assumptions be sixteen thousand feet. With a train one thousand feet from signal 1 on diagram 3, a preceding train must have passed signal 5 before signal 1 would indicate *proceed* and the distance between these two trains would be eleven thousand feet, thus making a saving for trains running under full clear or *proceed* signals of nearly one mile in favor of the Absolute Permissive System.

Comparison of the Spacing of Opposing Trains

Another interesting comparison of these two systems is the spacing of opposing trains, that is, the nearness with which two opposing trains may approach each other on single track, under signal control. Returning again to diagram 1. It has already been explained that a train may leave siding A with signal in the full clear position and, at any time while this train is running between signals 1 and 2, another train may leave siding B with signal 6 in the *proceed* position. These two trains will be stopped one at signal 3 and the other at signal 4 and the distance between them providing neither one over-ran its signal will be three thousand feet.

Referring now to diagram 3, it has already been explained that when a train leaves siding A, signal 6 at siding B is placed in the stop position.



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so that a west bound train can not leave that siding; the minimum distance therefore under these conditions between the two trains will be fifteen thousand feet.

It would, perhaps, be well at this point to call attention to a certain modification in the A. P. B. System as thus far described, which some signal engineers might consider advisable. In diagram 3, the control of signal 1 extends only to signal 6 at siding B, while the control of signal 6 extends only to signal 1 at siding A. It is evident, therefore, that if two opposing trains should pass signals 1 and 6 at exactly the same instant, both of these signals would be clear; but the east bound train would find signal 3 at stop and the west bound train find signal 4 at stop. Under these conditions there would be five thousand feet between them. If, however, the distance between sidings was sufficient to require six intermediate signals as on diagram 2 for example, then the distance between these two trains which had entered the single track simultaneously, would be ten thousand feet when they are stopped by danger signals. With the controls as shown in diagram 3, therefore, the minimum distance between opposing trains on single track would be five thousand feet, where only two pair of intermediate signals were in use, ten thousand feet where there were three pair and fifteen thousand feet where there were four pair and so on.

If this remote possibility of two opposing trains entering the single track at exactly the same instant is objectionable, it is quite easy to arrange the control, so that it would be impossible for two trains to leave the opposing sidings under clear signals, even if they arrived at those signals simultaneously. If the opposing control of signal 1—diagram 3— was carried to a point, for instance, mid-way between signals 7 and 8, then the train at signal 6 would place signal 1 at stop and thus effectively prevent two trains from entering the single track simultaneously. There is, however, some question as to the advisability of using this over-lap, for the reason, that a train standing at signal 6 siding B, would prevent a train from approaching that siding from siding A, so that if this over-lap is used, some special rules are necessary in order to prevent trains from standing on these over-lap sections and thus preventing certain train movements. It is the opinion of some signal engineers that these overlaps should always be provided and that they can be so located that they will interfere but very little with train movements. Other signal engineers are of the opinion, that these simultaneous movements would occur so very seldom, and further, that they only occur when one or the other of the trains have forgotten their orders, that it is better to stop them at the opposing signals than it is to put in the over-laps and provide the necessary special rules for their use. As far as the circuits of the system are concerned it is immaterial whether these overlaps are used or not. This comparison, therefore, as to head-on spacing can be summed up as follows: With the present day system, the minimum distance between opposing trains between sidings is three thousand feet; with the A. P. B. System this distance is five thousand feet when siding over-laps are not used and the distance between sidings when the siding over-laps are used.

Comparison of Delays Due to Signal Failures

Another interesting comparison is one which deals with delay to traffic due to derangements in the signal apparatus or, in other words, delay due to signal failures. In making this comparison it is only fair to make another assumption in regard to the equipment of the two systems. It is considered not only good practice but, in some cases, necessary to have telephones at each of the leaving signals at sidings, these telephones connected with the dispatchers office so that train crews, in the event of any abnormal condition, can communicate with the dispatcher and secure instructions for their guidance. Assume, therefore, the existence of such telephones. In double track signaling, when a train finds an automatic signal in the *stop* position, the rules provide that the train shall come to a full stop and then proceed through the block under control. In single track block, however this rule does not hold, but instead, when a train finds a signal in the *stop* position, a flagman must precede that train through the block thus causing more or less delay.

Referring now to diagram 1, and supposing a train finds signal 3 in the stop position, this stop indication may be caused by any one of four things; first, there may be an east bound train between signals 3 and 7; second, there may be a west bound train between signals 6 and 4; and third, there may be some derangement in the apparatus of signal 3 or in the circuits controlling that signal; and, fourth, there may be some derangement in the apparatus of signal 5, or in the circuits controlling that signal, for in this case, signal 3 remains at stop until signal 5 has been placed at least in the caution position. A train stopping at signal 3 under these conditions, therefore, would be obliged to have a flagman precede it as far as signal 5 at least, and if the failure was caused by apparatus connected with signal 5 then the flagman would be obliged to continue as far as signal 7 or a total distance of nine thousand feet. This would be the maximum flagging distance in this system and it would be necessitated not only by the failure of the apparatus of one signal but by the failure of the apparatus or circuits of either one of two signals.

