-RAILROADS SIGNALS-

Railroad Signalling is important not only on the score of safety but also of Economy. On a railroad of small (and especially of infrequent) traffic, the consideration is mainly that of safety, but the necessity even for safety is not always felt until the traffic becomes fairly frequent. When safety demands signals on account of frequent trains, it is almost sure that it very soon will be found that a satisfactory system of signals allows a very considerable increase of traffic beyond what would be considered allowable under any other conditions of working. Trains can be run more frequently when those in charge of a train know completely whether the track ahead of them is clear or not, and to show this is one of the important functions of signalling. It is fortunate on the whole that railroad managers may properly look at it that a system of signals demanded by safety, will at an early date be justified also on the score of operating convenience and economy.

Signals serve two main purposes:

1, to indicate conditions as to positions of trains -

2, to indicate conditions otherwise, mainly as to positions of tracks.

Signals in either of these cases may be intended -

a, to give information (informatory),

b, to direct the movements of trains (mandatory.

Signals of some some sort have been used for an indefinite period to indicate the positions of switches, targets being very common for this purpose, and of various forms; track signals indicating the positions of trains were very early used in some localities, but were not at first adopted generally, and are not yet in complete use.

Correct modern practice has demanded that at switches and crossings there should be signals for information and protection, and that they should be not only of approved outward form, but, in addition, so interlocked with each other that it becomes a mechanical impossibility that two conflicting signals should be given, and also, in general, by the use of a derailing switch a train passing a signal at danger is thrown off the track and into the ditch so that it is an impossibility that two trains should come in contact with each other even by disobeying signals (on single track lines for instance it is evidently impossible to absolutely prevent a collision). Such an arrangement constitutes what is called "Interlocking".

Modern practice also demands that a line of railroad shall be divided into short sections (often a mile long) called "blocks", and that no following train shall enter any block until the preceding train has passed to a point of safety without the block. This constitutes what is called "Block Signalling". "Interlocking" at yards or sidings generally becomes a material feature in a system of "Block Signalling" but "Interlocking" may frequently be introduced independently. It is reasonable and appropriate therefore to first consider Interlocking.

Interlocking.

In an interlocking system, any switch or signal can be moved only by an operator in a tower (generally) who operates (by means of levers) all the switches and signals of the system. Furthermore, the operator (sometimes more than one) has at any time, the choice of comparatively few movements of switches or signals, being restricted to those only which are safe, (under conditions existing at that time) regard being had to all other signals and avenues of travel which already allow the passage of trains. Mechanical arrangements are introduced such that the movement of a lever by the operator not only throws a switch or moves a signal, but also acts upon various other levers for throwing other switches and signals in such a way as to lock them so that the other levers cannot be moved. This interlocking is arranged in such a way that conflicting or unsafe combinations of switches or signals are made mechanically impossible. An incompetent or careless operator (or a blind man, as it is said) can at the worst produce a condition where train movements become impossible but cannot produce a condition where conflicting signals will be shown, nor where trains can come in collision unless in a single track, which necessarily allows pasaage in both directions if in either, and here even no conflicting signals will be possible; but on single track if signals are disobeyed, a head on collision or a rear end collision is clearly possible, but not a crossing collision.

The scheme of interlocking will be understood better by reference to the simple case of a double track crossed by a double track, as shown in Plate 4. In accordance with general practice, the normal condition is that all home signals are set at danger distant signals at caution and all switches (derailing switches) are open (or set to throw a train) into the ditch.

A derailing switch, in its more common form, is essentially a split switch which leads, not to a side track or turnout, but only far enough to cause derailment. Ordinarily if the derailment is to be to the right, the track or stock rail is bent to the right, and the right hand switch rail placed to fit close against it. The switch rod is attached to the switch rail and is connected with a switch stand or more generally with the switch tower from which the various switches and signals are thrown. The left hand switch rail is unnecessary and is not used when the derailment is provided for to the right.

Plate 1 shows the point only of a derail-

PLATE I

ing switch and with it a home signal on the high post, a dwarf signal near the base of the post and a machine for operating the switch, but which need not be further referred to here. A similar derail, differing in detail, however, and working on the principle of the Wharton switch and known as the Wharton derail is shown in Plate 2. The short rail at the extreme right engages the tread of the car wheel so that the flange is carried over the right hand rail of the track, being guided to the right by the switch rail proper. A "scotch block", shown in Plate 3, is sometimes used as a derailing device.

Referring to Plate 4, suppose a train to approach from the west. Before it is allowed to pass over the crossing it is necessary: (a) that the derailing switch 6 should be closed (or set for the main track); (b) that the "home signal" 4 should go to the "all clear" or "safety position"; and (c) that the distant signal 3 should also go to "safety". A clear distant signal authorises the train to proceed at full speed; a train may pass the distant signal 3 when it shows "caution" (the reverse of "safety") but in this case it must be under complete control as it approaches the home signal 4, which it is not allowed to pass unless this shows "safety". If the engineer should disobey this signal, and reach the switch 6, he either goes into the ditch if the derailing switch is open, or if this be closed, he passes the crossing, necessarily in safety for the reason that it is impossible for any conflicting train to reach the crossing when the switch 6 is set for the main track, because the switches 5 and 7 must of necessity be open (into the ditch); the levers are interlocked to secure this result. Until some train approaches, levers 5,6,7,8 are the only levers free to be moved. In order to properly pass a train from W to E, the operator throws (a) lever 6, (b) lever 4 and (c) lever 3. When the operator throws lever 6, proper

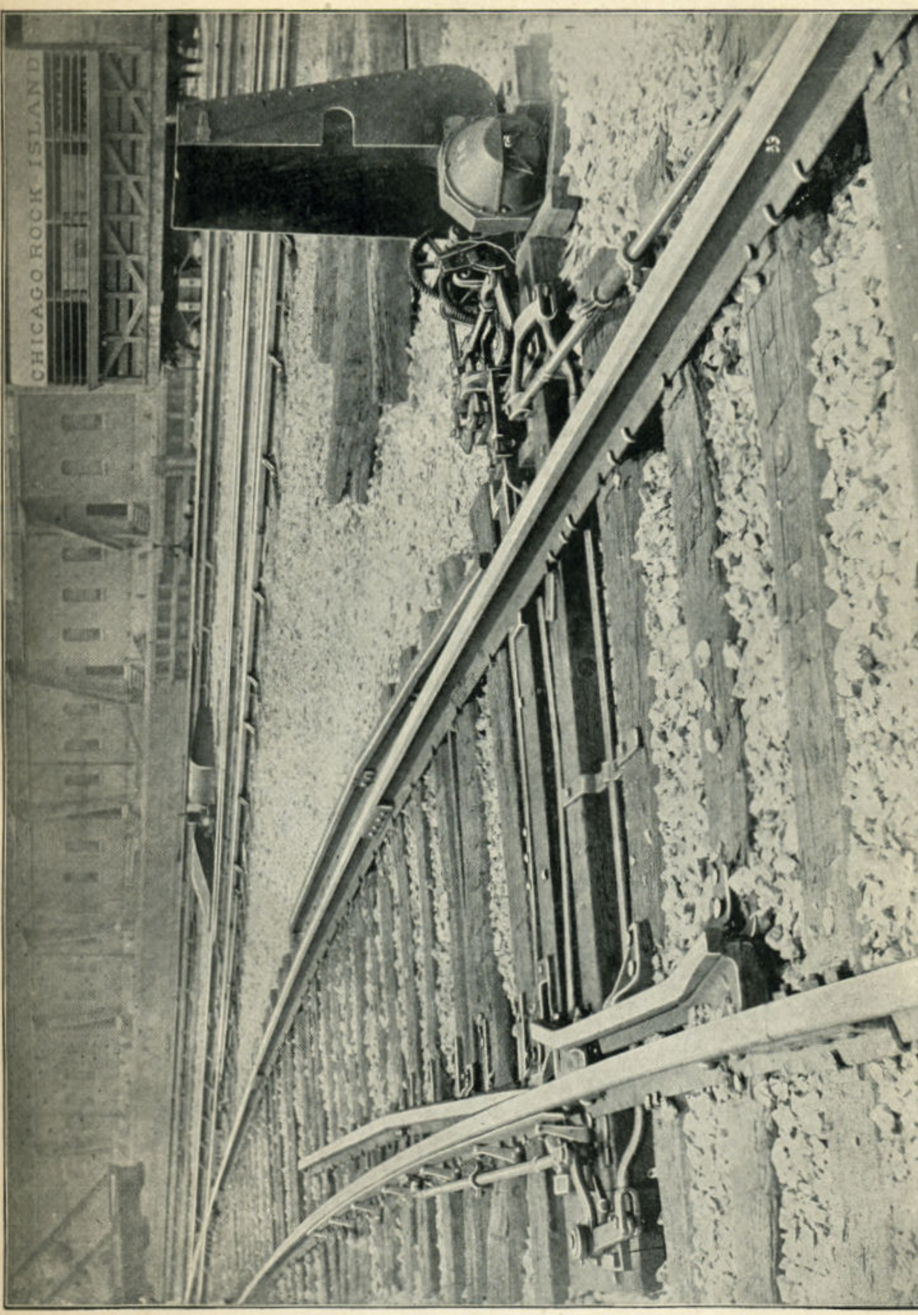
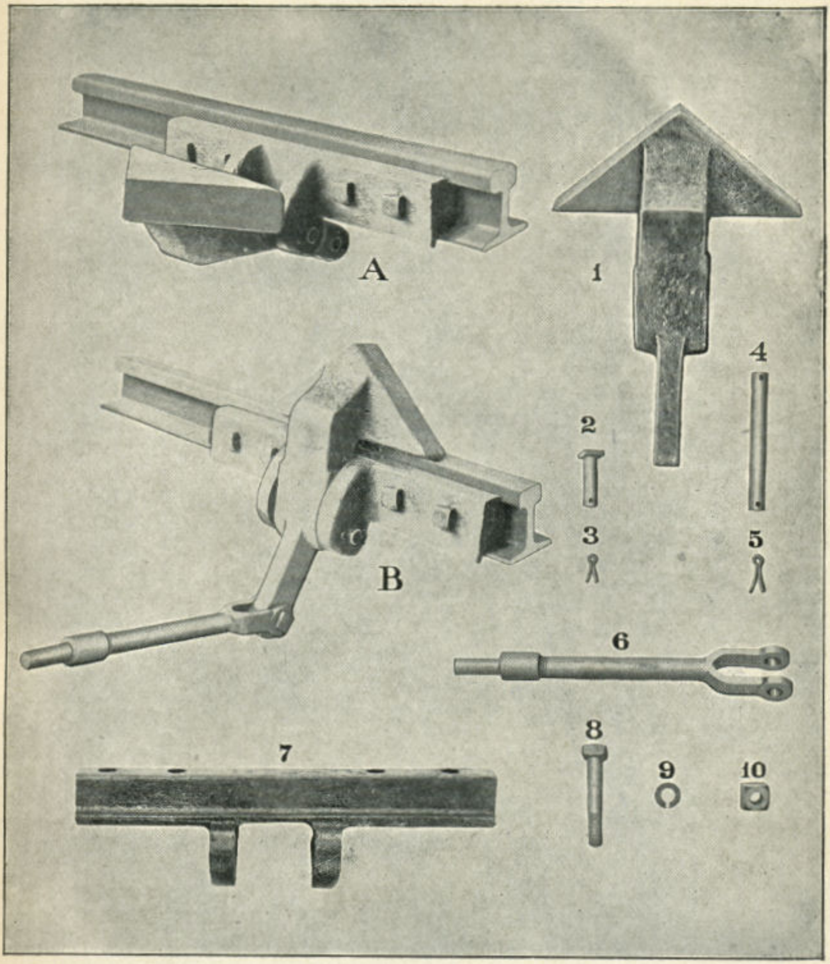


