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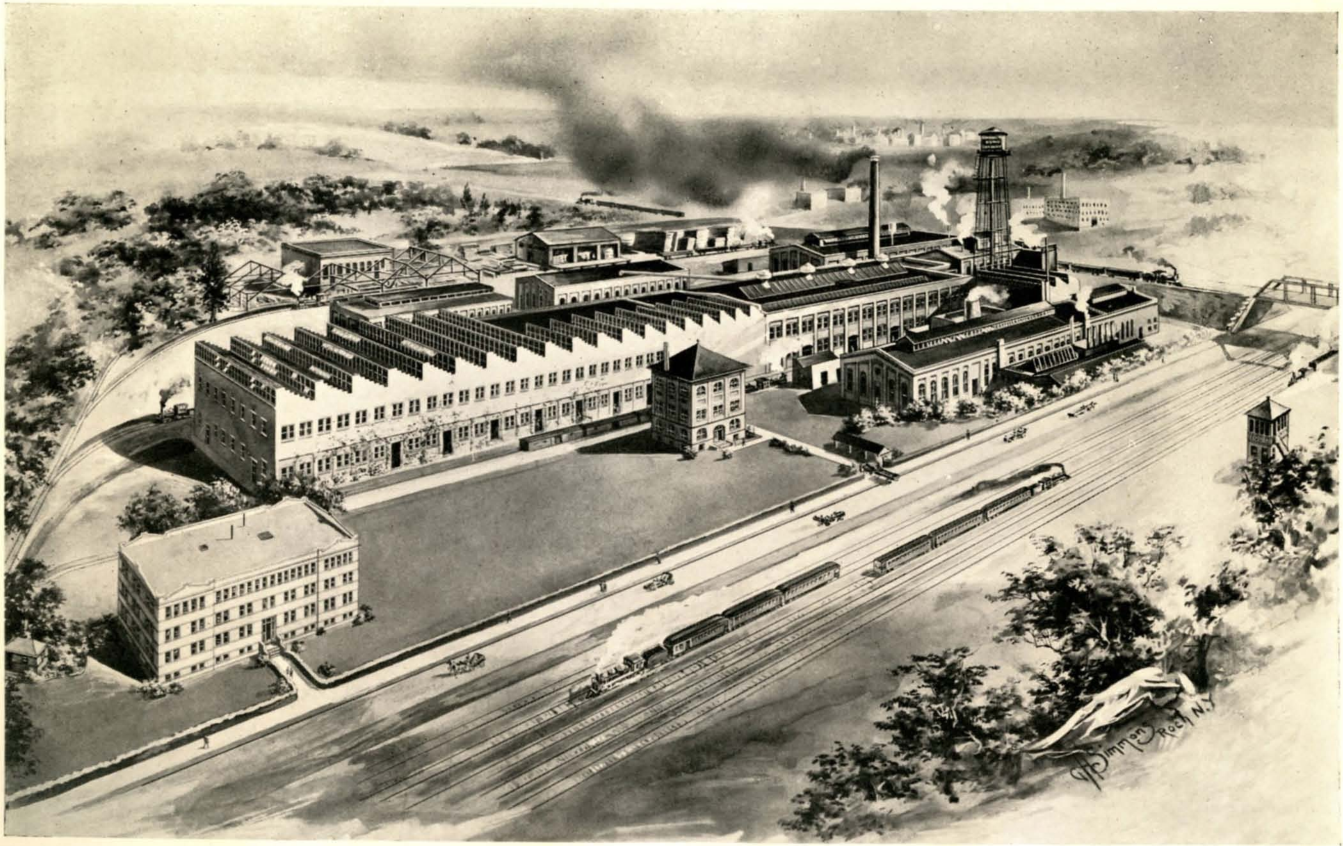
Automatic Signaling *for* Electric Railways



OFFICE AND FACTORY OF GENERAL RAILWAY SIGNAL CO., ROCHESTER, N. Y.

Automatic Signaling
for
Electric Railways

By
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IN presenting this paper to your notice, we desire to call your particular attention to the ABSOLUTE-PERMISSIVE-BLOCK system described on *pages 28, 29 and 39.*

This provides the *absolute* protection essential to safety in opposing traffic movements and the *permissive* following movement required with dense traffic, especially that in which the density is of one direction during one period of the day and in the opposite direction during another.

We are prepared to furnish signals of the type illustrated on *Page 39*, and will be glad to furnish full description and prices on application.

We have inserted an inquiry form which we would be pleased to have you fill out and return to us if, at any time, you are considering the installation of signals on your lines.

GENERAL RAILWAY SIGNAL COMPANY.

Rochester, N. Y.
March, 1911

Automatic Signaling for Electric Railways

I have been honored with a request to give an address before your association on the subject of signaling as applied to electric railways.

The following paper has accordingly been prepared, the writer having in mind especially those gentlemen who are studying such problems with a view to determining upon some adequate form of signaling for the electric railways in which they are interested: If any portion seems to be too elementary, I trust you will bear in mind that I have been urged to so treat the subject, having been advised that certain of the matters to be discussed while familiar to many steam road men on account of their having used automatic block signals extensively, are unfamiliar to many electric traction men.

In view of the fact that the phenomenal growth of interurban electric traction has brought such lines to a point where their operating problems are comparable in many respects with those of steam roads, it seems fitting that the principles which are employed on steam roads in the operation of trains, and which have been found by long experience to be safe and reliable, should have careful consideration in connection with the problem of interurban signaling which you are seeking to solve.

Before proceeding to a discussion of that type of signaling which it is believed will most nearly meet interurban requirements, let us briefly review the history of the movement of trains by signals and otherwise.

For the purpose of this paper it is unnecessary to review the origin and development of the methods used in the movement of trains prior to the time of adopting the controlled space interval which superceded the indefinite and uncontrollable time interval method formerly used.

The space interval method as its name suggests consists in maintaining a definite space or distance between trains and was named the **block system,** it may be divided into three classes, viz: the Manual, the Controlled Manual and the Automatic.

The **manual block** system may be defined as one in which trains are controlled by signals operated manually, upon information received by telegraph, telephone or other means of communication. It consists of a series of block sections with a block control station at each end of each section, at which there are placed signals to be used by the operator to control the trains in entering and using said block. In the operation of this system, information concerning the condition of a given block is obtained by communication between the operators at the ends of said block, and trains are instructed as to movement by means of the signals.

The various block operators in a given district are under the general supervision of a train despatcher from whom orders are received governing the irregular movement of trains, etc.

The safety of operation under the manual block system depends upon the accuracy with which orders are received and transmitted, there being no check either electrical or mechanical to prevent the display of a wrong signal. Errors in receiving or transmitting orders or information relating to block operation have resulted in some very serious disasters.

While it is true that many thousands of miles of single track steam roads are to-day being operated under the manual system with fairly satisfactory results, it is obviously out of the question on electric roads on account of the comparatively great number of passing points and the consequent expense were operators to be maintained at such points. Furthermore there remains the entire dependence upon the human element which is greatly reduced in other systems.

The **controlled manual block** is the same as the manual block just described except that the signals at the ends of each block are electrically interconnected in such manner that co-operation of the signalmen at both ends of the block is required to display a clear signal. The co-operation referred to is the physical moving of certain levers in a predetermined manner and is in addition to, and affords a valuable check on, co-operation by communication only, as in the purely manual system. It is a great improvement over the manual system but still does not prevent two operators from making simultaneous error. This is overcome by the use of the **continuous track circuit** so arranged that a train having entered a block it will automatically put the proper signals to stop and hold them there until the train is entirely out of the section regardless of any attempt on the part of the operators to clear them.

The controlled manual system has been largely used on steam roads and is regarded as a safe and flexible method of handling trains, especially on single track lines with a mixed traffic. Its use on many electric lines is prohibited on account of the large expense involved in maintaining operators at such frequent intervals.

Another form of controlled manual block is the so-called **staff, tablet or token** system which has been applied only to single track lines. In its operation no train is allowed to occupy a block section without the possession of a tangible object or token such as a staff, ball or tablet. The tokens are obtained from instruments located at the opposite ends of each block which are so interconnected, electrically, that but one token can be removed at a time, and until this one has been replaced in one instrument or the other no additional token can be withdrawn from either. Therefore, as but one token can be absent from the pair of interconnected instruments at one time, and as the possession of a token is the trains authority to enter a block, it is evident that there can be but one train in a section at a time except where permissive blocking is used, in which case the tokens are made in pieces, each train taking part of a token the last train taking all that remains. When therefore this divided token is put together and deposited in the other instrument another token can be withdrawn from either instrument etc.

The strong feature claimed for this form of controlled manual blocking is that it requires the train crew to take part in the operation and gives the engineman tangible evidence of his right to the block.

Its drawbacks are that thus far it has required the train to stop to deposit and withdraw the tokens or else requires operators at each passing point to receive and deliver them.

The use of this system has made very slow progress as shown by the fact that up to January 1st, 1910, only 270 miles of railroad were being operated by it in the United States whereas the automatic system to be described later has gone ahead with leaps and bounds.

It cannot be considered the equivalent of the track circuit for the reason that a train can enter a block without a token and not indicate its presence to an opposing train, whereas with the track circuit a train cannot enter a block without doing so. Furthermore broken or removed rails or a car in or fouling the block cannot be indicated by the staff without the track circuit: It is therefore believed that this sytem as it stands to-day is not well adopted to high speed electric traction. It may be considered where station stops can be made coincident with passing points although even under such conditions if the car must slow down or stop to obtain its authority to enter a block it can just as well do so to read signals which in such event can be miniature affairs and therefore very inexpensive, so that even with slow speeds it may still be a question whether or not the automatic system with track circuits may not prove best.

Still another method of controlling trains although not a block system is the **despatcher's signal system** in which signals located at the various passing points are under the direct control of the despatcher, and are used to stop trains for the purpose of giving them orders. With modern selective systems, signals of this kind can undoubtedly be operated with a high degree of accuracy and be made to give a return indication that the desired signal has been set. They have not however been successful in all cases and furthermore, the despatcher has no check on the trains and cannot be absolutely sure that the train had not passed by the signal he proposes to set, unless the trains are required to stop at every signal, which would be out of the question on most lines on account of the delay occasioned thereby. Furthermore there is a liabilty of changing a signal from clear to stop in the face of a high speed train which is undesirable. Even though these defects could all be overcome there still remains the objection to any purely manual system that, safety depends on human agency alone. Any error in transmitting or receiving orders may result in disaster as has too often been the case. In view of the above it would not seem advisable to depend entirely on such a system except as supplementary to an automatic system and for the purpose of stopping trains to give them orders.

In the **automatic block system** signals are provided governing the entrance to each block, said signals being automatically controlled by the trains as they proceed, in such manner that full head-on and rear-end protection is afforded.

Different forms of the automatic block system have been and are being used. Their essential difference comes in the manner in which the control of the signals by the train is effected. The wheel contact method using **track instruments** was at one time used by some of the steam roads but later abandoned in favor of the track circuit. **Trolley contacts** are being used by a number of electric lines at the present time with more or less success. Short track circuits at the entrance to each block have also been used. It is not however my intention to discuss these intermittent types of signal control, but rather to confine myself to that class in which the signals are automatically controlled by the continuous track circuit which is the only method embodying the fundamental principle of a car or train controlling, *at all times*, the signals governing the specific portion of track occupied.

Statistics taken from the *Railroad Age Gazette* show that there are now in use in the United States over 17,000 miles of railroad employing the continuous track circuit for the control of signals; that during the year 1910 an increase of over 3,000 miles was made in automatic block signaling as against about 450 miles of all other forms and that in some instances roads have replaced older forms of signaling with the automatic block. This seems to be the tendency of the time and is an eloquent testimony to the safety and reliability of the continuous track circuit as a medium of control.

Some of the advantages of the automatic block signal system using the track circuit as applied to interurban lines are as follows:

No operators are required at passing points hence it is comparatively inexpensive to operate.

It does not place dependence for saftey on human agency alone but makes the train itself master of the situation the entire time any portion of it is occupying such block.

The certainty of the indications given are independent of the train speed.

The proper signals will indicate stop under any of the following conditions: A train or a car of any description anywhere in the block or fouling it; an open switch or drawspan; a broken or removed rail; any failure of the signal power; or the breaking or crossing of the connecting wires.

An eminent authority on signaling in speaking of automatic signals says: "The sections can be as short or as long as the traffic demands; they are always on duty days, nights and Sundays, without any additional pay; they are reliable and quick of operation, and can be fixed in inaccessible places, such as deserts, on mountains, in tunnels and on bridges where operators could not easily be located; and finally they bring with them all the advantages that come from track circuits and are generally interlocked with the sidings and other points in the section."

The main objection to automatic signaling for many electric lines has been the high initial cost. Apparatus and systems have however been recently developed, which, while maintaining the same degree of safety and reliability that is found on the steam roads of to-day, are much less expensive; in fact automatic block systems employing the track circuit are now available at a cost which should appeal strongly to many of the electric lines. In view of these and other facts the automatic block system with continuous track circuit is confidently recommended to our electric railways as the best known means of providing for the safe and expeditious operation of their lines.

Having briefly discussed the various methods which have been and are being used for the control of train movements and having settled upon the automatic block signal system as the best adapted to the needs of electric lines in general and high speed lines in particular, let us now turn to a discussion of its distinguishing feature, namely, the track circuit.