Referring now to diagram 3, the effect of a failure of any apparatus in this system depends somewhat on the character of the failure. For instance, a failure of the line wire which controls the east bound signals would always result, in placing the starting signal of that line of signals in the danger position, so that no flagging would be required for such a failure, because the train would be stopped at a telephone location. Any kind of a track circuit failure would produce practically the same result; for instance, any such failure would always place at stop the signals protecting the piece of track in which such failure occurred, and it would further place at stop the leaving signal on one end or the other of the piece of single track, this depending upon the track circuit which failed; for example, supposing the track circuit immediately east of signal 3 to be the one that failed, signal 3 would be placed at *stop,* signal 1 at *caution,* while signals 4 and 6 would be placed at *stop.* If the track circuit immediately west of signal 4 was the one to fail, then signal 4 would be placed at *stop* and signal 6 at *caution,* while signals 1 and 3 would be placed at *stop.* In other words any sort of a failure between sidings will place at least one of the leaving signals at *stop,* so that it may be said, that on the average at least one-half of the train stops due to signal failures, will occur at the leaving signal at a siding or at a telephone location. Now when a train is stopped at an intermediate signal, there is no occasion for a flagman to precede the train through the block, because these signals are only spacing signals for following trains and play no part in the head-on protection, therefore they have the same force and effect as automatic signals on double track, so therefore, double track block rules can apply to these signals. The comparison, therefore, as to delays necessitated by head-on flagging, granting in both systems that when trains are stopped at siding leaving signals, they are able to get instructions from the dispatcher as to their movement, the present day practice requires a maximum of nine thousand feet which a train must run preceded by a flagman while with the A. P. B. System no such flagging is required.

Reliability of the Distant or Third Position Indication

It is of the utmost importance in a signal installation, that the trainmen shall with reason, have perfect confidence in the indications which the signals give and the only way that such confidence can be gained and kept, is to make sure that these indications are always right. Reliability of signal indications is therefore, of the utmost importance and a comparison of the two systems would not be complete without a consideration of this branch of the subject. There is no difference in the reliability of the home or caution indications but there is quite a difference in the 90 degree or distant indication.

Referring to diagram 1, assume an east bound train about to pass signal 5, and a west bound train about to pass signal 10. Under these conditions both signals 5 and 10 would be in the *proceed* position. When these two trains arrived at the next signal in advance, the east bound train would find signal 7 at *stop* and the west bound train would find signal 8 at *stop*. Both trains have had a wrong distant indication, that is, they have passed a signal in the proceed position and found the signal in advance in the *stop* position. Assume again that an east bound train is running between signals 5 and 7, and just before that train reaches signal 7 or in fact any time before it reaches signal 7, a west bound train passes signal 10, the west bound train would place signal 7 at *stop,* consequently the east bound train would have had a wrong distant signal indication. In these two cases, both trains would be running under signal control and also in accordance with orders, if it be assumed that the orders called for a meeting at siding B.

With the present day practice, therefore, when two trains are approaching a meeting point, there is not only the possibility that both of these trains may get a wrong distant signal indication, but there is a strong probability that one of them, at least, will get such an indication. If a train overlooks its orders and passes into a piece of single track there is always the possibility that such a train will set at stop signals which will cause another train to get a false distant indication. For example, refer to diagram 2;—and suppose that after an east bound train had passed signal 3 in the proceed position, a west bound train passes signal 9. In this case the east bound train will find signal 5 at *stop*. Return again to diagram 1 and assume that a west bound train is about to pass signal 8, and an east bound train is at signal 2, with these locations of the two trains signal 6 will be at caution and signal 8 at proceed. Now should it happen that the east bound train was a fast one, while the west bound train was slower, there is a possibility of these two trains arriving at signal 6 and 7 at the same instant, the fast, or east bound train, having passed signal 3 in the *proceed* position and signal 5 in the *caution* position, is intending to stop at signal 7, but the west bound train, however, having passed signal 8 in the *proceed* position does not intend to stop at signal 6. It is quite possible that these conditions combined with a slippery rail and a down grade west bound, might make such an occurrence disastrous. It must be, therefore, admitted that the reliability of the distant signal indication in the present day single track automatic block system is not all that it should be.