PLATE 2



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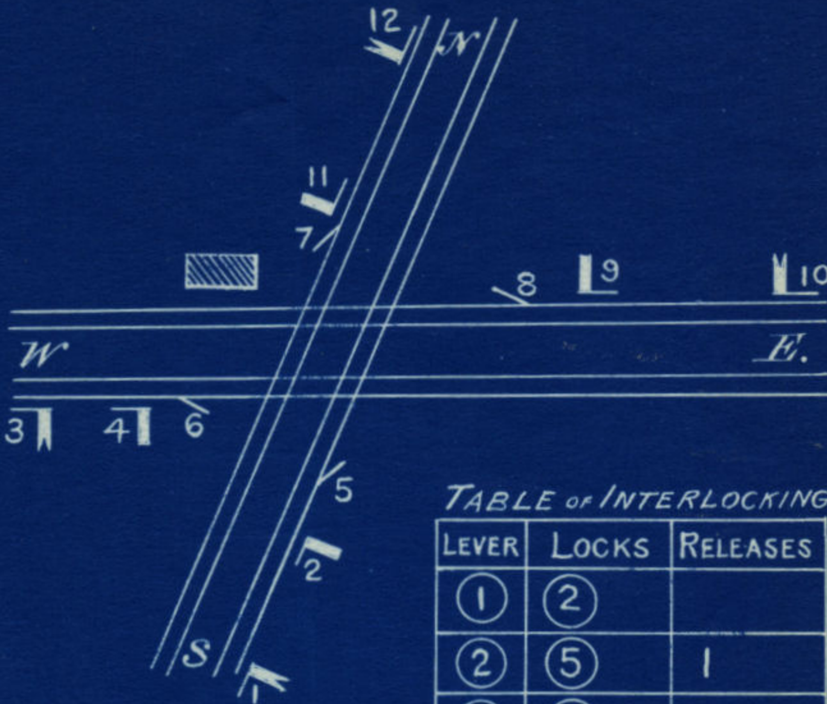

COMBINATION SHEET

ROUTE	LEVERS
W. to E.	6-4-3
E. to N.	8-9-10
N. to S.	7-11-12
S. to N.	5-2-1

TABLE OF INTERLOCKING

LEVER	LOCKS	RELEASES
1	2	
2	5	1
3	4	
4	6	3
5	6-8	2
6	5-7	4
7	6-8	11
8	5-7	9
9	8	10
10	9	
11	7	12
12	11	

Plate 4

connections from tower to switch cause the switch 6 to be thrown, so that it is "closed" (set for the main line). Throwing the lever 6 also acts upon the interlocking in the tower so that the conflicting levers for switches 5 and 7 are locked, and are no longer free to move. The switch 8 need not be locked since a train may safely pass from E to W, while a train is passing from W to E. Throwing the lever 6 also acts upon the interlocking mechanism in such a way that the "home signal" 4 may now be thrown to "safety" as is safe and proper. When 4 is thrown to "safety" it is necessary that the switch 6 should remain set for the main track. Accordingly throwing the lever 4 locks lever 6 in its reversed position and also releases the lever 3 so that the distant signal 3 may be set at "safety" as is proper. Throwing lever 3 in a similar way throws signal 3 to "all clear" and locks 4 in the reversed position ("all clear".) In the normal condition 5,6,7,8 were the only levers free to move. Levers 5 and 7 have been locked by throwing 6. It is evident then that the conflicting levers 6,4,5,7,1,2,11,12 are all locked, and the normal condition can be again reached only by a reverse process by moving in the order named levers 3,4,6.

A convenient and systematic way of formulating the requirements in this case is to make two tables, the first, called the "combination sheet" is to show what levers are to be moved, and in their proper order, so as to pass a train in each direction, as is shown on Plate 4.

This should be followed by a "table of interlocking" in which (1) signifies lever 1 in its reversed position and 1 signifies lever 1 in its normal position. (2) signifies lever 2 in its reversed position and other levers in the same way. This table of requirements is furnished to the manufacturers and they design their interlocking machine accordingly. The Table of Interlocking is also shown on Plate 4. The derailing switch (for example 6) is placed commonly from 300 to 500 feet from the crossing, more frequently the former on level or nearly level track. The home signal (for example 4) is placed about 50 to 200 feet further back, and the distant signal (for example 3), 1200 to 2000 ft. or more behind the home signal. These distances will be varied where special arrangements are necessary on account of grade, or physical conditions such as curves, buildings, or anything tending to interfere with a clear view of the signals, or sometimes to secure a satisfactory position for the derailing switch, which in turn affects the location of the home signal.

For signals to be used with interlocking plants, semaphores are almost universally employed. They are visible for longer distances than any other form of signal used. A semaphore is a long narrow blade (generally flat) attached to a post and arranged on a pivot or pin so that it may take either a horizontal position or an inclined position, or in some cases a vertical or nearly vertical position. Its length is likely to be between 4' and 5'6". The Philadelphia and Reading Semaphore is 4'6" long, 11" wide at outside end, tapering to 6" near the post. The outer end of the home signal is square (or nearly square) and the distant signal has its outer end notched or fish-tailed. Plate 1 shows an ordinary home signal semaphore; the distant signal is very similar except that it has the notched end.