The track circuit as its name indicates is nothing more than an electric circuit of which the track rails are made to form a part. Figs. 1 and 2 have been prepared to illustrate the fundamental principles involved in all track circuits.

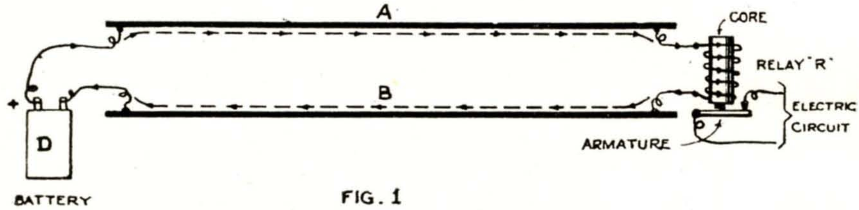

FIG. 1

Referring to Fig. 1, A and B represent a pair of rails connected at one end to an electric battery D, and at the other end to a coil of wire placed around the iron core of a relay R. When so connected the current from the battery D will flow over the rails and around the iron core of the relay as shown. The iron core will thereby become a magnet and attract to it the hinged armature which is also made of iron. The armature, acting as a switch, will cause a secondary electric circuit to be closed as shown, which in turn will permit a flow of current to take place through any device, such for example as an electric lamp, which may be connected to this secondary circuit, and thereby cause it to light.

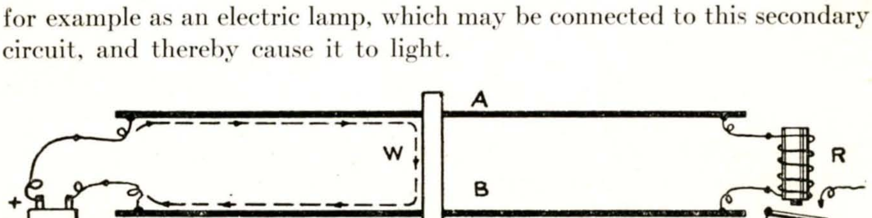

FIG. 2

In Fig. 2 is shown a metal bar W placed across the rails to represent the metallic connection which the wheels of a train make between the rails. It will be noted that the current from the battery D now flows through bar W as shown by the dotted lines and does not flow through the relay R. The core will thus become demagnetized allowing the armature to drop by gravity, opening the secondary circuit thus causing the current to cease therein and extinguishing the light. In lieu of a light a motor operating a semaphore could be used so arranged that the latter would be raised or drop depending on whether the bar W was across the rails or not.

It is believed that with the explanation above anyone, even though unskilled in the art, can see how it is that a train proceeding along the track and passing from one section of rail to another can be instrumental in causing signals to be properly displayed behind it.

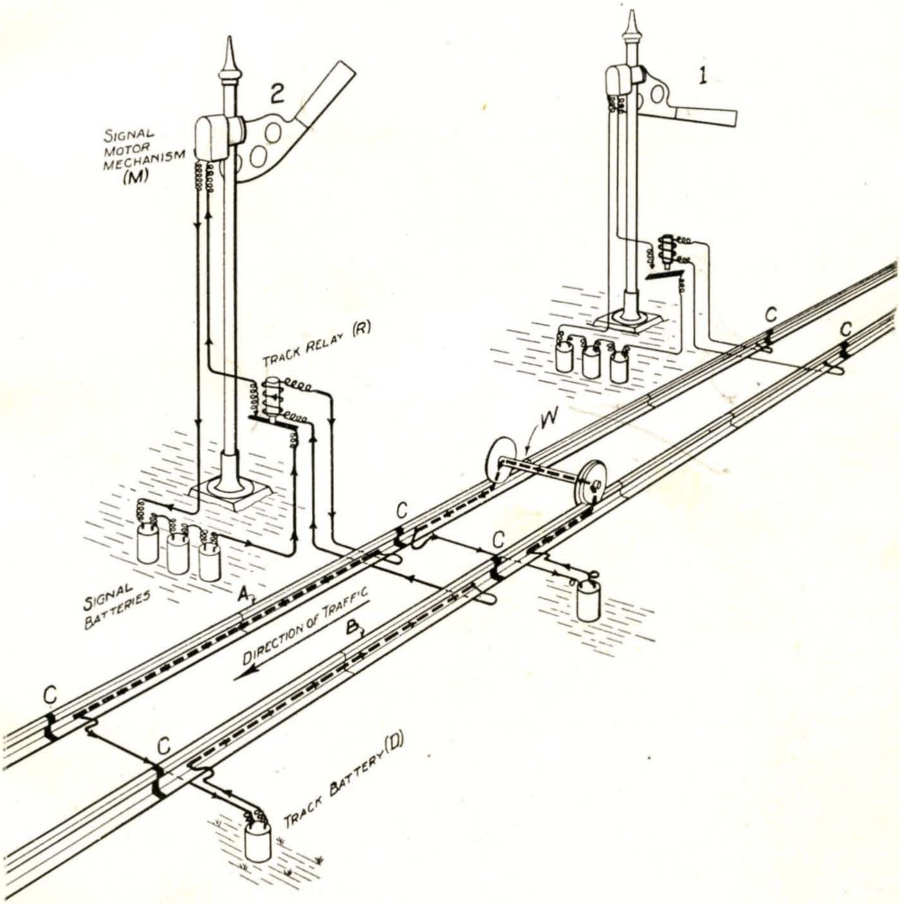

FIG. 3

To make this still clearer Fig. 3 has been prepared which shows in perpsective a section of railroad track with two signals numbered 1 and 2 and with the necessary batteries, relays, etc., required for their control. It is to be noted that each rail is electrically separated by insulating rail joints C, C, etc., placed opposite each signal and also opposite track battery D. These are for the purpose of dividing the track into electrically independent sections. It will further be noted that a track battery, as at D, is connected by wires to the rails at one end of each section and the coil of a relay, as at R, to the rails at the other end. It will also be seen that the secondary electric circuit partly shown in Figs. 1 and 2 is now shown complete leading from a set of signal batteries through the track relay armature and the signal motor mechanism H. In the place of the bar W in Fig. 2 is shown a pair of wheels W representing a train. Owing to the presence of the wheels, the relay for signal 1 is held open with the result that no current can flow from the signal batteries into the motor mechanism for that signal and therefore the semaphore will drop by gravity to its horizontal or **stop** position indicating to a following train that another train W is in the block ahead. There being no train in the block ahead of W the relay for that section will receive current over the rails from battery D, will cause its armature to close the motor circuit which in turn will cause the motor to rotate moving the semaphore to the clear or **proceed** position as shown, thereby indicating to train W that the block ahead is clear.

Thus it is that by means of the continuous track circuit and signals controlled thereby, trains are enabled to automatically protect themselves putting signal after signal at stop and allowing them to clear up only when the train is under the protection of another signal.

Signals are frequently controlled not only by their own immediate track circuit but by others in advance; this is effected by means of line wires running from one signal to the next and broken through separate contacts on the track relays of the various sections involved.

A signal may also be controlled by another signal in advance by means of line wires in such a way that its semaphore cannot move to the vertical position indicating proceed until the signal in advance has moved to or beyond the inclined or 45° caution position. Thus one signal can give advance information to an approaching train, of the position of the next signal. In fact an endless variety of combinations can be made to suit varying needs.

Signals can be spaced any distance apart up to several miles and still have continuous track circuit control. If they are too far apart for one track circuit, two or more may be employed one controlling the other in such way that the signal will be held at stop till the train has left the last track circuit in the series. When two or more track circuits are employed in this way we speak of them as **cut sections.**

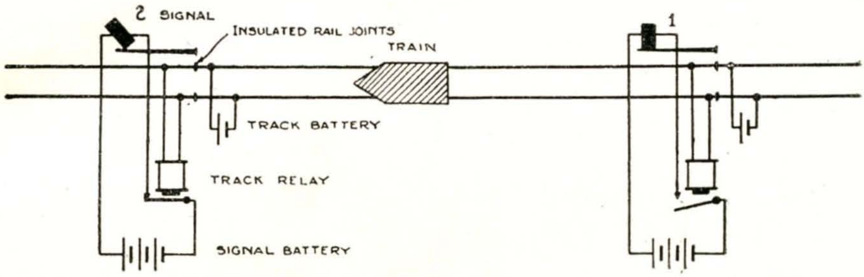

FIG 4

Usual way of showing track circuits, etc. in drawing circuit plans.

In preparing signal circuit plans the track circuits, etc., are shown as in Fig. 4, symbols being used for the various parts as indicated.

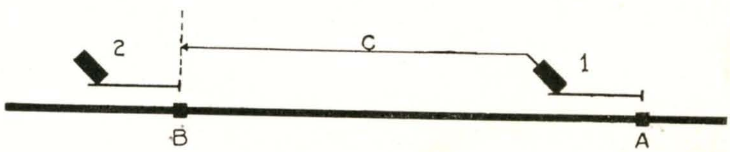

FIG 5

USUAL WAY OF INDICATING TRACK CIRCUITS WITH REFERENCE TO THE EXTENT OF SIGNAL CONTROL

When it is desired to draw up plans showing how signals are to be controlled, simplified diagrams as shown by Fig. 5 are used. The line C indicates that signal 1 will remain at stop as long as any part of a train is on the track section AB.

Thus far the illustrations have shown the rails divided into sections by insulating joints in such manner that they could not serve as a return for the propulsion current were the cars to be electrically propelled. To provide for this and at the same time keep the various block sections electrically independent for signaling purposes, reactance bonds T, T are used, connected across the rails and to each other as shown in Fig. 6.

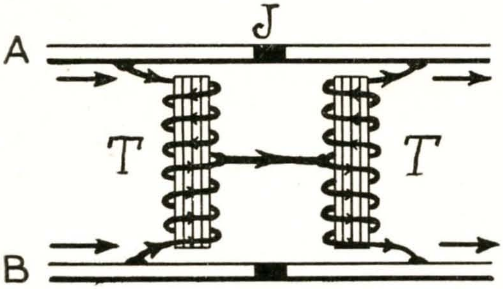

FIG. 6

These reactance bonds consist of a few turns of a very heavy copper wire wound around a mass of laminated iron something after the fashion of a transformer. When connected as shown in Fig. 6 the traction current flowing down both rails in the same direction passes through the bonds in such manner as to have no magnetic effect on the iron core, whereas when the alternating current (which is now used in place of the track battery current) tries to flow through the bond from rail to rail it encounters a comparatively high resistance which in turn causes some of the current to flow through the track relay which is of course connected across the rails exactly as in Fig. 3, a track winding (secondary) on a transformer being connected across the rails at the other end of the section to supply current in place of the track battery. In as much as alternating current is available for the track circuit it is also used to light and operate the signals.

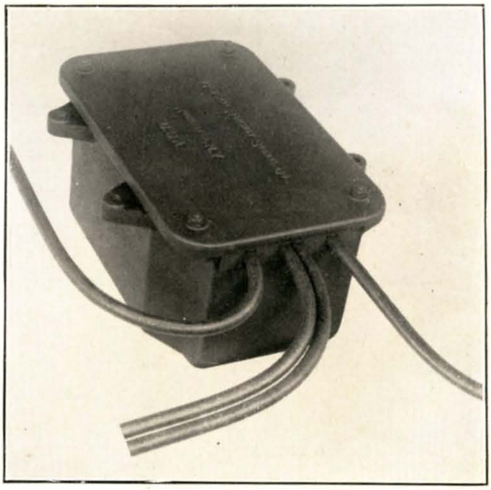

Figure 7.
Reactance Bond.

Fig. 7 is a picture of one of the bonds shown at Fig. 6. Fig 8

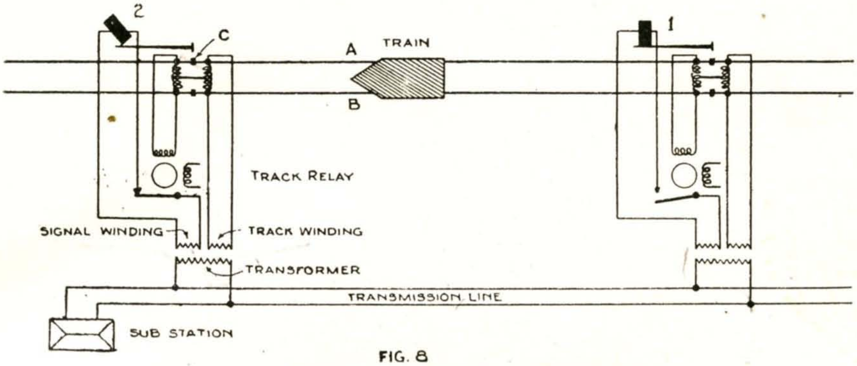

FIG. 8

Usual way of showing A. C. Track Circuits, etc., in drawing circuit plans.

is a typical circuit showing a track circuit, signal, etc., operated by alternating current obtained from substation, transmitted along the right of way at high voltage and stepped down at the various signal locations to the voltage required for the signals, etc. Fig. 9 shows the general appearance of an alternating current track relay; Fig. 10 one of the small transformers used as shown in Fig. 8; and Fig. 11 illustrates a semaphore signal with its signal motor mechanism. My object in illustrating Figs. 7, 9, 10 and 11 is to give you an idea of the general appearance of the essential devices used in electric traction signaling.