Referring now to diagram 3; for the purpose of comparing the reliability of the distant signal indication as given by the A. P. B. System, with what we have just found in the present day system. Assume first, an east bound train is about to pass signal 5, and a west bound train is about to pass signal 10. Following out the control diagram, it will be found that with these locations of trains, both signals 5 and 10 will be at *caution*, so that even if these two trains find signals 7 and 8 at *stop*, they will have been properly informed of this fact. It will be further noted, that a train approaching a siding can never get a false distant indication, because if there is a train approaching that siding in the opposite direction, no matter where this second train may be, the signal which acts as a distant signal for the siding will always be in the caution position. Further, with the system shown on diagram 3, a train having once entered a piece of single track, can never find one of the intermediate signals at stop unless an opposing train has disregarded a signal. For example, a train passing signal 9 places signal 14 at stop, and this train will always find signals 11 and 13 at proceed unless an opposing train disregards signal 14, and by so doing places signals 11 and 13 at stop. In fact, there is only one condition where a train can get a false distant signal indication in the A. P. B. System and that is, if while a train is running between signals 7 and 9 an opposing train passes signal 14, in this event signal 9 will be at *stop*, but it will be noted, that such an event would not occur unless one or the other of the two trains had forgotten orders. It needs no further argument to show that the A. P. B. System gives a more reliable distant signal indication than does the present day system.

MODEL 2A SIGNAL

Circuits

It is not the purpose of this bulletin to describe the detail circuits used in the A. P. B. System as it is sufficient to state that they are in no way complicated, in fact, they are as simple as the circuits used in any present day system of single track automatic block, further, these circuits do not violate in any way the fundamental principles of signal circuits, nor is there any special apparatus used to control either the signals or the circuits themselves. The A. P. B. System employs no more nor any different apparatus, than is used in the present day system.

Summary of the Advantages

To sum up the advantages gained by the use of the A. P. B. System, we have the following:

1st. Opposing trains are prevented from entering the same piece of single track between sidings.

2nd. With the same number of signals between sidings

(a) One and one-third miles less spacing distance for trains running under caution signals;

(b) One mile less spacing distance for trains running under proceed signals;

3rd. No head-on flagging with the consequent delay.

4th. Much greater reliability of distant signal indication.

5th. All of these advantages secured without sacrificing any facility for train movements found in the present day system.

6th. No special apparatus is required.

Special Conditions

So far in this Bulletin we have shown, how the A. P. B. System, is applied to a single passing siding. In the application of single track blocking, there are always other conditions to be met, such for example, as double sidings, lap sidings with or without interlocking plants, junction points, and switches between sidings. It will be of interest to see how some of these conditions can be handled with the A. P. B. System.

Interlocking at End of Double Track

Diagram 12 shows a signal location and control diagram of a portion of single track between two ends of double track and an interlocking plant at each junction point. In this case the stop control of signal 1 at A will extend to signal 2 at B. An overlap can easily be provided in this case, without any possible interference of traffic, by having the "head-on" control of signal 1 extend to signal 2 when the switch at B is in the normal position, and extend one track circuit section beyond signal 2, when the switch is in the reverse position. Likewise, the "head-on" control of signal 2 would extend to signal 1 at A when the switch at A is in the reverse position, and extend one track circuit section beyond signal 1 when the switch is in the normal position. The circuits would also be arranged so that clearing signal 2 at B would place at stop the east bound intermediate signals 3, 5 and 7 and at the same time prevent signal 1 at A from being cleared. Likewise, clearing signal 1 at A, would place at stop the west bound intermediate signals 4, 6 and 8, and also prevent signal 2 from being cleared. Of course, for following movements the signals would operate the same as they would on double track roads. For example, signal 2 could be cleared to the caution position after a west bound train had passed signal 8 and to the proceed position after the west bound train had passed signal 6 and so on. Without adding to the line wire, indicators could be provided in each tower. The indicator in Tower A for example, would announce the approach of a train from Tower B and at the same time act as a slot indicator for signal 1. The indicator in Tower B, would announce the approach of a train from Tower A, and also act as a slot indicator for signal 2. Another feature which could be added, would be to lock the switches so that, after they were properly set for approaching train, they could not be changed from that position while the train was approaching, for example, if the switch at Tower B was reversed after a train left Tower A, it could be placed normal but it could not again be placed in the reverse position until the approaching train had passed over it. As a striking example of the simplicity of the A. P. B. System, only three line wires are required between Towers A and B for operating all the signals shown in diagram 12, giving the annunciation, indicating the slot control and locking switches as described.

Double Sidings

Where there are double passing sidings as on diagram 13, it is customary for east bound trains to use siding B and west bound trains to use siding C. The "head-on" control only is shown in the diagram and needs no explanation. It will be noted, however, that it is immaterial which siding the train uses, as ample protection is given in either case;

there is, however, one additional feature in these controls, that is when a west bound train leaves siding D, signal 5 is placed at caution in addition to the usual signals, and likewise when an east bound train leaves siding A, signal 12 is placed at caution. This is done for the same reason that signal 5 in diagram 3 is placed at caution, that is, to prevent trains approaching the siding from receiving a wrong distant indication.