By common consent the horizontal position of the home signal indicates "danger" and demands "stop" and peremptorily, for all interlocking work (but not always with the block signals). Similarly the horizontal position of the distant signal indicates that the home signal may be expected to be at danger, and demands that the train proceed with "caution" and be immediately brought under control. For the "safety" or "all clear" or "proceed" position the blade is dropped through an angle

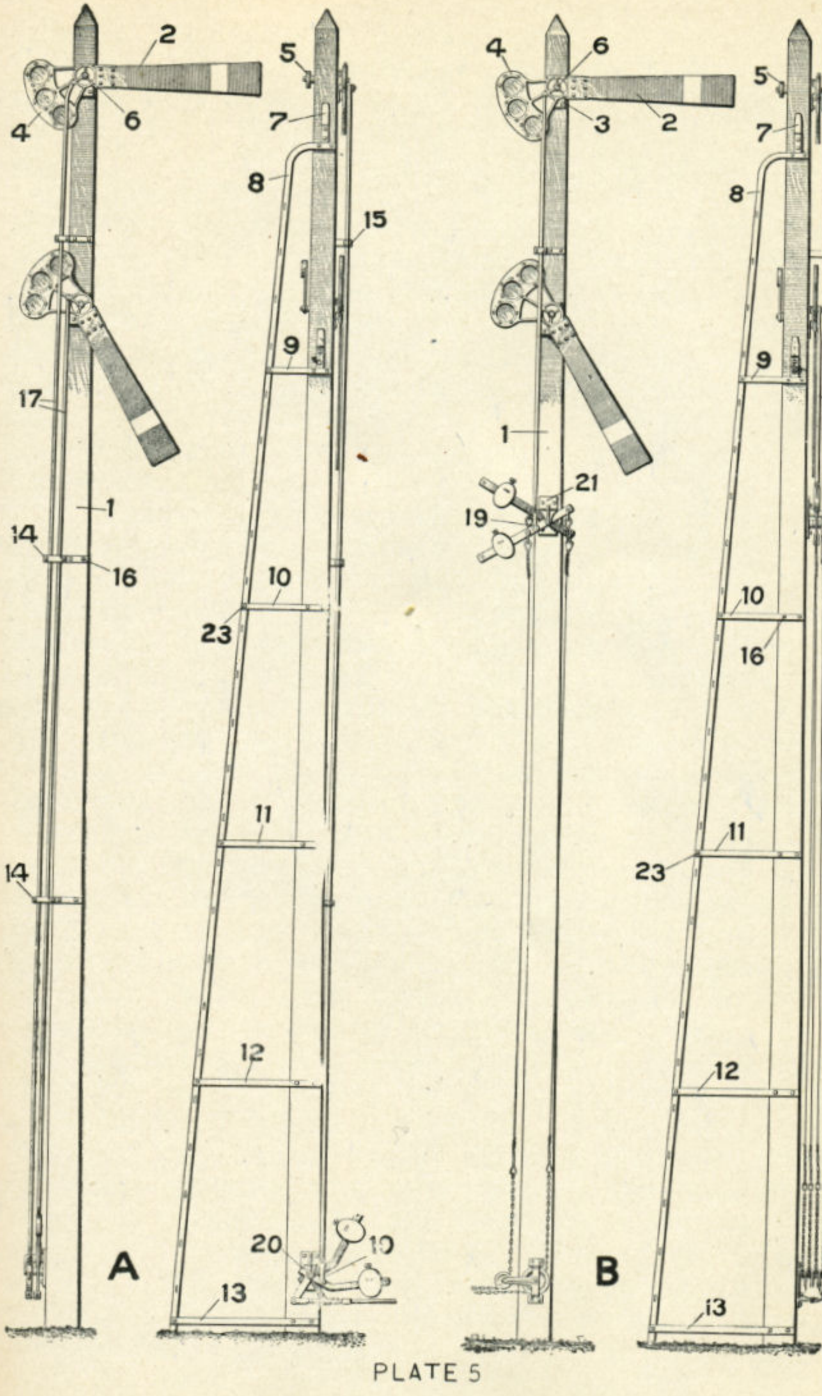

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PLATE 5

varying (on different railroads) from 45° to 90° from the horizontal; in the latter case care is taken to have it hang at the side and not in front of the post to which it is attached; an angle of about 60° represents the most common practice. Plate 5 shows a mast with two semaphores the upper at danger, the lower at safety. The home signals are very commonly painted red often with a white stripe across the blade near the outer end; the distant signals are often painted green, and frequently with a white stripe (fish-tailed like the end) near the outer end. The back of either home or distant signals is likely to be painted white.

Dwarf signals of the semaphore type are low signals with small and short blades; their use is generally confined to controlling train movements in the direction directly opposite to the general traffic at the point where a dwarf signal is used. The dwarf signal is frequently placed between the two tracks of a double track and the blade made of rubber so that it may bend if struck by a car step or other part of a moving train. Plate 1 shows a dwarf signal. For night signals a lamp is fixed to the post. An iron frame which is attached to the semaphore (at the other side of the pivot or pin upon which the semaphore turns) serves a good purpose as a balance to the arm; this iron frame consists of one or of two rings as shown in Plate 6. For the home signal a red glass is placed in one ring (even if there is only one ring) and in such position that when the blade is horizontal (danger) the fixed light shines through the red glass giving the red signal for danger, which is universally adopted for a danger signal both for railroads and for various purposes. The indication for safety differs on different railroads; some use green. Some use "white" (or common lamp) light; where green is used, the fixed light shines through green glass placed in the second ring; where

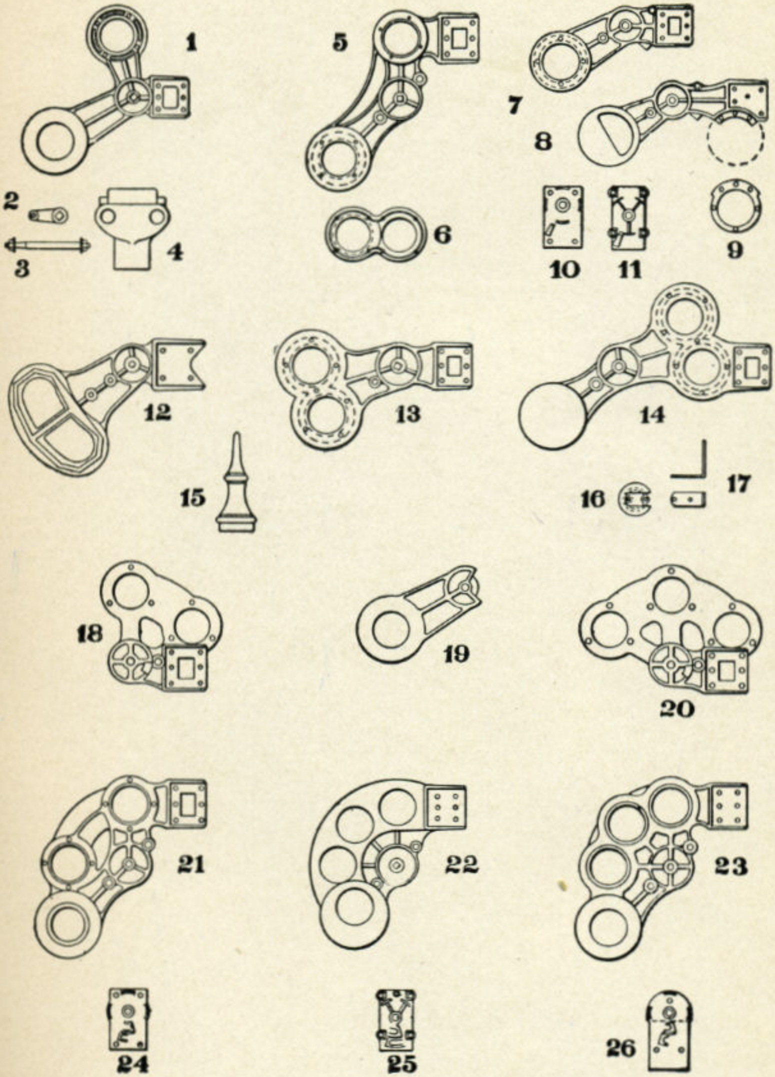

PLATE 6

white light is used the second ring is unnecessary. There is evidently a growing tendency to favor the use of a green rather than a white light for safety. The 1902 Statistics compiled by the American Railway Association establishes this fact. The objections to the white light for safety is that neighborhood lights may be mistaken for signal lights and that a broken red glass will result in a "safety" signal being given when "danger" should be displayed whereas good practice demands that defective apparatus shall cause a danger signal to be displayed. The objections to the green light are that it is not visible so far or so clearly as the white light and that it is difficult to find a third color to use for "caution", which is desirable for instance, at the distant signal when its semaphore is horizontal. Experiments made with "Nels yellow" glass have convinced many railroad men of its fitness for this purpose. Such experiments were made at the Institute, and were considered favorable to its use. The New York, New Haven & Hartford has seemed satisfied with this combination of green and yellow for colors, and other railroads also use them. There is a probability of their use being largely extended. Accordingly, the practice most favored seems to be to use red light for "danger", green light for "all clear" and yellow light for "caution". For the home signal then the red light corresponds to the horiaontal position, and the green light to the inclined (or the vertical) position (in interlocking). For the distant signal the yellow light corresponds to the horizontal position and the green light to the inclined (or the vertical) position. Otherwise stated red light indicates "danger" or "stop", green indicates "all clear" or "proceed" and yellow light indicates "caution" or "proceed under complete control". Some roads use red for "danger" green for "all clear" and a combination of red and green for "caution". Many