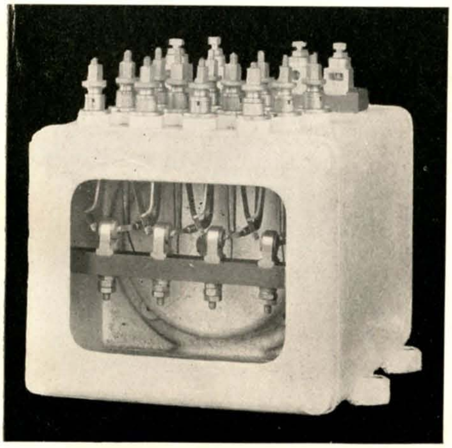

Figure 9. A. C. Relay.

Figure 10. Transformer.

Figure 11. Model 2A, A. C. Signal

Those who may wish to go more deeply into the subject of alternating current track circuits are referred to an address given by the writer before the Railway Signal Association in New York on June 8th, 1909, which will be found in the various railway publications of about that date.* In this address it was stated that track circuits of the type illustrated in Fig. 8, where the traction current is D. C., could be operated up to 2,000 ft. in length whereas now, due to the various improvements made since then, track circuits over two miles long can be operated without cut sections and with reasonable energy consumption where the ballast is good, as shown by Fig. 12. Under like conditions by feeding energy in at the center of the section and using a relay at each end, track circuits approximately five miles long can be operated. Track circuits of this kind are known as center fed circuits. It will interest you to note the effect of ballast on the permissible length of end fed track circuits as shown by Fig. 12 which shows the energy required from the substation for track circuits of various

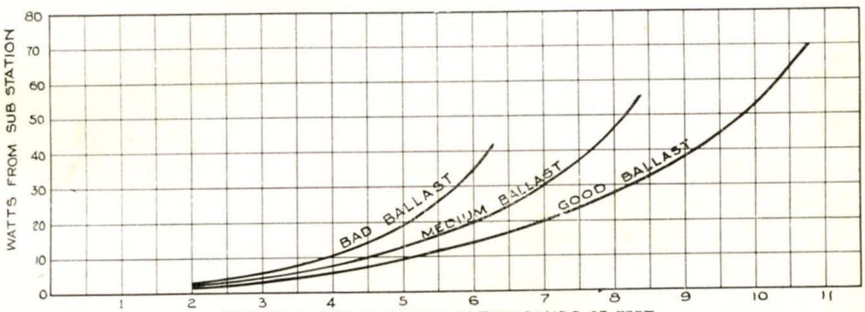

FIG. 12
APPROXIMATE POWER CURVES FOR END FED DOUBLE RAIL TRACK CIRCUITS

lengths. With ballast such as occurs when the rails are buried in wet earth or when cinders are used brought up around the base of the rail and are wet the permissible track circuit length is roughly 6,000 ft. With medium ballast such as wet gravel, etc., the length is about 8,000 ft. and with good rock ballast kept away from the base of the rail even when wet the track circuits can be upwards of 10,500 ft. in length. In figuring track circuits we always consider the worst conditions, viz: when the ballast is soaked after a continued rain. You will of course understand that the curves shown in Fig. 12 are approximate as conditions will very widely

* Reprinted as bulletin No. 116.

depending on the size of rail, amount and nature of propulsion current, frequency of the alternating signal current, etc. The curves shown are based on the use of 80 lb. rail and a signaling current of 25 cycles.

Having now told what the track circuit is, how it operates and what must be done to adapt it to electric railroads, I wish to direct your attention to the following miscellaneous facts in regard to its use on electric traction lines:

On account of the greater amount of available power and the absence of all batteries, track circuits operated by alternating current are even more reliable and require less attention than the battery operated track circuits on steam roads which is saying a good deal.

In answer to the question as to the effect of poor rail bonding on the operation of track circuits would state that any condition of the bonding that should be tolerated from a traction standpoint is good enough for the operation of signals. What to a traction return would be equivalent to an open circuit would not be noticeable in a track circuit. Reports received from a number of electric traction signal systems covering a number of years show very little trouble due to this cause.

In view of the fact that alternating current must be used for the track circuits and hence a transmission line must be run anyway to distribute said current for such purpose, the various signals, relays. signal lights, switch lights, etc., should also be operated from the same source thus avoiding all batteries and reducing the operating charges to a minimum.

The track circuit is an essentially simple arrangement, easily understood and readily installed and cared for. It is unexcelled as a safe and reliable means of control.

On electric lines using alternating current for propulsion, a signaling current having a different characteristic from that of the propulsion current is used and relays provided which are responsive only to such signaling current and not to the traction current. The track circuit and other apparatus would be arranged in most respects as shown in Fig. 8 the only exception being that the track relay will take all of its energy from the rails instead of the most of it locally as in the case of direct current propulsion. The reactance bonds would be smaller as the propulsion current to be carried is less. The cost of such a system would be somewhat higher than with direct current propulsion on account of the greater number of cut sections that would have to be employed.

It is possible to operate track circuits, where A. C. propulsion is used, by employing ordinary direct current batteries as shown in Figs. 3 and 4.

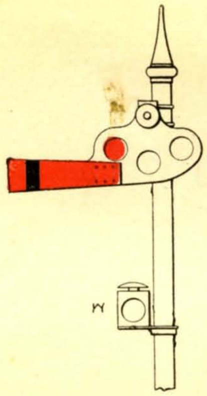

FIG. 13

STOP AND STAY

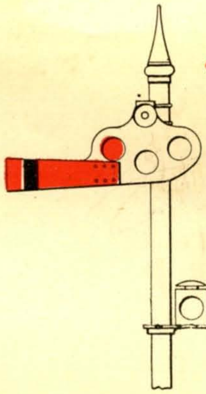

FIG 14

STOP AND PROCEED

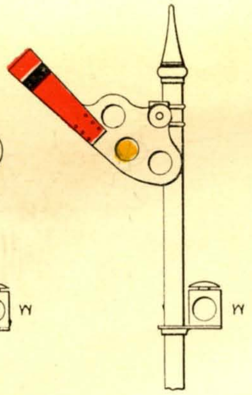

FIG. 15

PROCEED AT NORMAL SPEED PREPARED TO STOP AT NEXT SIGNAL

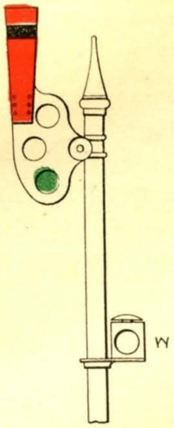

FIG 16

PROCEED AT NORMAL SPEED PREPARED TO PASS NEXT SIGNAL AT NORMAL SPEED

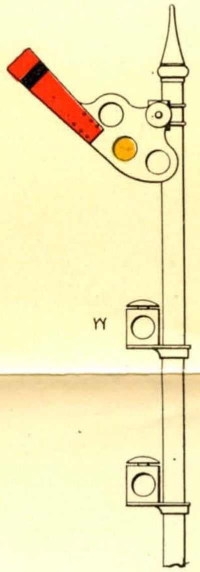

FIG 17

PROCEED AT NORMAL SPEED PREPARED TO STOP AT NEXT SIGNAL

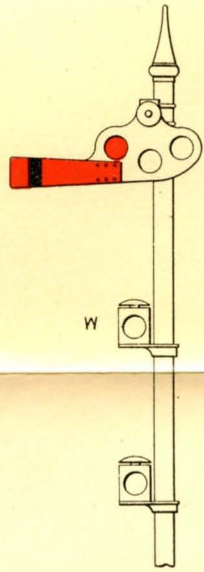

FIG 18

STOP AND STAY

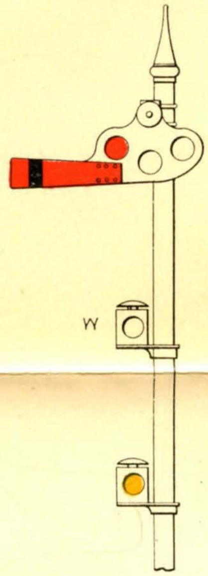

FIG 19

PROCEED BLOCK OCCUPIED

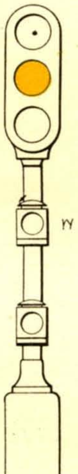

FIG. 20

PROCEED AT NORMAL SPEED PREPARED TO STOP AT NEXT SIGNAL

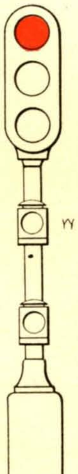

FIG. 21

STOP AND STAY

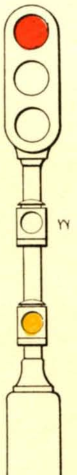

FIG. 22

PROCEED BLOCK OCCUPIED

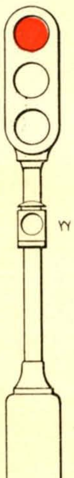

FIG 23

STOP AND STAY

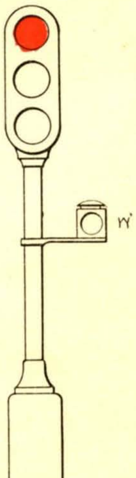

FIG. 24

STOP AND PROCEED

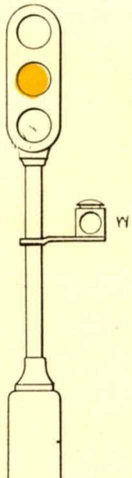

FIG. 25

PROCEED AT NORMAL SPEED PREPARED TO STOP AT NEXT SIGNAL

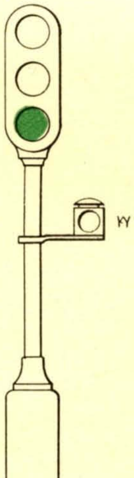

FIG. 26

PROCEED AT NORMAL SPEED PREPARED TO PASS NEXT SIGNAL AT NORMAL SPEED

In such event one of the rails would have to be abandoned for the propulsion current return and used for signaling only, the other rail being continuous for the propulsion current return. The relays would be of the ordinary direct current type with a copper shell around each magnet core thus making them unresponsive to such traction voltage as might exist between rails. The matter of using direct current apparatus as above suggested should be approached with great caution since there is liability of a large amount of foreign direct current being present where a rail is continuous from one end of the line to the other. This foreign direct current would be liable to falsely operate the track relay. An experience of this kind is familiar to the writer in which apparatus as described above was actually installed. It operated in a satisfactory manner as long as both rails were separated by insulators at each signal, but the minute one of them was made continuous for the propulsion current return, direct current appeared in such large quantities that the scheme had to be abandoned. In view of this situation it is believed to be inadvisable to attempt the use of battery operated track circuits on alternating current lines, not so much on account of what might exist at the time, as on account of what might occur in the future were direct current traction lines, for example, to be built in the vicinity of such alternating current lines.

Having briefly discussed the track circuits as the essential controlling factor, and which includes the transformer, the rails, the track relay and the reactance bonds as described, let us now consider the signal proper.

Signals for the purpose of this article may be divided into two general classes, viz., **absolute** and **permissive**. Absolute signals (stop and stay) are those which normally permit but one train in a block at a time except by special permission such as an order from the despatcher or another signal displayed in conjunction with the absolute signal, etc. Permissive signals (stop and proceed) are those which normally permit trains to follow each other into the same block under certain prescribed rules. Absolute signals are used to govern the entrance to a piece of single track which, of course, could not be used by trains in the opposite direction at the same time. Permissive signals are used to govern the movement of trains following each other.

Figs. 13 to 19 inclusive show a series of day and night indications in which an arm in the horizontal position, or a red light, always means stop; the arm inclined upwardly at an angle of 45°, or a yellow light, displayed above a white light always means proceed at normal speed prepared to stop at the next signal and a blade in the vertical position, or a green light, always means proceed at normal speed prepared to pass the next signal at normal speed. Furthermore; a yellow light displayed below a white light gives authority to proceed into an occupied block and is named a **call on signal** as* shown in Figs. 19 and 22. The white light next below the semaphore is used as a marker and to show whether a signal is absolute or permissive.† Lights in a vertical line indicate an absolute signal as shown by Fig. 13 and when staggered, as shown by Fig. 14, indicate a permissive signal. These signals are always so designed that the breaking of a glass cannot give a dangerous indication. This of course bars white for clear and requires the use of the distinctive colors red, yellow and green as explained. This color scheme prevents mistaking a foreign light for a signal. Furthermore these signals are so arranged that the going out of a light will not give a wrong indication with the exception of the signals shown in Figs. 19 and 22 where the absence of the lower yellow light will leave signals Figs. 18 and 21 respectively; but as these are stop signals no dangerous conditions can result. The use of the upward inclination of the blade in going to clear reduces the tendency for an accumulation of snow or sleet to hold the signal in the clear position which exists with the downwardly inclined signal blades.

A very important matter which has had consideration in planning this series of indications is to have them as few and simple as possible and to always have them indicate only one and always the same thing, so that the motorman can easily learn and remember what they mean, and further, so that they can comprehend their meaning the instant the signal is seen. The simplicity of the above scheme is apparent when compared with the practice on some steam roads where the engineer, in making a run, has to read over 100 different indications. The system of signal indications shown is the result of a prolonged and careful study of the subject made by prominent members of the Railway Signal Association.* It is safe, uniform and consistent and will meet practically all of the conditions to be encountered in automatic block signaling on electric lines. It is worthy of careful consideration by those having such matters in charge.

As interurban lines grow, as their equipment becomes heavier and their traffic denser, and as they become involved with the steam lines at crossings, junctions, etc., the need of uniform methods of signaling will become more apparent. The history of steam road signaling has been

* See appendix under aspects and indications.