Lap Sidings

Diagram 14 shows the "head-on" control for a lap siding with the entrance switches interlocked. Owing to the presence of the interlocking plant, head-on overlaps can be used without interfering with traffic. The "head-on" control of signals 16 for example, extends to signal 6, if switch C is normal but only to signal 19 if that switch is reversed. Likewise the "head-on" control for signal 1 would extend as far as signal 11 if switch B was normal, but if that switch was reversed then the control of signal 1 would extend only to signal 8. The slot control of interlocked signal 9 will extend to siding D as would the control of the automatic signals 11, 13 and 15, likewise the slot control of signal 8 would extend to siding A, as would the control of automatic signals 2, 4 and 6. If so desired, electric locks could be provided at the out going end of the lap sidings and controlled either directly from the signal circuit or from the signal circuits in conjunction with the tower operator. In either case the electric locks could not be operated when the train was approaching them on single track, for example, the lock on the east end of siding C could not be operated when a west bound train was running between signals 16 and 10, but it could be operated while an east bound train was running between 13 and 16. Annunciators could also be added to the circuits which would both announce approach of trains from sidings A and D and also act as slot indicators for signals 8 and 9.

If there was no interlocking plant, the control of the signals would be the same as those shown on the diagram with the exception that the manual part of the control of signals 8 and 9 would be omitted. It might also be necessary under some conditions to omit the overlap.

Switch Protection

It sometimes happens, that there is a single switch between passing sidings leading to a short track for an industry or other purposes where a local or a work train may enter and remain for some length of time, so that this single switch becomes in reality a passing siding. In such cases it is best with the A. P. B. System to place a pair of intermediate signals as close to the switch as possible. These two signals will then act as switch indicators and give just the right kind of information in regard to approaching trains. For example, suppose such a switch were located near signals 10 and 11 in diagram 3. If there is no train between sidings B and C, signal 11 will be at proceed and if there is no east bound train between the siding and switch, signal 10 will be at proceed. Again, if signal 11 was at stop it would indicate that a west bound train was approaching the switch, and likewise if signal 10 was at stop it would indicate that an east bound train was approaching the switch. A rule to the effect that a train should not leave an intermediate switch unless both signals indicated proceed would give the proper protection for this kind of a train movement. Now as to the operation of signals when a train uses this switch. First, suppose the train approached the switch from siding B; in this event signals 10, 12 and 14 would be at stop. Now, when the train has entered the siding and the switch returned to normal position, all the signals between sidings B and C will go to proceed, and the circuits will be restored to their normal condition. Again suppose a train approaches from siding C. In this event signal 9 will be at stop, thus protecting the train ahead and the usual signals would be at stop in the rear. This condition will remain until the train has backed in to the siding and the switch returned to normal position. All signals between sidings A and B will then go to proceed and the circuits will return to their normal condition. Suppose a train desires to leave the switch, if both signals 10 and 11 are at proceed, it shows that there is no train approaching and as soon as the switch is opened, signals 9 and 14 will go to stop, as well as the other signals between the sidings B and C. The reason for thus placing the two starting signals at stop is, that thus far there is no indication as to the direction the siding train intends to take, after it gets onto the main line. Suppose first, that the train proceeds to siding B. After it has passed signal 10, signal 12 would go to caution and signal 14 to proceed, thus allowing a west bound train to follow. If, however, the train goes to siding C, after it has passed signal 13, signal 11 will go to caution and signal 9 to proceed. In general it may be said, that the opening of a main line switch between sidings causes the leaving signal at the sidings to go to stop, and as soon as the train has entered the main line from the switch and has passed a clear signal, it establishes its direction of movement as far as the signal circuits are concerned. It is thus shown that the protection at an intermediate switch, is all that could be desired.