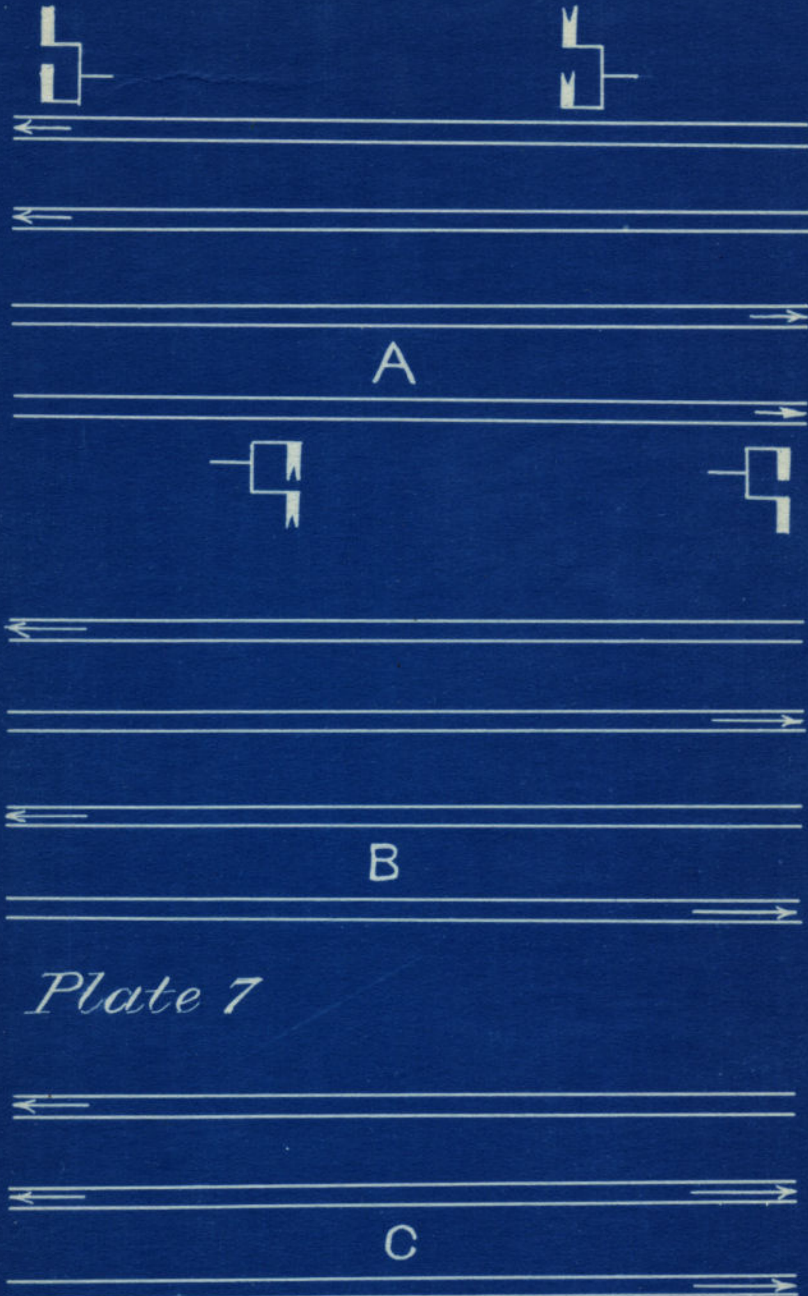

Plate 7

roads still adhere to the older practice of red light "danger" white light "all clear" and green light "caution". As to the position of the signal home or distant, approved practice for single or double track railroads is to place a post at the right of the track (trains run right-handed) and to have the semaphore arm project to the right of the post. (This will bring the lights just to the left of the post for night signals). In the case of an interlocked crossing (as shown) there will be one signal only upon a mast. In the case of a branch or turnout it is customary to put two semaphores upon the same mast, sometimes of equal size, sometimes with the larger for main line and the smaller for the branch or siding. A common arrangement is for the upper signal to control main line and the lower the side line. Sometimes three signals are placed on one mast but this is less common in more modern practice. Where three signals are used the practice is not uniform.

Practice A. Top signal controls main or fast line. Next signal below controls line of next importance. Lowest signal controls line of least importance.

Practice B. Top signal controls main or fast line. Next signal below controls side line to right. Following signals control side lines towards the left in regular order.

Practice C. Top signal controls line to extreme right. Next signal below controls line next to this and to the left. Lowest signal controls to extreme left.

For a four track route the arrangement may be one of two described below.

1. The semaphore arms are mounted on bracket posts; where the trains run as indicated in Plate 7 (Fig. A), the arrangement of signals would be as shown in that figure. On some railroads the signal for the higher speed trains would be set at a higher elevation than the other (6 or 7 ft. higher) as indicated in Plate 8, (Fig. 26).

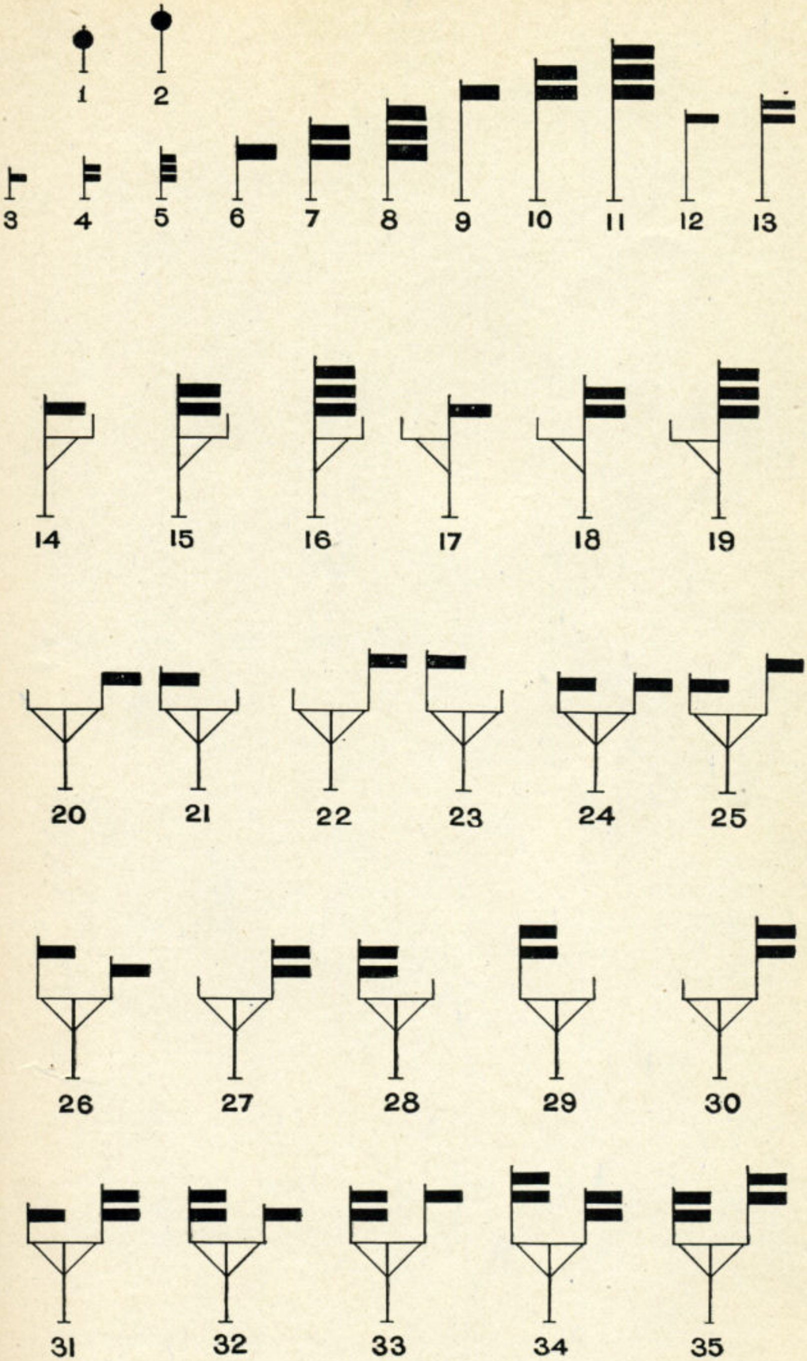
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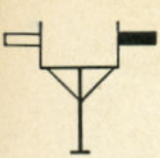
PLATE 8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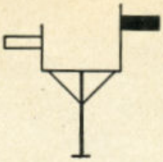
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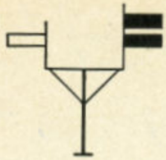
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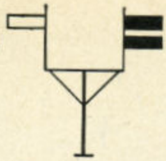
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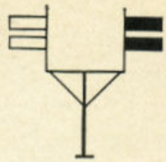
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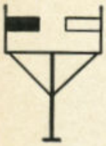
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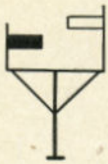
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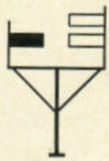
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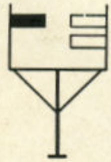
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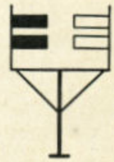
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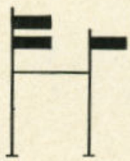
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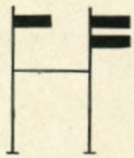
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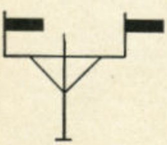
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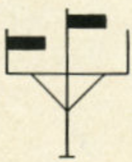
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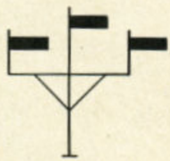
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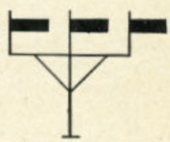
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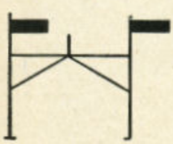
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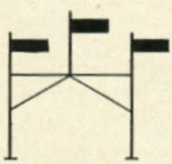
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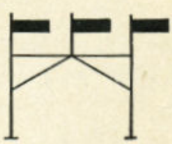
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PLATE 9