† See appendix under marker lights.

largely "Every man for himself" in the matter of signal aspects and indications as well as in the apparatus required for their display, with the result that a great variety of devices have been made to accomplish the same thing, many of which are obsolete as a look at the stock rooms of any large signal company will eloquently testify. Were the steam roads to start over again there would be a very different story to tell and it is hoped that the electric lines will profit by their experience.

The signals shown in Figs. 20 to 26 inclusive are purely light signals corresponding as regards their day and night indications to the light indications of Figs. 13 to 19. By the use of large and powerful lenses and reflectors and by suitably hooding each light they can be clearly seen several hundred feet in the bright sunlight and of course very much further at night.* They are recommended where the speeds are moderate or where the trains can afford to slow up at all sidings. They are very simple and inexpensive as compared with semaphore signals, their only objection being that they cannot be seen so far in the day time. Their use for electric railway signaling is more justifiable than in steam road signaling for the same reason that siding signs are, as described elsewhere in this article. Light signals have the advantage as compared with semaphores in that there are no exposed moving parts to be interfered with by sleet, ice or broken wires.

Having briefly discussed the signal proper let us now consider some of the matters which should be observed in the location and control of signals in single track operation; first, with respect to the various sections of single track proper and second, with respect to passing points.

Each section of single track should be protected by absolute starting signals placed one at each entrance thereto, and so controlled that two trains approaching from opposite directions can never both get clear signals into the same block at the same time. This is accomplished by overlapping one signal by the other; that is to say by having the control of one signal extend beyond that of the other as shown in Fig. 34 for example. It will be noted that signal No. 2 will go to stop before a train approaching signal No. 3 reaches it, and that signal No. 3 will go to stop when a train coming from the other direction reaches signal No. 2. If now one train should pass signal No. 2 before an opposing train had reached the overlap for signal No. 2, the latter train would find signal No. 3 at stop and vice versa. The distance which the control for signal No. 2 extends beyond signal No. 3 is known as an **overlap**.

* For a further description of the light signal see appendix.

Before a proceed signal can be given into a piece of single track the opposing signal should be required to be at stop. This can be guaranteed by electrically interlocking opposing signals and by so designing the circuits and apparatus that no breaks or crosses between the line wires controlling such signals can by any possibility cause the opposing signals, which should be at stop, either to remain in, or be moved to, the proceed position. This can be accomplished in a very simple manner.

Now with regard to the arrangement of signals at passing points. It must be recognized at the outset that as conditions are at present there is a great difference between steam road and interurban electric railway practice as regards the weight, speed and make up of the trains moved, and hence as regards the braking distances which can be depended upon: That is, in the one case (steam roads) the signaling must be arranged to protect trains of widely varying weights and speeds—where as in the other (electric lines) both weights and speeds are practically uniform—and the signaling is correspondingly simplified. On account of this and other reasons to be named later, there is little doubt that for equal safety electric lines operating practically uniform equipments can dispense with some of the provisions necessary on steam roads.

On single track lines various arrangements at passing point are used, namely:—distant signals, staggered signals, siding signs or a combination thereof.

To take care of certain situations signals on single track work are frequently **staggered**, that is to say opposing signals are set at a certain distance from each other, as for example, signals 6 and 7 Fig. 29, and signals 5 and 6 Fig. 31. In this arrangement approaching trains stopping at their signals will have a predetermined space between them. The need for this separation becomes less as speeds become less and the equipment becomes more uniform and lighter and therefore the braking distance shorter and more uniform. It also becomes less as the distance at which seeing a signal can be guaranteed, is greater than the braking distance, or when distant signals or fixed siding signs are used to indicate the approach to, and the position of, the signal at the point of danger. The siding sign indicates to a motorman that he is approaching a danger point that is a definite distance away and that he must be on the lookout to see that the switches are properly set and no other trains are in the way. Siding signs are frequently set 2,000 ft. in advance of the danger point, are generally on a level with the headlight, close to the track and frequently very large and conspicuous. Furthermore the motorman is located in the extreme front of his car and has very little to do or think about except to observe his signals and control his car accordingly. There is therefore very little chance that siding signs will be missed; in fact the writer has been advised by a number of motormen with whom he has talked that they never have any trouble in seeing them, and that they are of great value in indicating the approach to a siding especially in foggy weather, etc. On steam roads there is a different set of conditions. Owing to the physical surroundings, siding signs can not be brought as close to the track, and then too the engineer has more things to think about in connection with his engine, is not located in the front thereof as in the case of the motorman, and the smoke from the engine may interfere with his vision. It is therefore believed that siding signs in electric traction work are a greater safeguard than they ever could be in steam road work.

The distant signal, performing all of the functions of the siding sign, is in addition an informant of the conditions at the point of danger. If clear the motorman knows that the way is clear and he can proceed at speed. If at caution he knows that he must apply his brakes ready to stop. It is a time saver especially in bad or foggy weather. It is very useful where the view of the home signal is regularly obscured. The distant signal says what to do and when to do it. The siding sign only says when to get ready to find out what to do. Distant signals if used should be fully automatic; that is they should go to stop behind a train and remain so until the train is under cover of the next signal in advance if there is ever any chance of a following train getting into the same block with another train. If the distant signal was not fully automatic and a train should be standing between it and the signal next in advance, a following train seeing a clear signal would have the right to run at full speed past such signal with the likelihood of an accident. To make a signal fully automatic a track circuit must be used as formerly described. A distant signal No. 15 is shown in Fig. 30. Figs. 14 to 16 and 24 to 26 show signals which can be used as a distant. Fig. 14 shows its position if a train is standing between it and the next signal ahead. Fig. 15 shows the position with no train between it and the next signal ahead but with said last named signal at stop, and Fig. 16 shows its position when clear. Signals 24 to 26 show an arrangement of light signals which can also be used as distants. The larger and more conspicuous the home signal becomes the less the need for a distant signal, especially where siding signs are used.

From what has just been said it will be evident that any degree of protection desired can be given and that the degree required depends on the braking distance, etc., as described: Furthermore as the requirements become more severe the expense will go up. For moderate speeds, or when traffic conditions permit slowing up on the approach to each passing point, the simple scheme using light signals opposite each other as shown in Fig. 27, with siding signs, will be found satisfactory and is the least expensive. The next thing in the scale of expense would be to stagger such signals as 1 and 2, Fig. 27 and the next, to use distant signals as shown at 2 and 3, Fig. 28, or use semaphore signals as at 1 and 2, Fig. 29, and so on up until the elaborate arrangement shown by signals 10 to 13 inclusive Fig. 30 is reached. In this connection it should be remembered that a starting signal into a given piece of single track, when clear, tells the motorman that said block is clear and that it is safe for him to proceed to the next signal only, and that he must approach said signal prepared to stop short of it. The motorman knows that an ample distance before he reaches the next signal a sign conspicuous in all kinds of weather, both day and night, will tell him of his approach thereto. If upon reaching this sign he is unable to distinguish the indication of the next signal he must bring his car under full control and continue under control until the indication of said next signal is visible; if clear he can resume normal speed and if at stop he will be able to come to rest before reaching it. With a full size semaphore, in moderately clear weather either day or night and when the view is unobstructed, a high speed electric car will be able to sight the signal in plenty of time to stop if said signal is at danger, it being necessary to slow down when the signal is clear, only when weather conditions obscure the view. With light signals, high speed cars would have to slow down in all kinds of weather hence such signals are only recommended where the speeds are moderate say about 30 M. P. H.

In view of the foregoing and other reasons it, is believed that on many electric lines it is neither necessary to stagger the home signals or use distant signals if the view of the home signal is unobstructed and if siding signs are used. If the locality is such that much bad weather prevails, or if the view of the home signal is obstructed by a curve, or if for any reason the view of the home signal is often obstructed, it would be economical to use distant signals.

In addition to the foregoing, the arrangement of signals at passing points is largely influenced by the nature of the siding as indicated in Figs. 27 to 30 inclusive. For stub end or short passing sidings two signals, with or without distant signals, will generally be found sufficient; but where long passing sidings are employed, as shown at the right hand end