TYPICAL SIGNAL CONTROL AND LOCATION DIAGRAM

PRESENT DAY SYSTEM

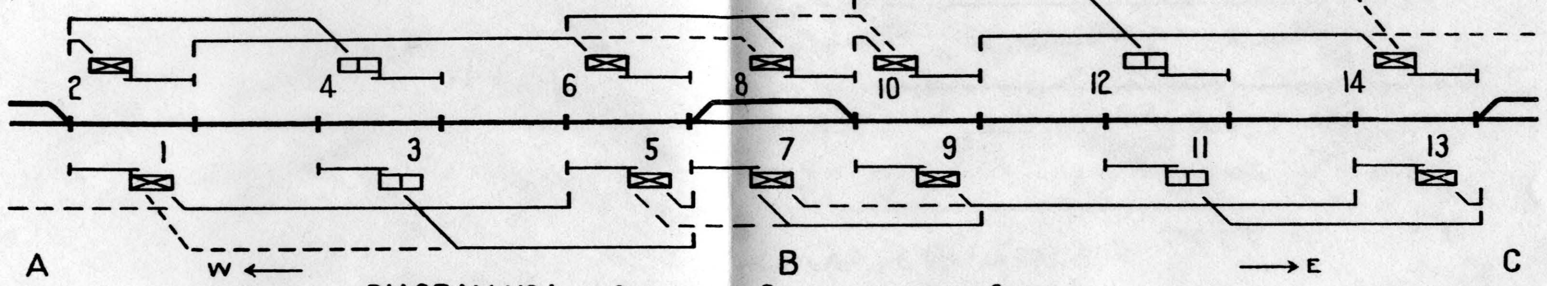


DIAGRAM No 1 ONE PAIR OF SIGNALS BETWEEN SIDINGS

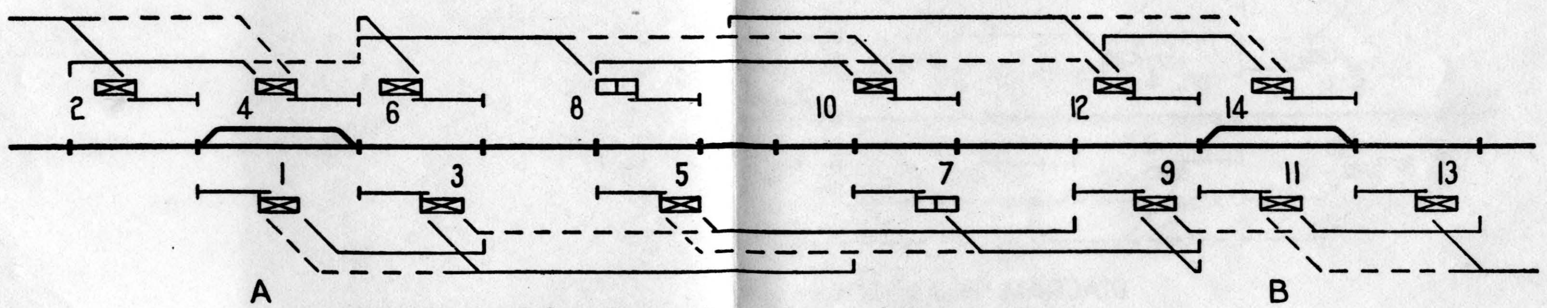


DIAGRAM No 2 TWO PAIR OF SIGNALS BETWEEN SIDINGS

A. P. BLOCK SYSTEM

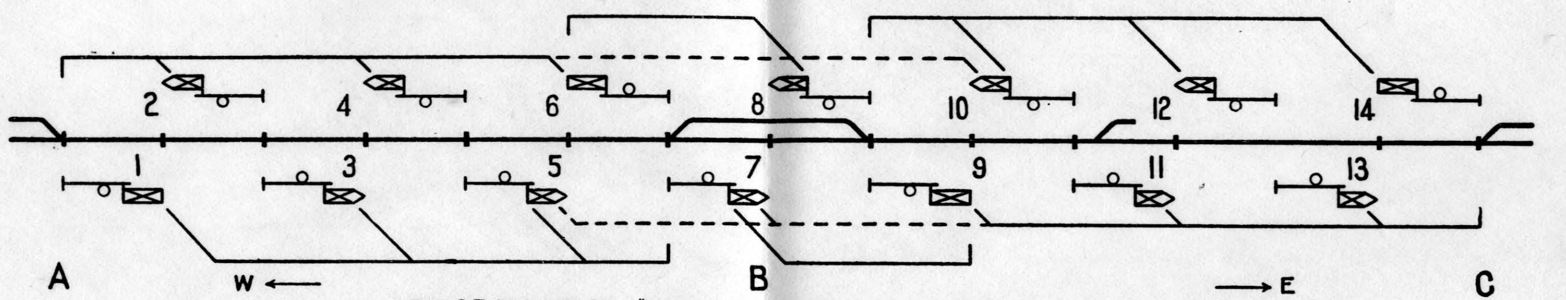