Where the trains run as indicated in Fig. B, Plate 7. The signals may well be arranged the same as in Fig. 1; this is also true for the case of three tracks, where the middle track is used sometimes in one direction, sometimes in another.

Another approved arrangement is to set the signals upon a bridge, in which case the signal is placed over or nearly over the track to be controlled (2 ft. to right of right-hand rail upon the Baltimore & Ohio). Here sometimes the high speed signal is placed higher than the other. Distant signals would be mounted in a similar way. (All this refers to Interlocking and may or may not apply to Block Signals).

Plates 8 and 9 show various arrangements of signals on posts and on brackets.

Interlocking is also necessary, and is largely used, at branches, turnouts, and junctions, and the problem here is somewhat different. An example will best illustrate as shown in Plate 10.

Little explanation appears necessary here in addition to what is shown on the plate. One lever 5 can properly throw two switches as both must be removed to pass a train from S to W, and it is customary to use one lever for these two switches. Home signal 2 (top) controls main line and signal 3 (below) controls the branch. The more common and best practice appears to be for distant signal 1 to show "all clear" only when main line is clear. Trains, therefore, must always approach with "caution" when they intend to take the branch line. It is not uncommon to omit the distant signal 10 as all trains on the branch are expected always to approach the main line with caution and under complete control.

Modern practice also demands that all "facing point switches" shall have a "facing point bolt" to make sure both that the switch is fully thrown and also that it shall remain in place while the train passes over it. Many

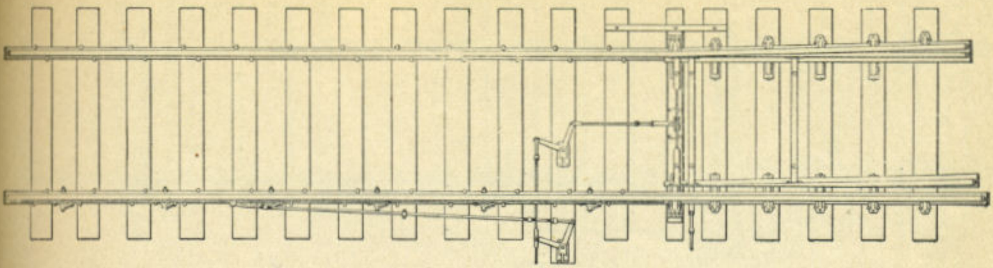
TABLE OF INTERLOCKING

LEVER	LOCKS	RELEASES
1	2	
2	4	1
3	4	
4	5-3	2
5	4-6	9
6	5	7
7	6	8
8	7	
9	5	10
10	9	

COMBINATION SHEET

ROUTE	LEVERS
W. to E.	4-2-1
W. to S.	3-
E. to W.	6-7-8
S. to W.	5-9-10

Plate 10



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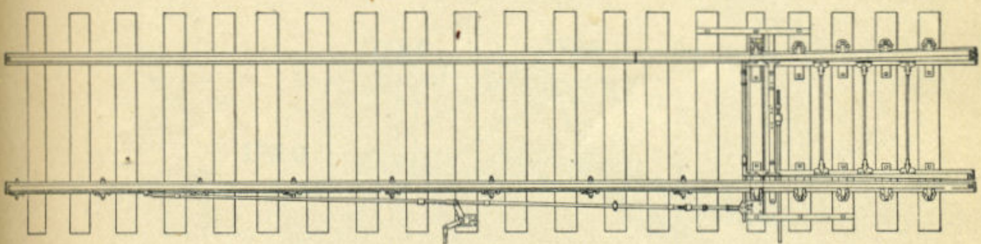

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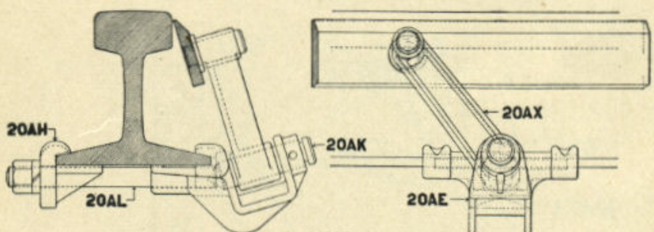

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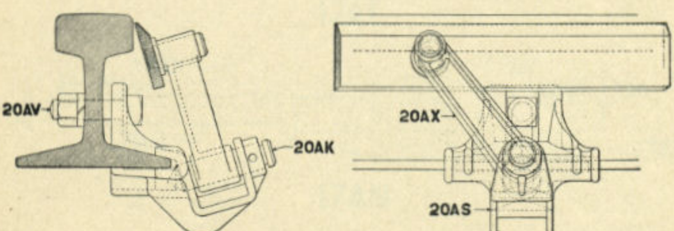

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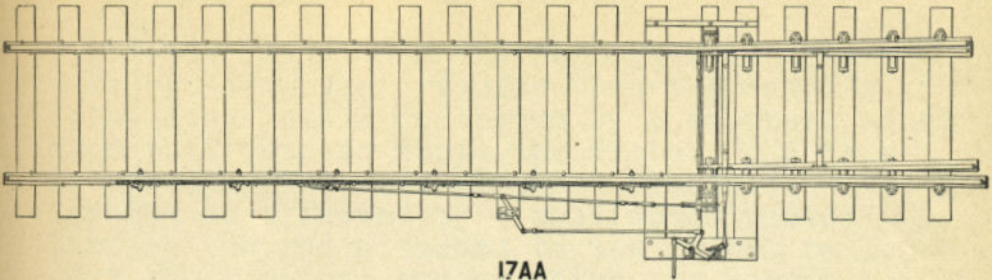
PLATES 11-12-13



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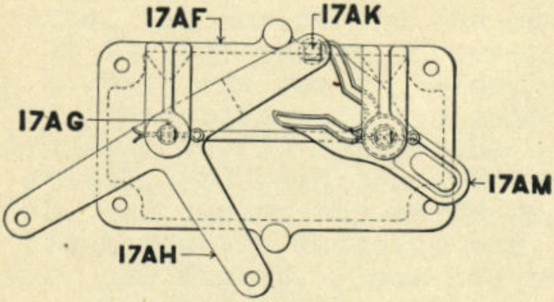
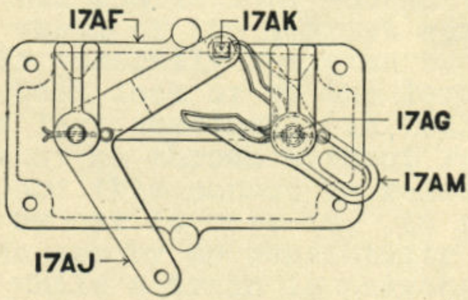
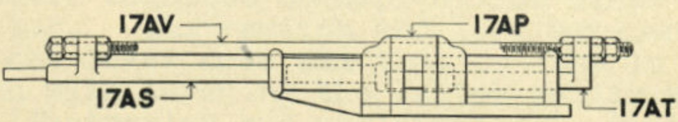