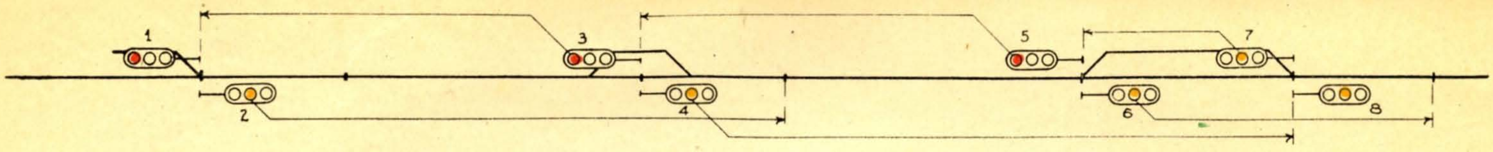

FIG. 27

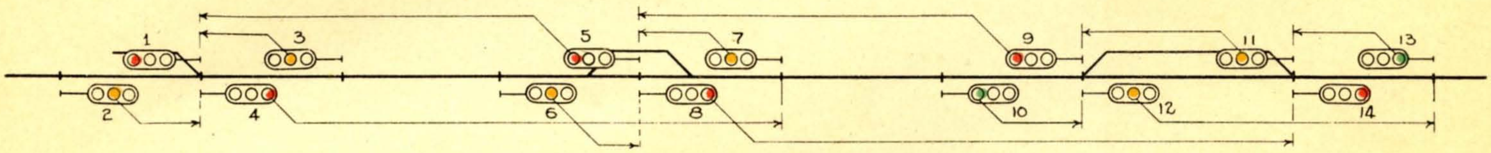

FIG. 28

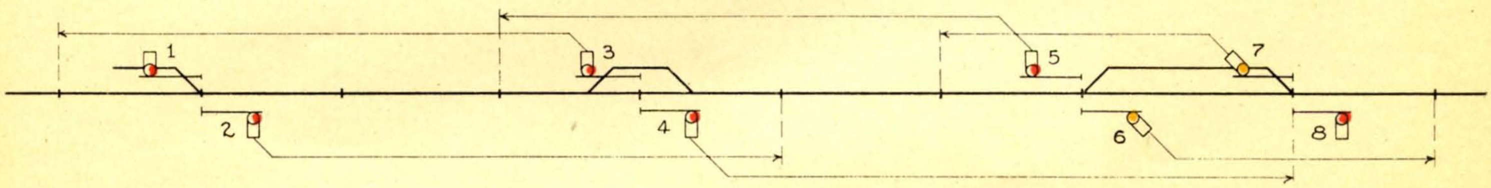

FIG. 29

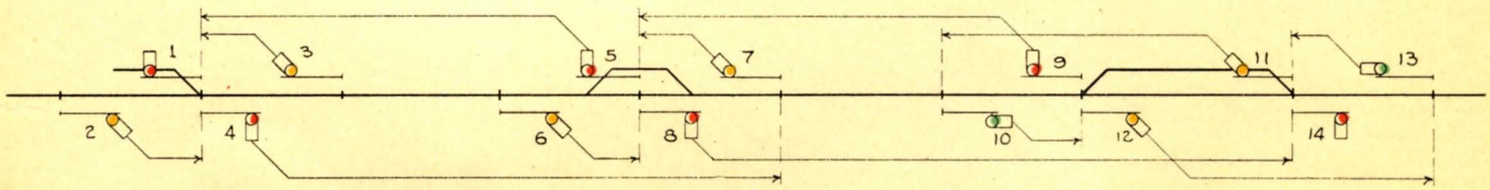

FIG. 30

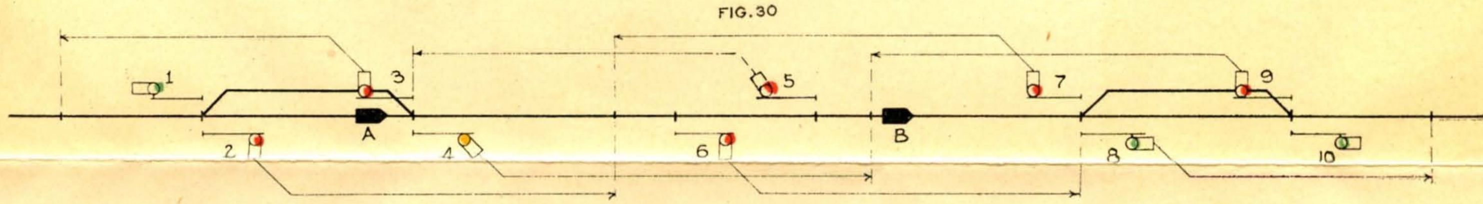

FIG. 31

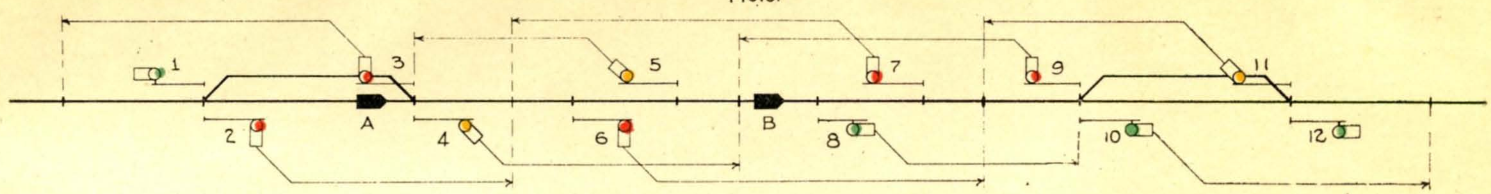

FIG. 32

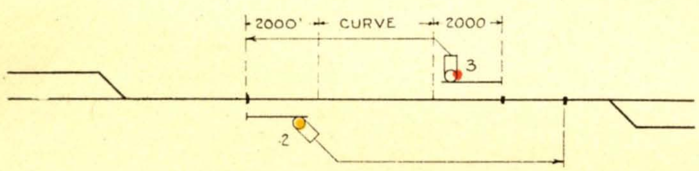

FIG. 33

CURVE PROTECTION

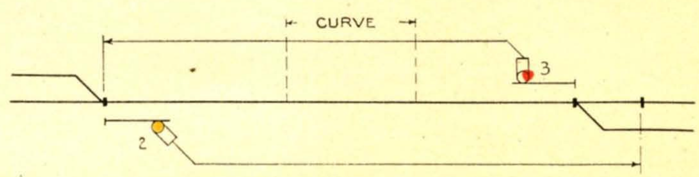

FIG. 34

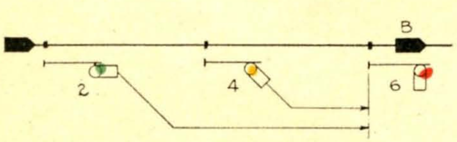

FIG. 35

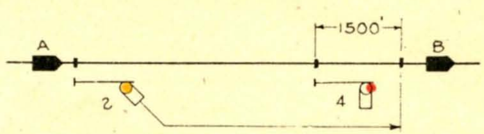

FIG. 36

DOUBLE TRACK SIGNALLING

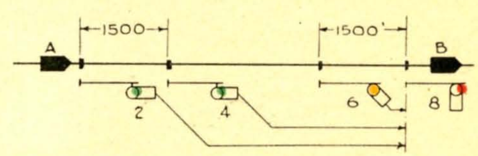

FIG. 37

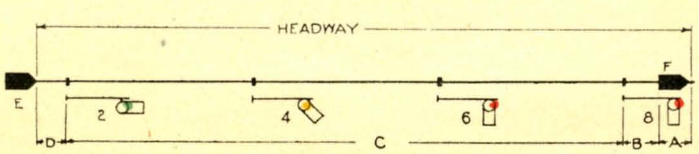

FIG. 38

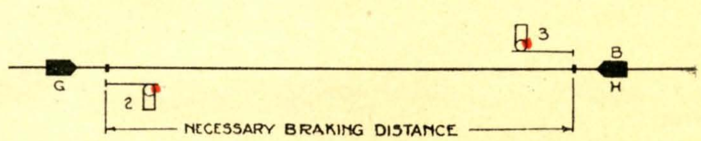

FIG. 39

of the figures above referred to, four signals, with or without distant signals, should be used. Incidentally, the practice employed by some roads of requiring cars to head in and back out is to be heartily commended from the standpoint of safety, insuring as it does the setting of the switch in the main line position.

Wherever spurs or sidings exist other than at regular passing points, they should be protected by switch indicators so arranged that they will show whether or not it is safe for a car to leave the siding, and so that all signals governing over the switch will be set at stop when the switch is thrown, indicating to any approaching train that the block is occupied.

All signals at passing points should be controlled by the switches in such manner that they will give the proper indications when said switches are opened and when closed.

Another important though generally overlooked consideration in determining the number and arrangement of signals and in fact the type of signal system to be employed, is the cost of stopping or slowing down high speed trains which is necessary with some systems in order to find out whether or not to enter the next block. It has previously been intimated in this paper that systems, initially less expensive than the track circuit automatic block system advocated, may be employed where trains are required to slow down or stop at all passing points. I refer to the staff system or an automatic system using miniature signals, etc. While it is true that such systems are comparatively inexpensive, it is a question if they could be justified, especially on high speed lines, in view of the higher car operating costs, loss of time, etc. Through the courtesy of an officer on one of the large interurban railway systems of the country, I have obtained the cost of stopping and starting an ordinary 40-ton car running at 40 miles per hour; this cost including power, brake shoes, wear and tear on the brake rigging and on the trucks. The cost of power was taken at $1\frac{1}{4}$ cents per kw. hr. Based on this information it was found to cost approximately 3 cents to make a stop. Assuming this to be correct and with a train movement of 20 a day each way, the cost per day at one passing point would be \$1.20 and per year \$438.00 which would pay the interest on an investment of \$8,750.00. For higher speeds and greater weights this would be more, and for slower speeds less; also if the train did not come to a full stop it would be less. Be this as it may, if my figures are anywhere near correct it shows conclusively that any system in which trains have to do much stopping for the sake of getting information as to the condition of the block, is a poor investment. Not only is stopping expensive but it means a loss of time. In the case cited above one minute was lost per stop. Where a road gives limited service, and where there are many sidings and only a few stops for the limited train, it would be a serious handicap to even slow up at the various passing points. The loss of time and money occasioned by the stopping or slowing down of trains is a subject which will bear further investigation and should have careful consideration by those who are contemplating the installation of signaling systems.

With the foregoing in mind let us pass to a discussion of the various signaling schemes shown in Figs. 27 to 49 inclusive, bearing in mind that in every case the lines indicating the extent of signal control mean that as long as any part of a train is occupying that section of track between the base of the signal in question and the point of the arrow, that the signal will remain at stop; that signals shown opposite each other may be staggered if neccessary; that the various schemes shown are based on the system of indications in Figs. 13 to 26 inclusive; that marker lights or their equivelent on the signals although not shown, would be used; that the continuous track circuit is used throughout as the means whereby the signals are automatically controlled by the trains and finally, that siding signs will be used governing the approach to each siding where there are no distant signals.

The various schemes shown may be divided into the following groups:

(a) Single track signaling in which following trains are spaced not less than the distance between passing points as shown by Figs. 27 to 30 inclusive.

(b) Single track signaling in which the spacing of following trains is less than the distance between passing points and is limited by intermediate signals as shown by Figs. 31 to 32.

(c) Single track signaling in which the number of trains follow each other between passing points is unlimited as shown by the Absolute-Permissive-Block system Figs. 40 to 49 inclusive.

(d) Curve protection for single track, see Figs. 33 and 34.

(e) Double track signaling, see Figs. 35, 36 and 37.

Taking up the various groups in the order given:

(a) In single track signaling where the traffic requirements will permit following trains to be held apart the distance between sidings or more, the scheme shown by Figs. 27 to 30 inclusive will be found satisfactory. All of the schemes of this group are absolute for both head on and following moves, that is to say if two trains approach the same piece

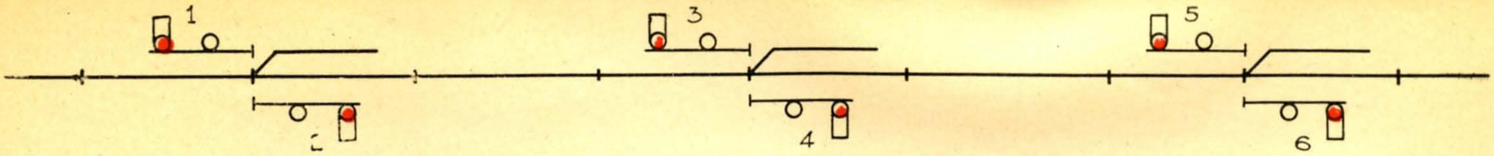

FIG. 40 NORMAL CONDITION

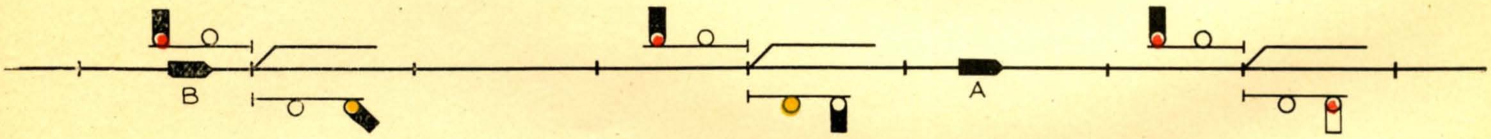

FIG. 41 TRAINS FOLLOWING UNDER CLEAR SIGNALS

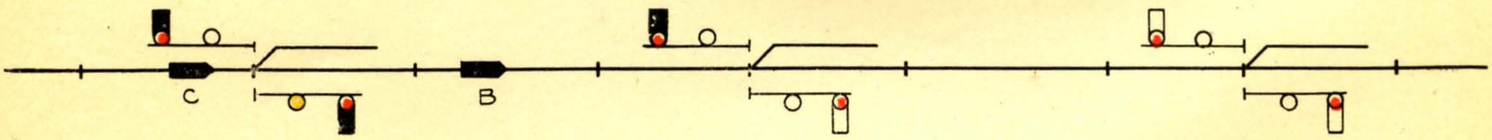

FIG. 42 TRAINS FOLLOWING UNDER CAUTION SIGNALS

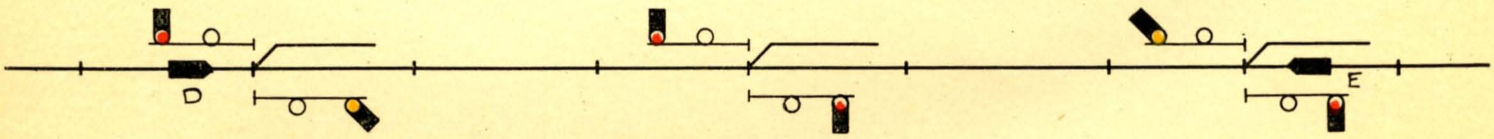

FIG. 43 TRAINS APPROACHING

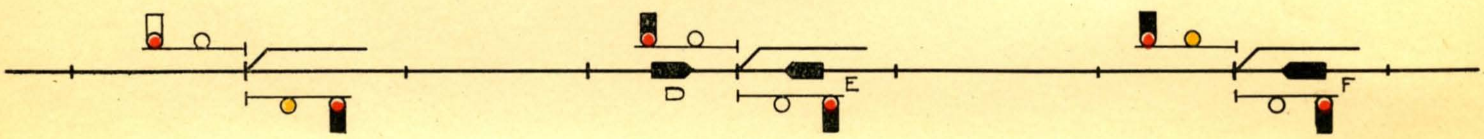

FIG. 44 TRAINS APPROACHING

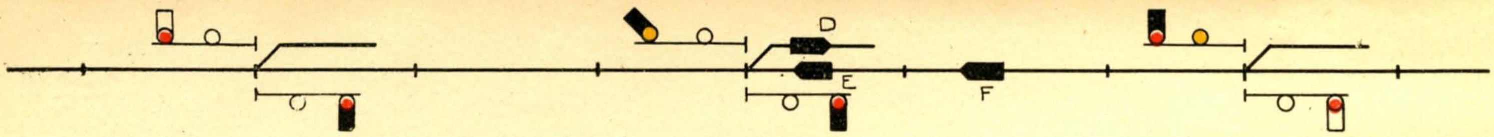

FIG. 45 TRAIN "E" PASSING, "F" FOLLOWING, D IN SIDING.

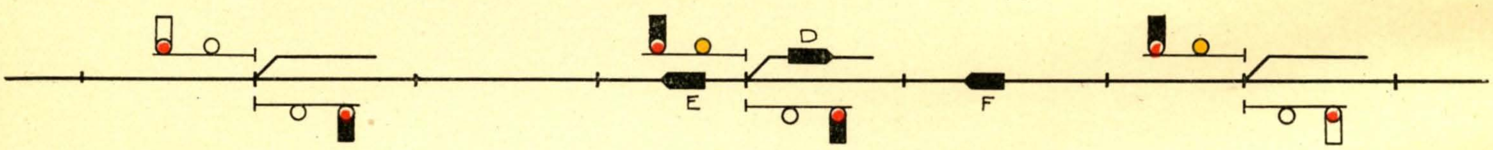

FIG. 46 TRAIN "E" PASSED, "F" FOLLOWING "D" IN SIDING

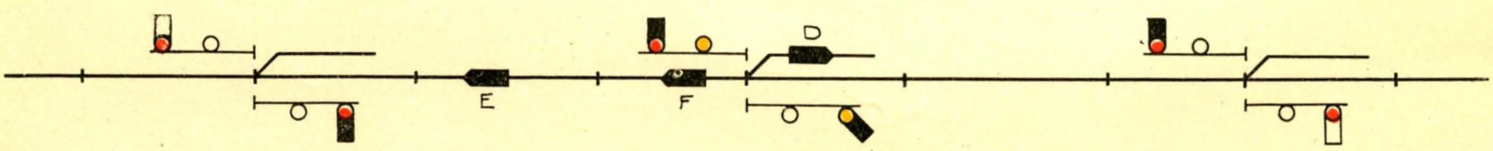

FIG. 47 TRAINS "E" AND "F" PASSED, "D" IN SIDING

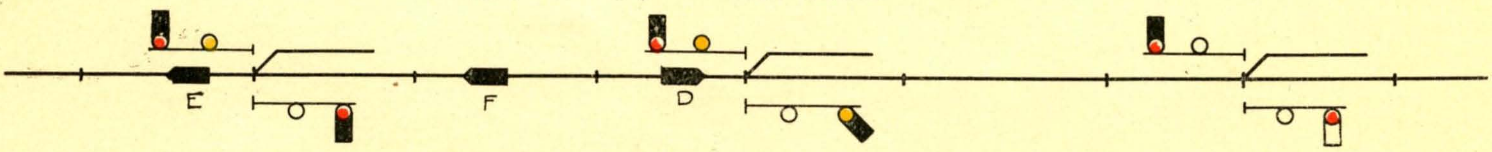

FIG. 48 TRAINS "E" AND "F" PASSED, "D" BACKED OUT READY TO PROCEED

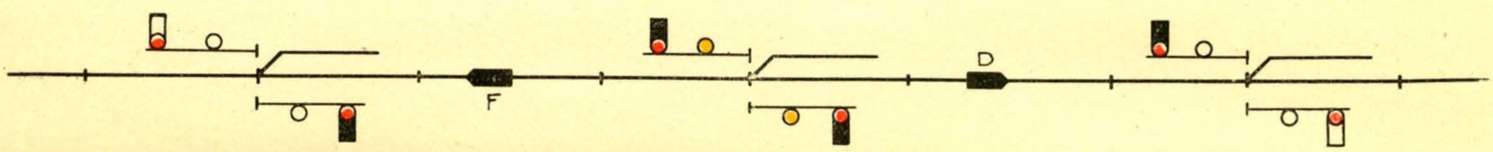

FIG. 49 TRAIN "D" PASSED

SINGLE TRACK AUTOMATIC BLOCK SIGNALING.
ABSOLUTE HEAD-ON WITH PERMISSIVE FOLLOWING MOVES.

of single track, but one of them can get the right to it. Likewise if one train is following another the following train cannot enter the block until the preceding train has left it, all as shown by the lines indicating the extent of signal control. Each pair of opposing starting signals is electrically interlocked in such manner that one must be at stop before the other can clear. In each of the four schemes is shown at the left a single stub end siding, in the center a double stub end or short passing siding and at the right a long passing siding. Both light and semaphore signals are shown with and without distant signals. With the foregoing explanation in mind let us now refer to these schemes individually.