DIAGRAM No 3 "HEAD ON" CONTROLS ONLY

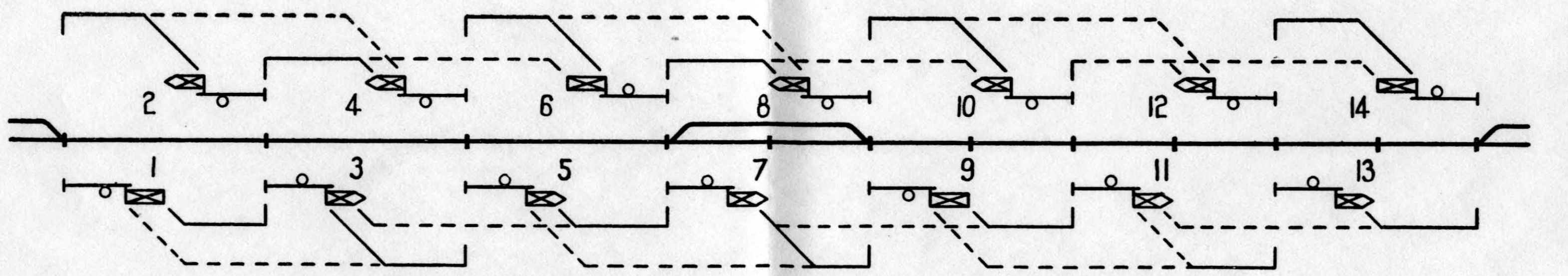


DIAGRAM No 3a "FOLLOWING" CONTROLS ONLY

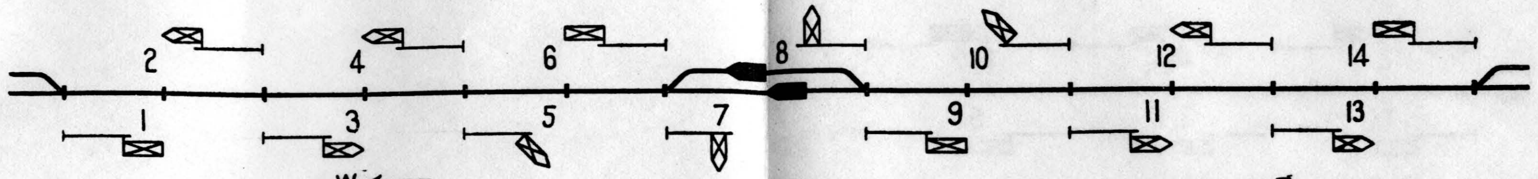


DIAGRAM Nº 4

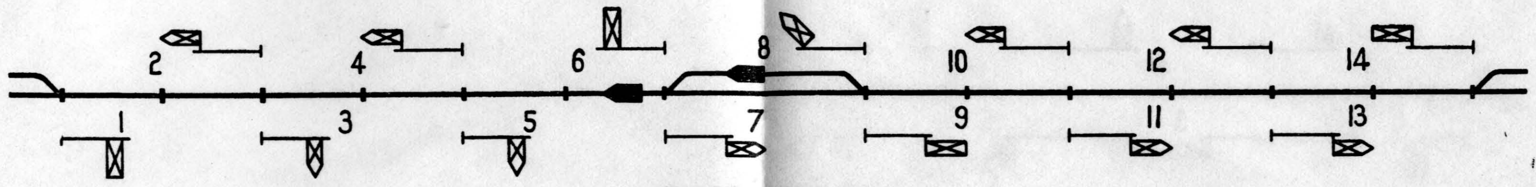


DIAGRAM Nº 5

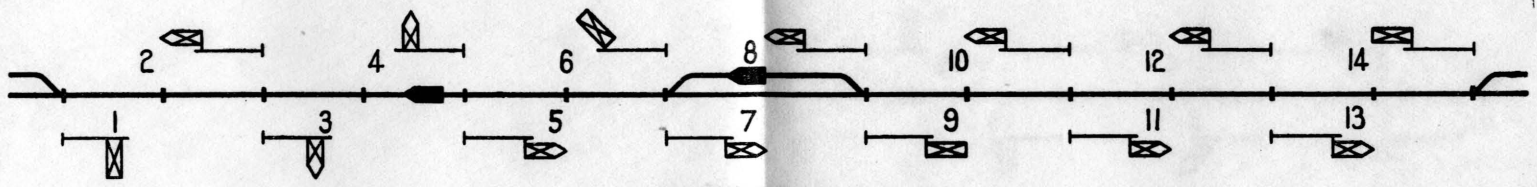
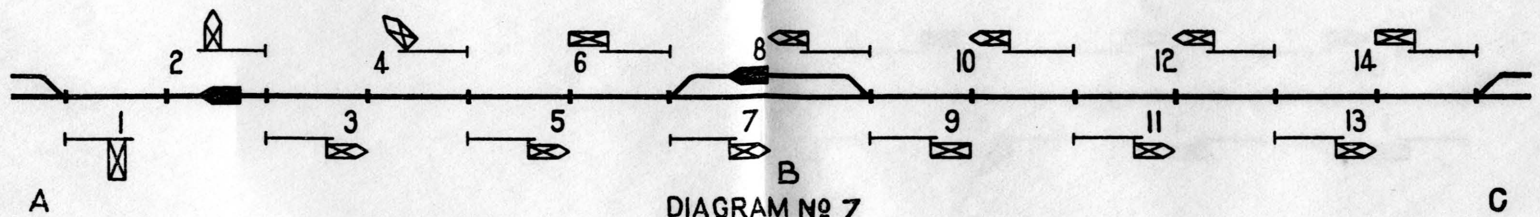