17AD



17AE



17AN

railroads among them the "Pennsylvania Lines west of Pittsburg" require that the "facing point lock" shall be thrown by a separate lever from that used to throw the switch, and this is probably the most advanced practice. The locking is effected by a bolt which passes through the rod attached to the switch rails near their point, and by which the switch is moved. The bolt hole is sometimes about half way between the rails but the best practice probably is to have the bolt hole (or the locking) outside the track. Plates 11 and 12 show two forms, the inside and the outside locking. It is very common, however, in interlocking to have one lever perform several functions in connection with the switch, or more specifically to (1) remove the bolt, (2) throw the switch, (3) bolt the switch in the new position, and during the three processes mentioned (4) throw the detector bar. The detector bar, see Fig. 2, Plate 13, is a long bar which is attached to the rail close to the switch rail, and has its upper surface at the level of the rail and is long enough to reach from wheel to wheel of the longest car. The detector bar is generally operated by the lever for the bolt lock or by the lever for the switch and lock combined; it follows that the switch cannot be thrown without raising the detector bar, and this cannot be raised while the wheel of any car is over it; it follows that the switch can by no possibility be carelessly thrown while a train is passing over it. The ordinary "facing point bolt" worked alone by a lever requires no explanation other than by sketch. The "switch and lock movement" by which one lever does all that is done in connection with throwing the switch requires special illustration and explanation. Plates 14 and 15 together show fairly well how the movement is effected by the Standard Signal Company. The first movement of the crank withdraws the bolt and also raises the detector bar. As the crank continues its movement, it acts upon A M which throws the switch, after

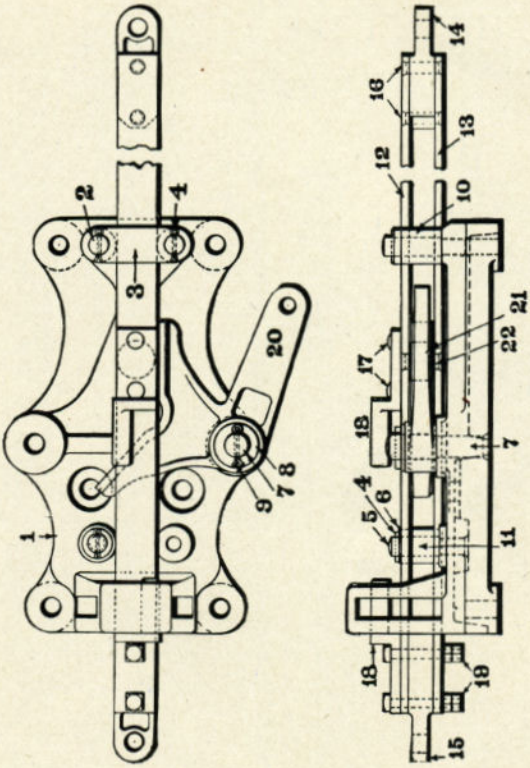


PLATE 19

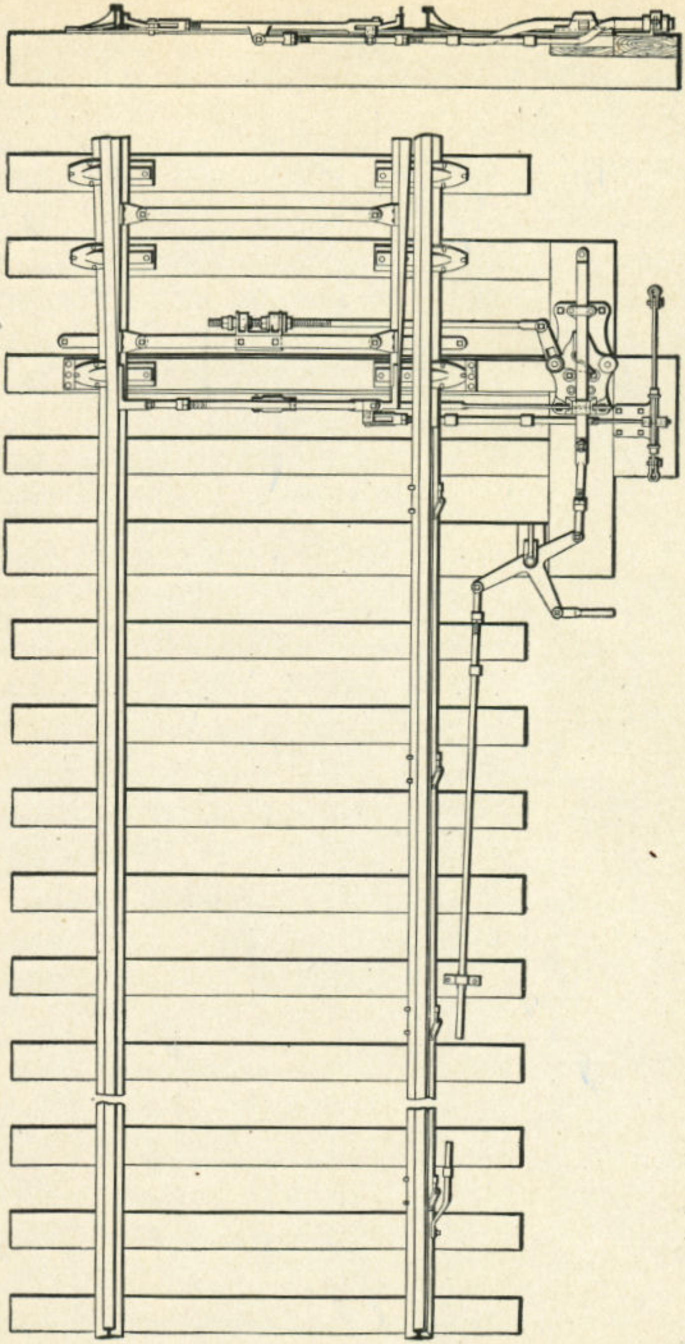
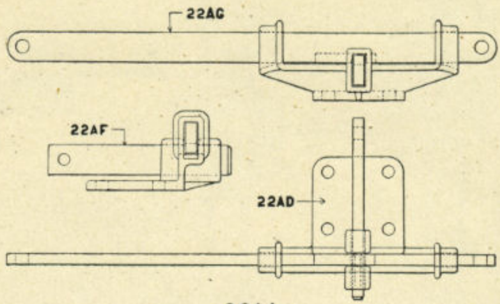


PLATE 20

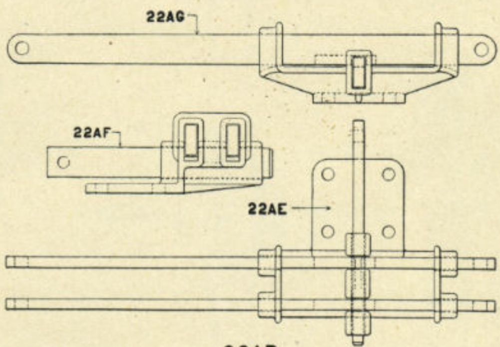
the continued movement of the crank acts only on the detector bar (which drops into its new position) and on the bolt which by its further travel, locks the switch in its new position. Plates 17 and 18 show a similar arrangement formerly in use by the Johnson Signal Company, and Plates 19 and 20 the same for the Union Switch and Signal Company. Some engineers' objection to the switch and lock movement is that only a short movement is available and when the connections are long, it is possible that the pipes may spring enough to allow the lever to be thrown home, even when the switch has not been thrown enough to allow the locking to be affected. Therefore, some railroads specify a separate lock movement, but even this has sometimes failed because of a break in a switch connection, so that although the switch had not been thrown, the bolt was pushed home, but into the same hole; an arrangement of square and round holes has been used to prevent this. Some competent signal engineers consider the switch and lock movement safe up to 500 feet from the tower.

An arrangement which is common for the purpose of meeting this difficulty is to have the wire (a pipe is sometimes used) to the home signal interlocked (at the switch) with the switch rod, so that the home signal cannot be thrown to safety unless the switch is in place. Such an arrangement is shown in Plates 20,21,22,23.