Fig. 27 shows an arrangement of light signals having an overlap in one direction only. The object of having the overlap is to prevent two trains approaching each other from entering the block simultaneously, under clear signals, as previously explained. All of the starting signals such as 1, 4, 5, etc., are two position absolute signals as shown by Fig. 23, it being understood in the case of signals 1, 3 and 5 that the red changes to yellow on the approach of a train provided the opposing signal is red, meaning stop. Signals 6 and 7 are permissive as shown in Fig. 25 and change to red as a train passes. The scheme shown by Fig. 27 is the least expensive, extremely simple and well adapted to roads operating at moderate speed.

Fig. 28 illustrates an arrangement similar to 27 except that automatic distant signals are added allowing higher speeds to be employed and permitting uniform operating conditions in all kinds of weather. The distant signals are three position giving indications as shown by Figs. 24, 25 and 26. Indication 24 would be given with a train between the home and distant signals, 25 with no train between the home and distant signals but with the home at stop and 26 with the home at proceed.

Fig. 29 illustrates an arrangement similar to 27 except that semaphore signals are employed with an overlap in both directions. The former in the interests of visability, and the latter in the interests of following protection at passing points. All starting signals such as 1, 4, 5, etc., will be as shown by Fig. 13 changing to yellow upon the approach of a train. The home signals 6 and 7 will be as shown by Fig 15. Figs. 27 and 29 are about the same as regards permissible speeds.

Fig. 30 shows a scheme similar to 29 except that distant signals are added and an overlap in one direction is employed. All distant signals give three indications as shown by Figs. 14, 15 and 16 and as described in connection with Fig. 32. This arrangement permits high speed to be maintained in all kinds of weather.

(b). Coming now to **single track signaling in which the spacing of following trains is less than the distance between passing points** and is limited by intermediate signals as shown by Figs. 31 and 32.

On many lines to space following trains the distance between sidings as shown by Figs. 27 to 30 would result in such serious delays to traffic that it could not be tolerated and therefore means must be employed to permit closer following moves. Figs. 31 and 32 show how this can be accomplished by using intermediate signals. In Fig. 31 one pair of intermediate signals, 5 and 6, is used which will allow following movements as shown by trains A and B. By adding another pair of intermediate signals, 7 and 8, as shown in Fig. 32 following movements can be still closer as shown by trains A and B and by adding more intermediate signals a still closer headway can be provided for. This method of providing for close following moves has the drawback that it is very expensive especially where trains must follow each other as closely as certain classes of interurban traffic demand; and furthermore two trains can get into the same piece of single track head on, one of them having to back out, but of course the staggered intermediate signals will prevent collision.

(c). The objections just named can be overcome by a system of **single track signaling in which the number of trains following each other between passing points is unlimited** as shown by the scheme Figs. 40 to 49 inclusive and which is known as the **Absolute-Permissive-Block** signaling system. In this scheme opposing signals are electrically interlocked and overlapped in such way as to guarantee against opposing moves into the same piece of single track at the same time, exactly as in the scheme shown by Figs. 27 to 30 inclusive. The distinctive feature of the scheme consists in the use of a ***call-on signal**, shown by Figs. 19 and 22, so controlled that it will be displayed only provided both opposing high speed signals and the opposing call-on signal are at stop, and provided a train is in the block having entered at the end where the call-on signal is displayed. In other words opposing train movements are prevented and following train movements are automatically permitted by a signal that says *"Proceed the block is occupied" hence the name **Absolute-Permissive-Block**.

In lieu of the call-on signal another position of the high speed arm could be employed.

* See appendix under Signal aspects and indications also the Absolute Permissive Block System.

In the various figures illustrating this scheme the shaded signals show those under the control of trains and the wording under each will make them self-explanatory. Especial attention is called to Fig. 42 which shows train C following B under a call-on signal. Also to Fig. 46 which shows signal 4 at stop indicating to D that another train is coming and that he must not attempt to leave his siding. Fig. 47 shows signal 4 at clear indicating that no more trains are following and that it is now safe for train D to back out and proceed.

Although not shown, distant signals can be used, the starting signals can be staggered and siding signs would be used were there no distant signals. The scheme can be applied to any of the situations shown in Figs. 27 to 30.* .The call-on signal is not a new creation having been in use for a long time and for the purpose of letting a train or engine into an occupied section. Heretofore it has been operated manually whereas in this scheme its operation is automatic. It is believed that the system just described admirably meets the requirements of those electric lines where close following movements are necessary.

(d). **Curve protection.** Figs. 33 and 34 show two schemes for curve protection. Fig. 33 shows the signals located 2,000 ft. from the ends of the curve. The object in doing this is as follows: assume two trains approaching, A from the right and B from the left. If B passed No. 2 before A reaches the overlap for No. 2, B will have a clear signal and A will be held at No. 3. If now No. 3 had been close to the end of the curve B could not have seen A in time to stop, whereas with No. 3 2,000 feet away B will have a good chance to see A in time to stop; likewise if A gets a clear signal. Locating the signals near the curve as shown in Fig. 33 as compared with locating them at the nearest siding, (see Fig. 34) is in the interests of economy where curve protection is the only kind of signaling to be done by a given road for some time to come. When however curve protection is only a stepping stone to a more complete system, or if there are a series of several curves taking up a greater part of a given block, then the signals should be placed at the entrance to the block and in the place they will occupy permanently, as shown by Fig. 34.

(e). **Double track signaling.** Figs. 35, 36 and 37 show various methods of double track signaling. Fig. 35 shows the 3 position scheme largely used on steam roads. The signals would be in accordance with Figs. 14 to 16 inclusive or Figs. 24 to 26 inclusive. This is by far the most satisfactory form of double track signaling where the blocks are not too long as each signal gives advance information as to the position of the next, etc.

* See appendix under Signal aspects and indications also the Absolute Permissive Block System.

Fig. 36 shows a less expensive scheme using two position signals with an overlap. The signals would be as shown by Figs. 14 and 15 or 24 and 25. The overlap would vary in length from nothing up to that shown, depending on the various conditions outlined in discussing the principles of signaling heretofore in this article.

Fig. 36 shows still another scheme using 2-position home and 3-position distant signals. Its virtue lies in being able to locate the distant better with reference to the home when the length of the block is very great.

Assuming that you have an automatic block signal system such as described what about its effectiveness, its advantages, etc.

One sometimes hears the remark, "Train men will not obey signals so what is the use." In the first place I do not believe that the trainmen employed on the high speed electric lines are reckless as a rule. On the contrary I have been very much impressed with the care which has been exercised by the motormen who have come under my observation. I believe as a rule they are well inclined and would be glad to run under and be governed by a signal system which will tell them the truth; that is one in which signals will be at stop when they ought to be and at clear when they ought to be. That trainmen have in many instances disregarded signals with disastrous consequences is well known. For example a terrible accident comes to my mind which was caused by an engineman running his distant signal at caution. The towerman had for a long time prior to the wreck been failing to clear the distant signal. The engineer, finding that the route was always clear anyway, was accustomed to run through at high speed in spite of the fact that the distant signal was at caution. The day came however when he should have observed it, with the result mentioned. The signal had been telling the wrong story. Signals are much like people, "Once detected always suspected" or like the boy who cried, "Wolf! Wolf!" when there was no wolf and when the wolf actually came and he wanted assistance, none came. It is my belief that this idea at the bottom of much of the disregard of signals.

Another important thing in securing obedience to signals is to locate them properly. For example if a distant signal is set too far away the motorman will soon find out that he need not shut off and apply brakes when he passes it, for if he does he will probably lose time, and that generally he can just as well apply them later and stop soon enough. He may some day, under such conditions, do it too late. Cases have also come to my attention, where, due to misplaced signals, trains were regularly delayed when they need not have been; hence the tendency on the part of the engineer or motorman to disregard the signals and in so doing have it happen once too often. In short whatever disobedience there may have been to signals is largely due, in the opinion of the writer, to faulty apparatus, misplaced signals or faulty manipulation. With up-to-date systems and mechanisms and with a better understanding of traffic requirements, the operation goes on with surprising accuracy with the result that the causes leading to the disobedience to signals have been very greatly reduced.

Coming now to some of the reasons which may justify an electric line in spending the money necessary to properly signal.

The writer recently had occasion to ride in the motorman's compartment on a limited car running between two large cities, a distance of about 60 miles. The first several miles lay in a city street and our car had the misfortune to follow a heavily loaded local street car with the result that by the time we reached the open road a delay of over ten minutes had been occasioned. The motorman then started to make up time, impelled to do so on account of their practice of having fixed meeting points, with the result that, when one train was late a number of other trains were delayed. It was certainly a lively ride and I was glad when our destination was reached. The train crews with whom I talked said they liked the idea of having fixed meeting points as there was so much danger attached to changing them. With a suitable signal system these meeting points could be made flexible without danger and therefore but one train need be seriously delayed and hence less necessity of making up lost time. The English railways have a rule that lost time is not to be made up; recognizing the dangers in such practice. In view of the practice on the road just mentioned a signal system would increase the capacity of the line, reduce the liability to accident, avoid delays, increase the confidence of the travelling public and provide a good insurance against accident.

Again with strong line construction a properly designed signal system will give much less trouble than a telephone despatching system with its delicate apparatus, thus making it possible to operate with comparative freedom with the telephone line in trouble. Do not understand me to say that the telephone should be abandoned. Far from it; as I believe it to be a very valuable adjunct in the handling of trains on single track. In fact automatic signals, when used on single track, could, if so desired, be under the control of the despatcher, permitting him to stop trains when necessary to change schedules, etc.

A suitable signal system will also permit schedules to be maintained safely in all kinds of weather which is an important consideration in sections of the country where there is much foggy weather and the like.

Other arguments might be advanced in favor of signaling but I believe I have said enough to show that far from being merely an expense without any tangible return, a properly designed signal system will in the end pay for itself, in operating returns, to say nothing else.

Automatic stops. There is quite a difference of opinion on this subject, some claiming that automatic stops will have a tendency to make motormen relax in vigilance and others that they will have the opposite effect. Possibly these differences of opinion would not be so pronounced if it were borne in mind that there are stops which record their operations against the motorman and those which do not.

If automatic stops are used in interurban service it is believed they should record every time they operate and that the motormen should account for such record. I doubt if under these conditions a relaxation in vigilance would result. In an installation recently put into service in the Northwest glass tubes mounted on top of the car are used and so connected with the braking system that when broken a service application of the brakes will result. A motorman is given so many tubes for which he must account every so often. When the signal is at stop an auxiliary arm comes down to a position such that, if the car attempts to pass it the tube will be broken. The system is understood to be very successful.

It is not considered good practice to use automatic trips located down in the roadbed on surface lines except in tunnels, etc. They must therefore be located on top of the car, that is if a mechanical trip is used. This means that the inter-state commerce maximum equipment diagrams should be adhered to as it sometimes becomes necessary to run foreign equipment over a line, such as box cars, etc., and therefore any fixed object such as a stop arm must not project within this line and also any projection on the car such as a trip arm must not strike objects along the right of way; and with all there must be a good safe overlap of the trip arm and stop arm when the latter is down, to take care of variously loaded cars, swaying, etc. It is very difficult to satisfy all these conditions.

Stops f used should be so connected with the air system that an emergency application will not result when the trips operate. This will frequently require the use of auxiliary air controlling apparatus on the car.