DIAGRAM Nº 6



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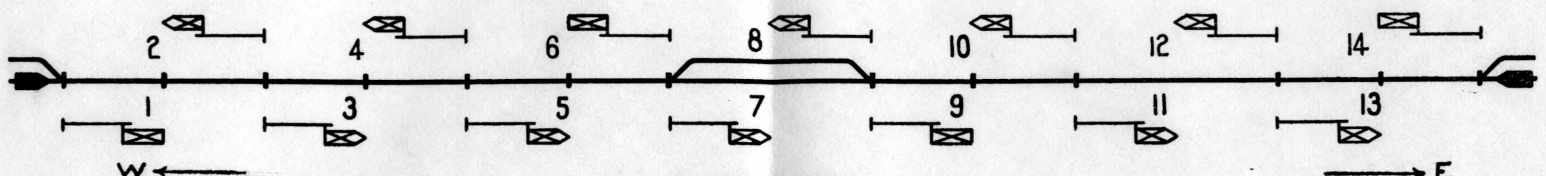

DIAGRAM Nº 8

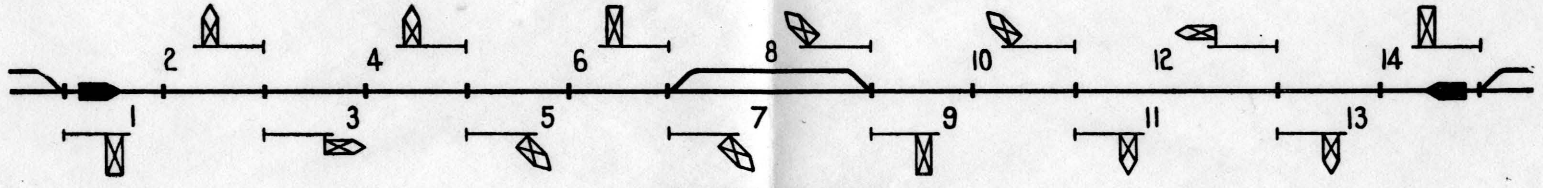

DIAGRAM Nº 9

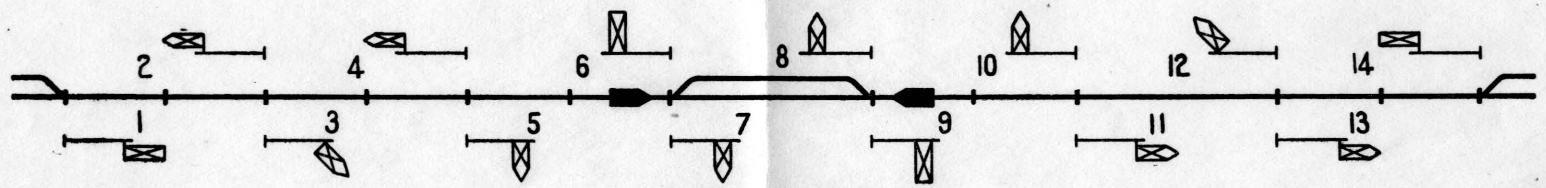

DIAGRAM Nº 10

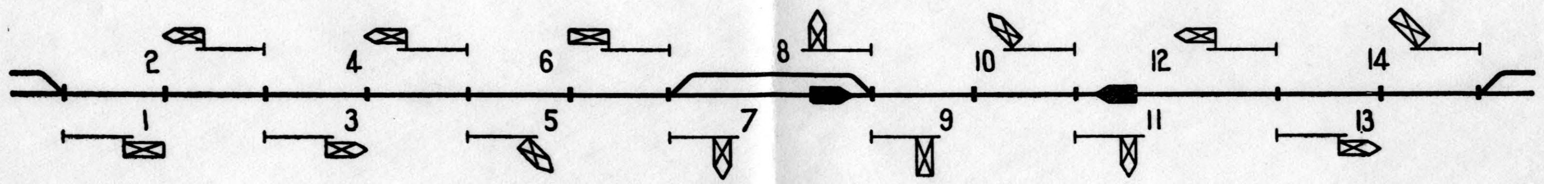

DIAGRAM Nº 11

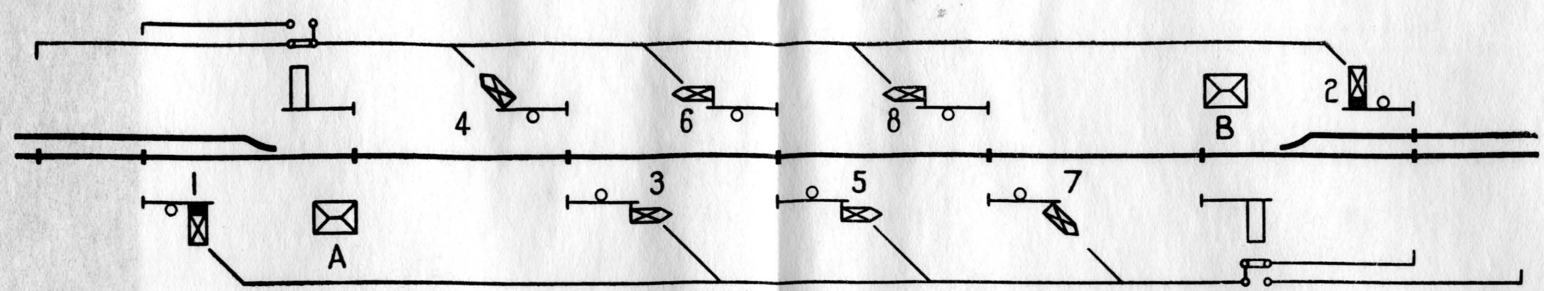