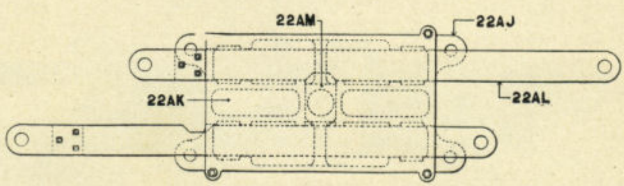
The connection from switch (or from facing point lock) to the lever (at the signal cabin) is made by pipes, about 1" in diameter, usually. Bell cranks as shown in Plate 25 serves to secure change of direction. Where the length is considerable, some provision must be made to compensate for expansion or contraction. The common arrangement is by a "lazy-jack" compensator placed midway between lever and switch. Plate 25. A simple lever will serve the purpose, but requires a shifting of line. If circumstances allow a bell



22AA



22AB



22AH

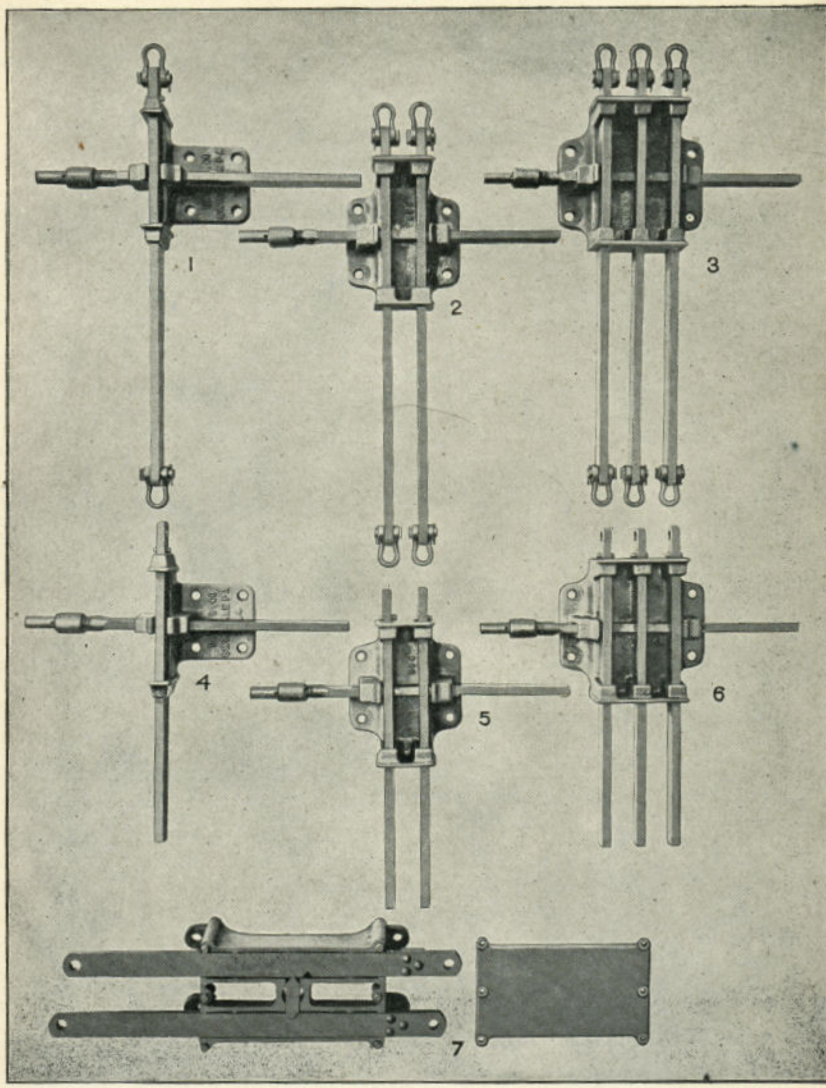
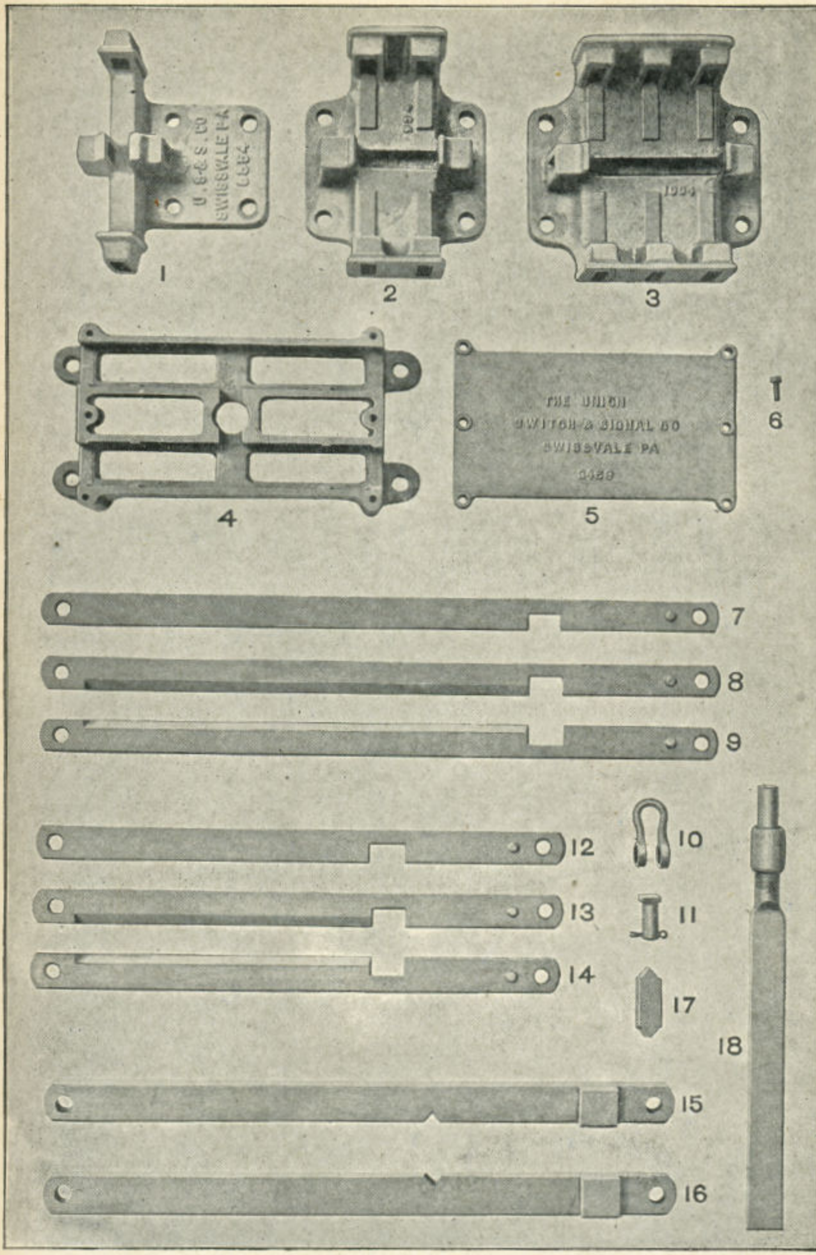