To make automatic stops of their highest value, it frequently becomes necessary to rearrange the signals on single track to secure the necessary braking distance as shown by Fig. 39. When so re-arranged a system becomes much more expensive: In double track work a full block overlap, as shown by Fig. 38, is usually provided, the stops remaining active a full block behind each train. For example the stop used in connection with signal 6 would be active until train F had passed out of the block it is shown as occupying. With this arrangement about 33% more signals are needed than without stops, to maintain the same headway.

Stops have a very pronounced value in addition to their function of causing a train to stop if it attempts to pass a danger signal, and that is to record whenever a stop signal is run by, thereby requiring an explanation. This will act as a very strong influence in preventing disobedience to signals.

Much more might be said in regard to stops and other devices used for compelling obedience to signals, but it is believed that enough has been said to show that they have their disadvantages as well as their advantages and it is a question if their use can be justified in all cases.

In conclusion I wish to emphasize the following points which have been touched upon in this paper:

1st.—Where the traffic conditions on electric railways are such as to require block signals the automatic system employing continuous track circuits is recommended. Its use is urged from the standpoint of safety, reliability and economy. It is now successfully employed on over 17,000 miles of steam road in this country and its use is rapidly increasing and to the exclusion of other block systems.

2nd.—Automatic block systems employing track circuits for electric lines are now available which, while maintaining a full degree of safety, reliability and economy, are much less expensive than ever before.

3d.—Of the various systems of single track signaling available, the one in which opposing moves are controlled absolutely and following moves permissively under a distinctive signal, is recommended for those roads where following moves closer than the distance between passing points are required.

4th.—The adoption, by the various electric railroads of the country, of a uniform system of signal aspects and indications is urged. The system proposed by the *Railway Signal Association, as far as it will apply and as described in this paper, is recommended.

* See appendix under Signal Aspects and Indications.

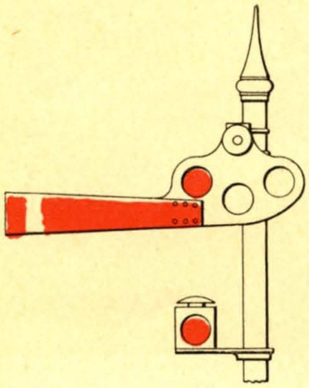

FIG. 50
STOP

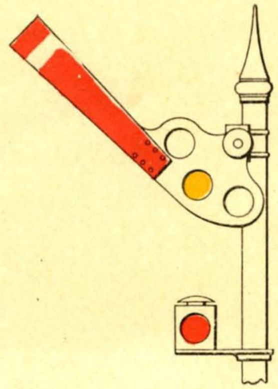

FIG. 51
PROCEED, PREPARE TO
STOP AT NEXT SIGNAL

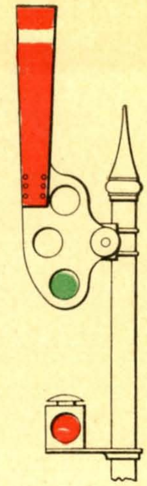

FIG. 52
PROCEED

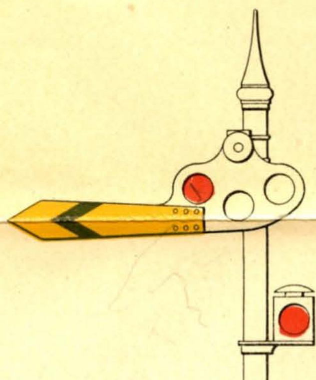

FIG. 53
STOP THEN PROCEED

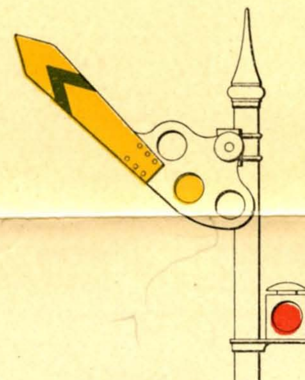

FIG. 54
PROCEED, PREPARE TO
STOP AT NEXT SIGNAL

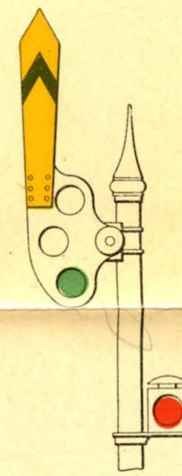

FIG. 55
PROCEED

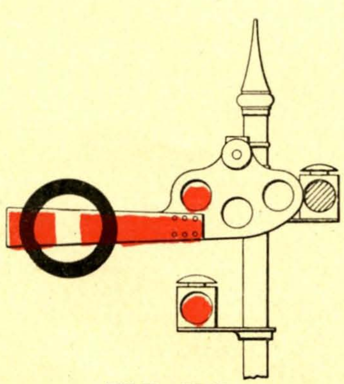

FIG. 56
STOP

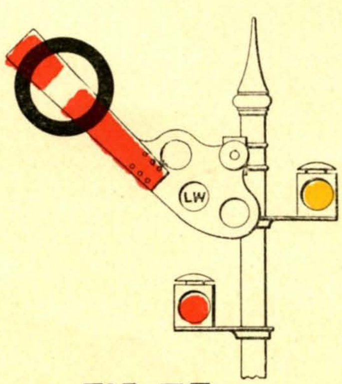

FIG. 57
PROCEED PREPARE TO STOP SHORT OF
ANY OBSTRUCTION IN THE BLOCK

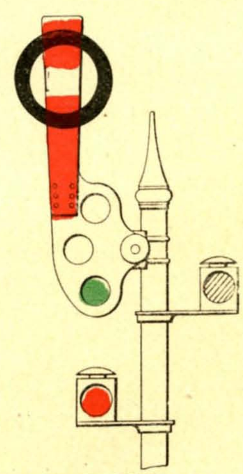

FIG. 58
PROCEED

APPENDIX

Signal Aspects and Indications

Referring to the note at the bottom of pages 20, 21, 28, 29 and 33, attention is called to the fact that the series of signal aspects and indications shown and described in the original paper, while a practical scheme, has been found to conflict in some respects with the latest published majority recommendations of the Railway Signal Association which at the time of the preparation of this paper, were overlooked. The writer is therefore showing in this appendix, a revised scheme which he believes does not conflict with said recommendations, will serve the purpose, and should probably be used in preference to the original arrangement as it is his firm conviction that the greatest good will be accomplished by hearty co-operation with the committees of the above named association in their work of reducing signaling to a uniform and consistent practice.

The points at issue are as follows:—

1st. The use of the "Call on" signal in the manner described on page 28 and as shown in Fig. 19 without any distinguishing mark in connection therewith, conflicts with its use in interlocking practice. Indication "No. 9" as recommended by the Railway Signal Association and as shown by Fig. 57 is therefore proposed in its place.

NOTE:—It is believed by the writer that a separate signal on the same mast with the high speed signal, as shown by Fig. 19, is a neater arrangement, has the advantage that it only shows when required and by the use of a suitable distinguishing feature such as a ring, would not conflict with its use in interlocking practice; but until such time as this has the sanction of the Railway Signal Association its use is not urged. With regard to the ring on the blade as shown by Fig. 57. It is suggested that it does not make a very good looking signal and that as an extra light must be used as the night indication, said light could shine through a target which in the daytime would be the distinguishing feature for this indication.

2nd. Pointed blades, as shown by Figs. 53, 54 and 55 are recommended for permissive signals in lieu of the square ended blades shown by Figs. 14, 15 and 16.

NOTE:—Square ended blades where shown in the interests of uniformity, and are being used by some roads for both absolute and permissive signals with satisfactory results.

3rd. Red marker lights are recommended in lieu of white.

NOTE:—White marker lights are being used but red is more generally employed, and it is the writers belief that its use is justified.

4th. The vertical position of the blade with green at night is recommended as the running signal, as shown by Fig. 58, in lieu of the 45° position with yellow at night, as shown by Fig. 17.

NOTE:—The original interpretation placed on the vertical position of the blade with green at night was "Proceed at normal speed prepared to pass the next signal at normal speed." As proposed in connection with single track signaling (See page 24) it would not do for the motorman to assume that the next signal is clear; on the contrary we want him to be prepared to stop at the next signal; hence the use of the indication Fig. 17. As shown in Fig. 58 however, the interpretation is merely "proceed" meaning continue at normal speed until otherwise instructed. When so defined it may do but it is believed that some modifying feature should be employed to distinguish it from the proceed indications shown by Figs. 52 and 55.

5th. Attention is called to the modifications in the wording under the various indications from that originally given.

The following is a further description of the revised scheme of aspects and indications:

Figs. 50 to 58 inclusive show a series of day and night aspects in which an arm in the horizontal position or a red light always means stop; the arm inclined upwardly at an angle of 45° or a yellow light always means proceed with certain restrictions and the arm in a vertical position or a green light always means proceed without restriction as far as that signal is concerned.

A train stopped by an absolute signal, Fig. 50, must remain until authorized to proceed whereas when stopped by a permissive signal, Fig. 53, it may, after having stopped, proceed cautiously until a new indication is received.

The marker lights shown below the semaphore are used to indicate whether a signal is absolute or permissive. If the signal is absolute the marker will be directly under the semaphore light as shown by Fig. 50 and if permissive the marker will be staggered with reference to the semaphore light as shown by Fig. 53. Absolute signals should furthermore be distinguished from permissive signals by the shape of the blade, having a square end in the former and a pointed end in the latter case.

A train passing a signal at caution *i. e.* a plain arm in the 45° position or showing a yellow light as in Figs. 51 or 54, must at once prepare to stop at the next signal meaning of course the next signal of like character. In this connection it is assumed that a signal which gives this

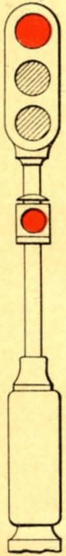

FIG.59
STOP

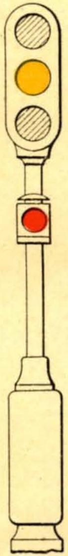

FIG.60
PROCEED
PREPARE TO STOP
AT NEXT SIGNAL

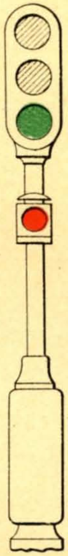

FIG.61
PROCEED

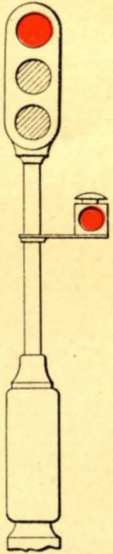

FIG.62
STOP
THEN PROCEED

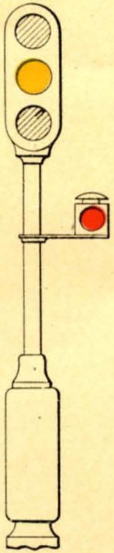

FIG.63
PROCEED
PREPARE TO STOP
AT NEXT SIGNAL

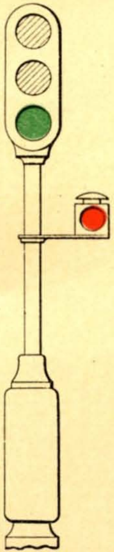

FIG.64
PROCEED

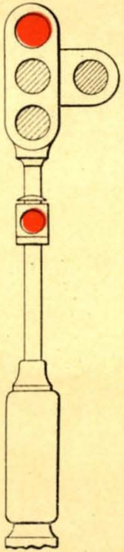

FIG.65
STOP

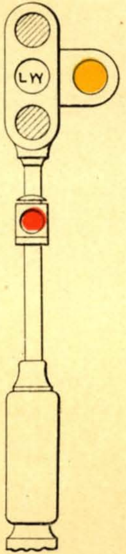

FIG.66
PROCEED PREPARE TO
STOP SHORT OF ANY OB-
STRUCTION IN THE BLOCK

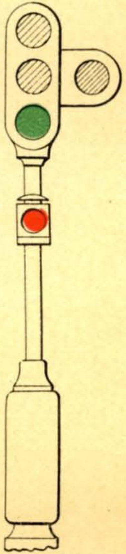

FIG.67
PROCEED

indication will be located approximately "stopping" distance ahead of the signal next in advance and will be used to give an approach indication thereto.

If the arm has a ring on it or if an additional light is shown side by side with the semaphore light as shown by Fig. 57, it means that the train must proceed, preparing at once to stop short of any obstruction in the block. The ring has no significance when the arm is in the vertical or horizontal position. Signals giving this indication are proposed for use in connection with starting signals into a piece of single track, permitting one train to follow another. This indication would only be given if the opposing signal or signals were at stop and a train were in the block, having entered from the end at which the signal in question is located.

A train passing a proceed signal as shown by Figs. 52, 55 or 58 is permitted to continue at normal speed until otherwise instructed.

The color schemes illustrated prevents giving a false clear indication due to the breaking of a glass and also prevents mistaking a foreign light for a signal. This of course bars white for clear and requires the use of the distinctive colors red, yellow and green as explained.

The use of the upward inclination in going to clear reduces the tendency for an accumulation of snow or sleet to hold the signal in the clear or caution position which exists with the downwardly inclined blade.