DIAGRAM Nº 12 INTERLOCKING PLANT AT END OF DOUBLE TRACK

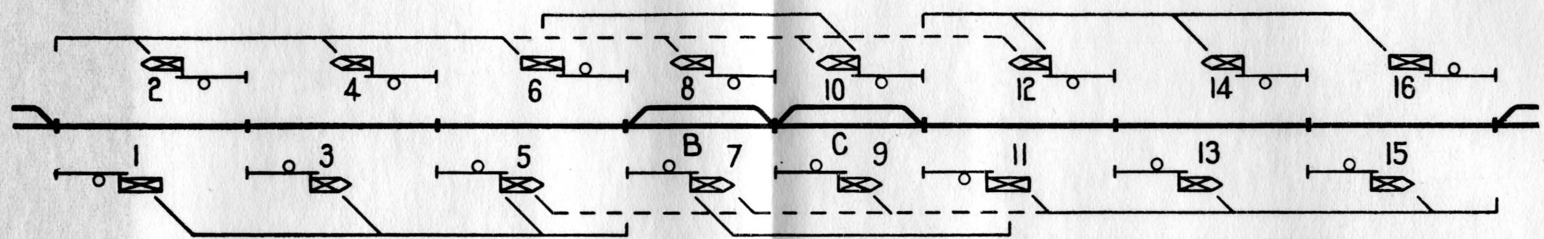

DIAGRAM Nº 13 DOUBLE SIDINGS

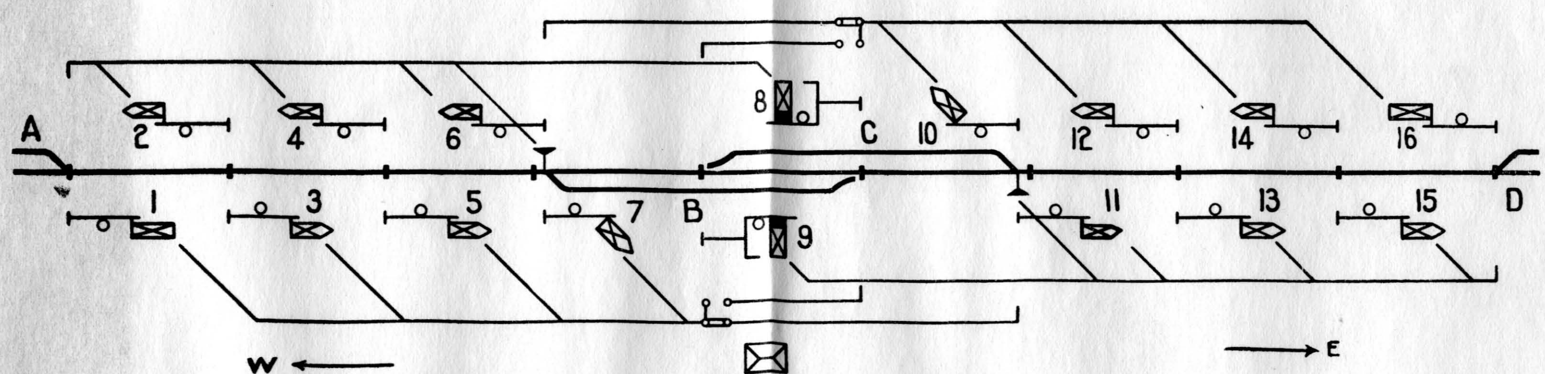

DIAGRAM Nº 14 LAP SIDING

A. P. BLOCK SYSTEM

for

SINGLE TRACK STEAM RAILROADS

GENERAL RAILWAY SIGNAL COMPANY

ROCHESTER, N.Y.