The marker light above referred to, in addition to distinguishing between a permissive and an absolute signal, is useful as an indication of the presence of a signal in case the semaphore light should be out—in other words the use of two lights on every signal prevents its disappearance due to the going out of one light. A further argument in favor of the marker is the claim that two lights make a better signal than one. It is believed that this is true, due to the fact that lights always show up better by contrast than they do alone. Under certain conditions of the atmosphere, red alone looks yellow and vice versa, but when contrasted with an adjacent light which is known always to be red, there will be no chance of mistaking red for yellow or vice versa in the semaphore light. This is a good argument for red as a marker in addition to the claim that if the semaphore light goes out a stop signal should remain. This color has been objected to on the score that it requires a man to pass a red signal. In this connection it should be remembered that it is common practice to pass a red light when modified by a suitably located light of another color, by the shape of a blade or by other means, and further that in the scheme of signaling shown it is not the one light but a combination of lights that makes a signal.

Those who may wish to go more deeply into the matter of aspects and indications are referred to the published proceedings of the Railway Signal Association.

A series of light signals is shown in Figs. 59 to 67 inclusive which conform as regards indications with the series Figs. 50 to 58 inclusive. For a further discussion of light signals, see page 21.

Marker Lights

Since the original paper was read a question has been raised as to whether or not the marker light can be justified on Electric Roads. It is claimed that as the signals can be comparatively low down and close to the track the great illuminating power of the head light will serve to show what a signal is without marker lights. While this may be true on straight track, it is not so where there are grades or curves in the vicinity of the signal because of the fact that the headlight may not be directed toward the signal in such cases. It is therefore believed that the matter of the illuminating power of a head light should not be considered in this connection on electric roads any more than on steam roads. Again it has been claimed that the two lights, which it is admitted should be on every signal, can be behind the same lense when the signal is electrically lighted instead of being behind separate lenses as in the case of the marker light and thus economize on equipment while maintaining an equal degree of safety. The objection to using two lights behind the same lense is that when one goes out there is not a sufficiently noticeable change in the brilliancy of the light and therefore this condition is not likely to be reported; whereas with the lights behind separate lenses, if one goes out it will be quickly noticed, reported and fixed up thus reducing the chance of having a signal without a light. The writer admits that marker lights as a means of distinguishing between an absolute and a permissive signal while very effective are not absolutely necessary since a train must stop anyway and the motorman can then tell what the signal is either by the shape of the blade or by some distinguishing feature on the pole; the general illumination of the car affording sufficient light for this purpose. In view of the foregoing remarks and of the fact that an electrically lighted marker is a very inexpensive arrangement and does not involve any extra expense for maintenance it has been shown in the various illustrations of signal aspects accompanying this article and its use is recommended.

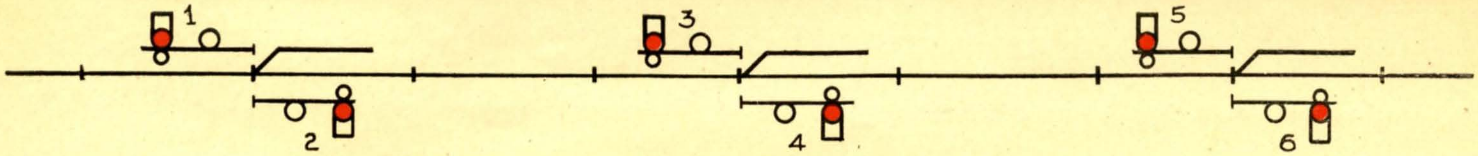

FIG. 70 NORMAL CONDITION

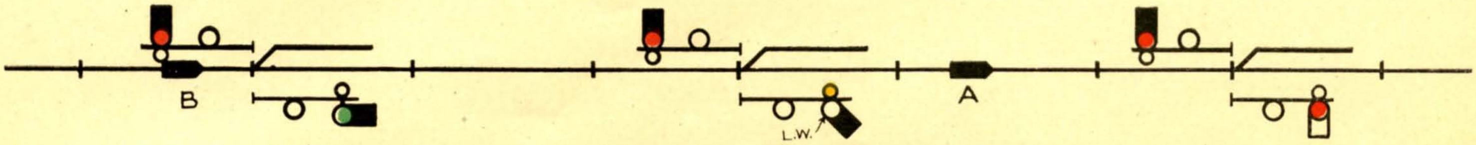

FIG. 71 TRAINS FOLLOWING UNDER CLEAR SIGNALS

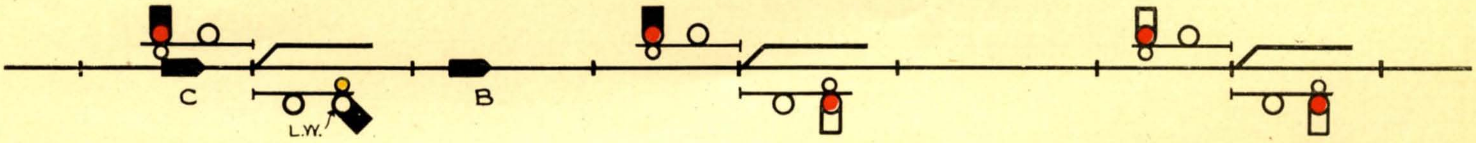

FIG. 72 TRAINS FOLLOWING UNDER CAUTION SIGNALS

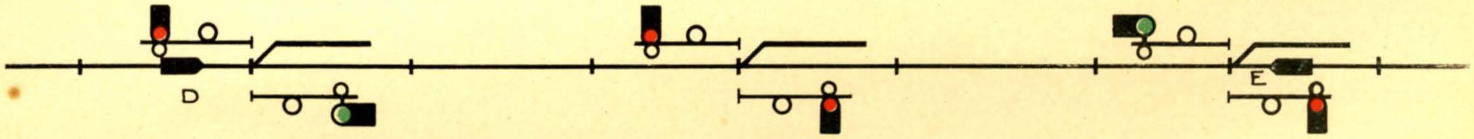

FIG. 73 TRAINS APPROACHING

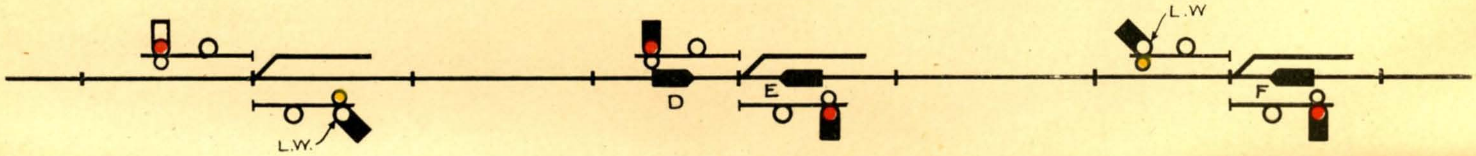

FIG. 74 TRAINS APPROACHING

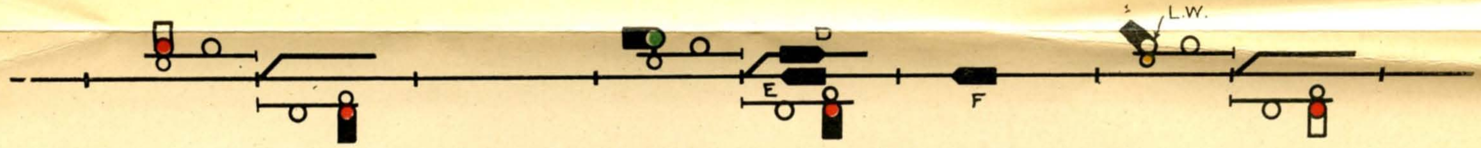

FIG. 75 TRAIN "E" PASSING, "F" FOLLOWING, D IN SIDING

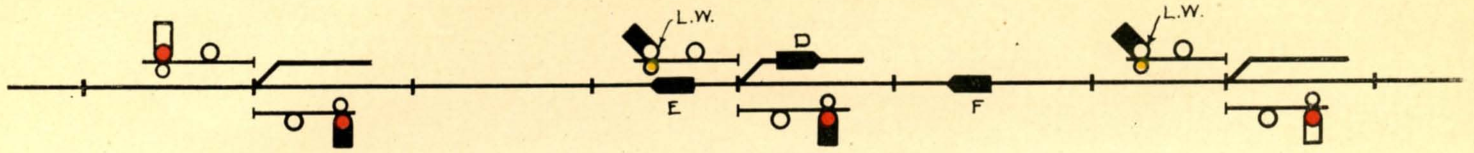

FIG. 76 TRAIN "E" PASSED "F" FOLLOWING "D" IN SIDING

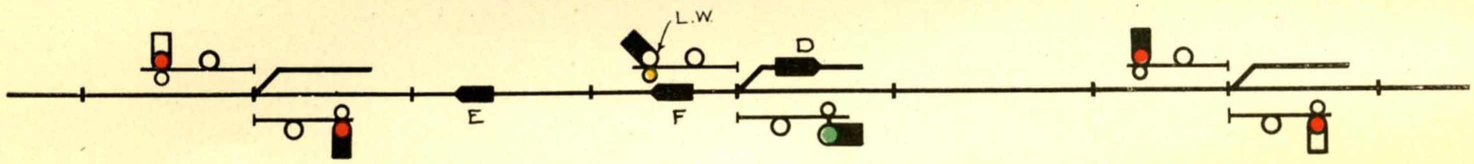

FIG. 77 TRAINS "E" & "F" PASSED "D" IN SIDING

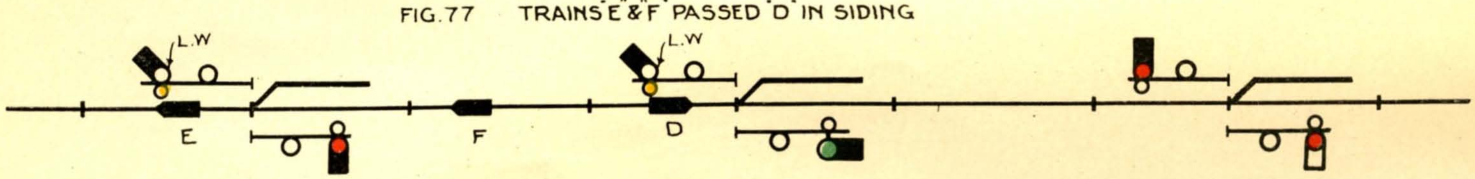

FIG. 78 TRAINS "E" & "F" PASSED "D" BACKED OUT READY TO PROCEED

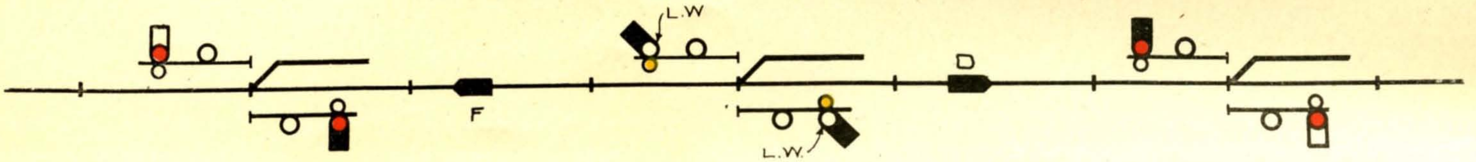

FIG 79 TRAIN "D" PASSED

SINGLE TRACK AUTOMATIC BLOCK SIGNALING.
ABSOLUTE HEAD-ON WITH PERMISSIVE FOLLOWING MOVES.

Light Signals

FIG 68

On page 21 the writer made reference to light signals. Since then, further tests have been made which have demonstrated that such signals when properly designed will furnish an arrestive signal at a distance of from 1,200 to 1,500 feet in the bright sunlight and with a covering of fresh snow on the ground. The cuts, Figs. 68 and 69 show the front and side view of a two position, double light signal. This signal will take care of such locations as shown by signals 1 and 2 Fig. 27 for example. In fact it can be used wherever Light Signals can be employed opposite each other combining in one device the signals for both directions. They will be made two position where signals are not required to give over two indications or three position wher three indications are to be given. Each lamp box is independently revolvable side ways to permit of proper focusing. The signals will also be made with a single lamp box and either two or three position for use where one signal will be used alone as in the case of a distant signal for example. The case at the bottom is arranged to accommodate the various relays required.

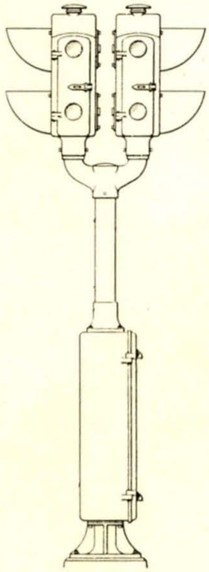

FIG 69

The Absolute-Permissive-Block System

In Figs. 70 to 79 inclusive is shown a series of track diagrams the same as those shown by figures 40 to 49 inclusive and as explained on pages 28 and 29 except that the revised series of aspects and indications as shown by Figs. 56 to 58 inclusive are used in lieu of the call-on arm originally shown.

Attention is called to the fact that in the Absolute-Permissive-Block system without intermediate signals, ample facility for switching movements at sidings can be arranged for without holding trains at adjacent sidings. Furthermore, intermediate signals if required can be installed and can have the permissive attachment applied and which when in the cautionary position will tell from which direction a train ahead has entered the piece of single track in question.

Furthermore using intermediate signals the circuits can be so arranged that a starting signal into a given piece of single track cannot be given unless the starting and permissive signals at the other end of said piece of single track are at stop. In fact an endless variety of combinations can be made, the net result being that for a given outlay greater safety and greater capacity can be afforded with the Absolute-Permissive-Block system than with any other form of automatic block signaling known to the writer.

GENERAL RAILWAY SIGNAL COMPANY.

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Automatic Signaling
for
Electric Railways

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