PLATE 22


1
2
3
4
THE UNION
SWITCH & SIGNAL CO
SWISSVALE PA
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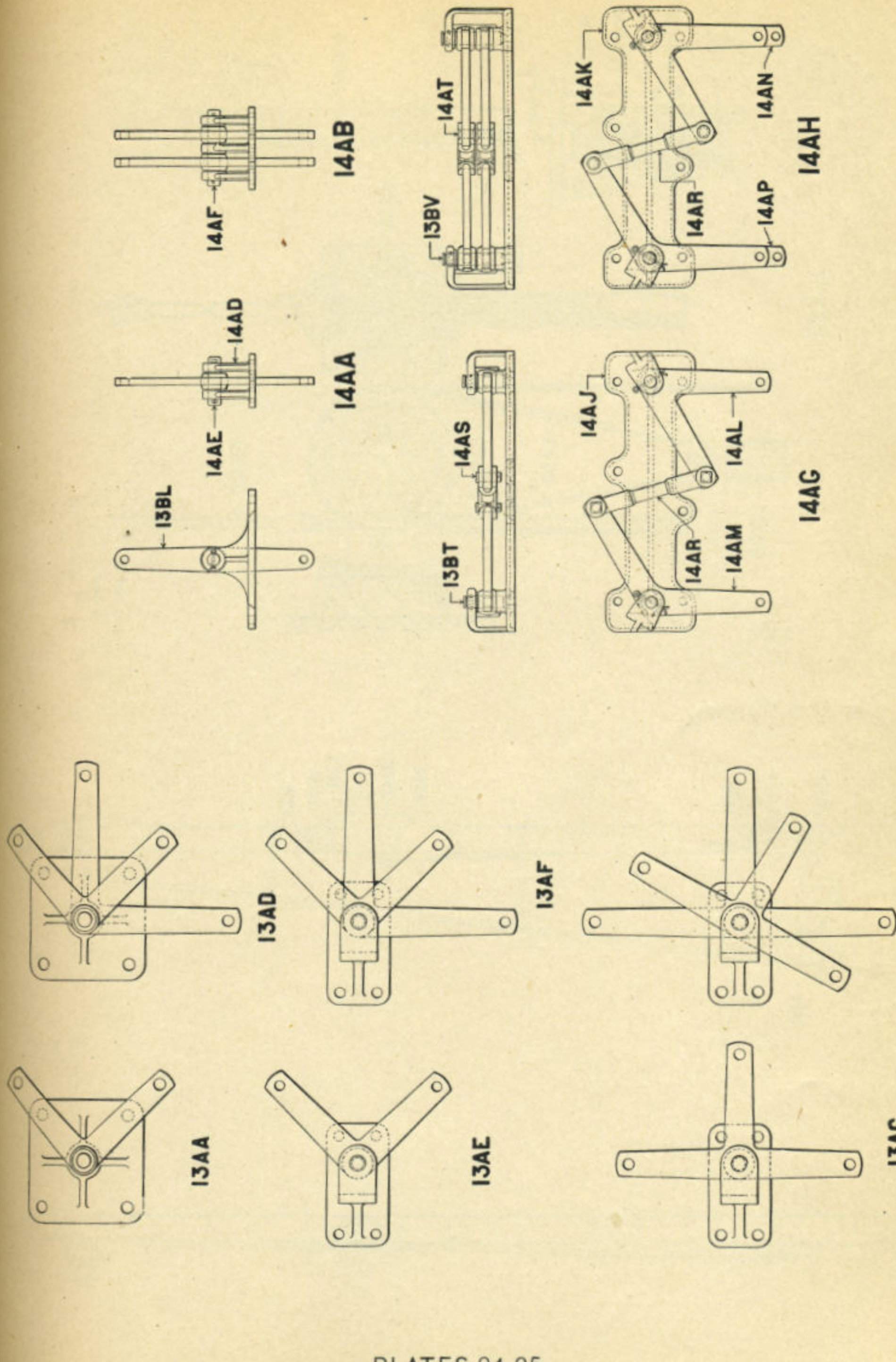
18

PLATE 23



14AB
14AF
14AA
14AE
14AD
13BL
14AT
13BV
14AS
13BT
14AH
14AK
14AN
14AR
14AP
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14AJ
14AL
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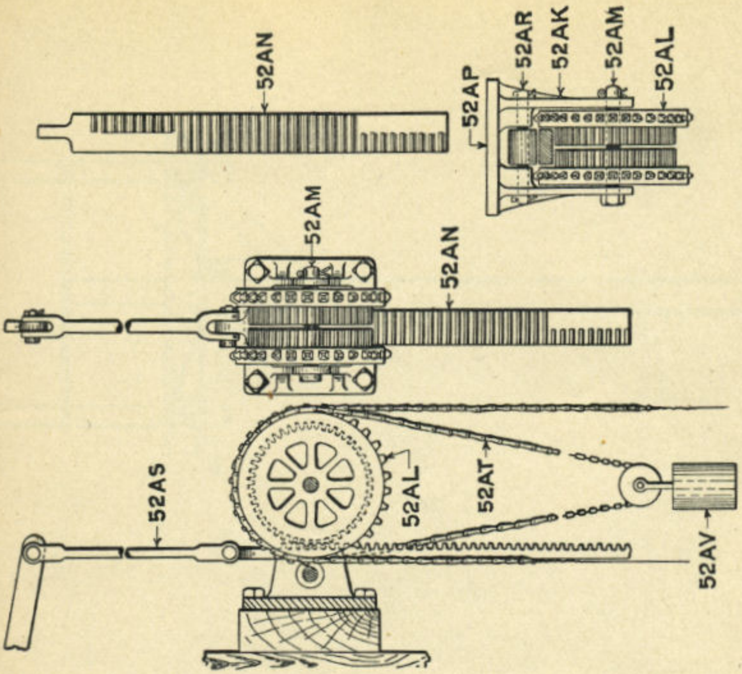
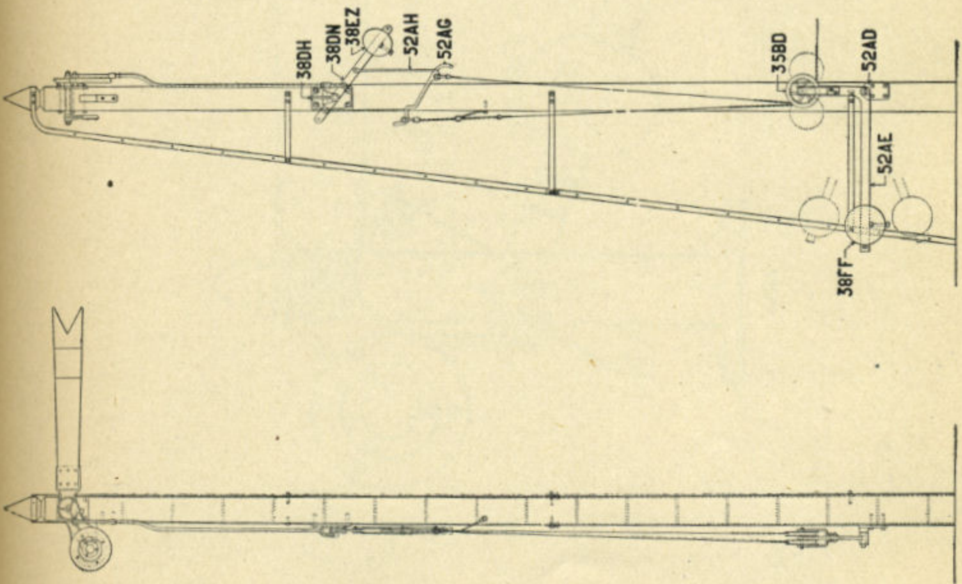
14AM
13AD
13AF
13AH
13AA
13AE
13AG

PLATES 24-25



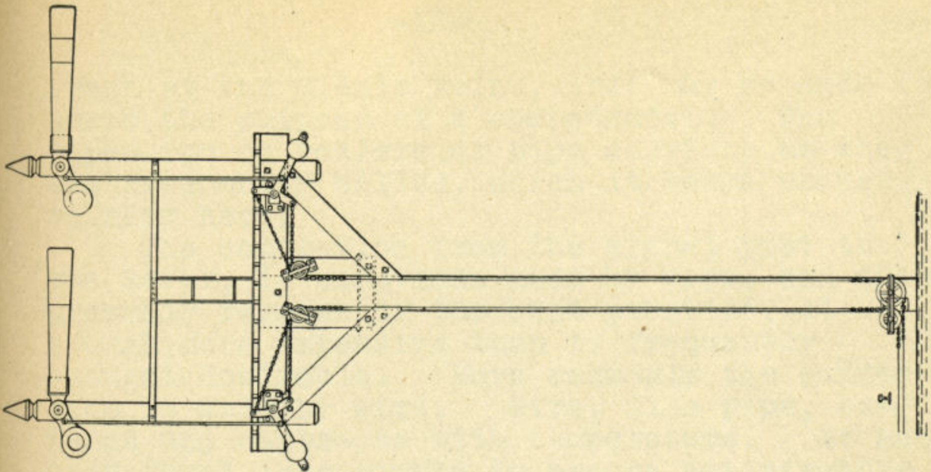
52AN
52AR
52AK
52AM
52AL
52AP
52AM
52AN
52AS
52AL
52AT
52AV

52AJ

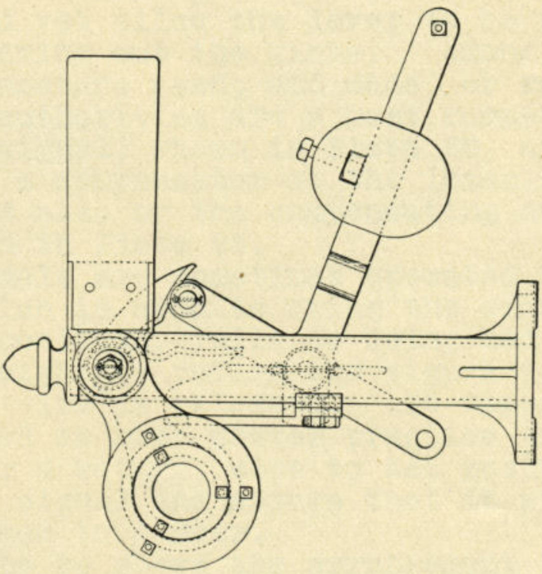


38DH
38DN
38EZ
52AH
52AG
35BD
52AD
52AE
38FF

52AA



39AA



42AA

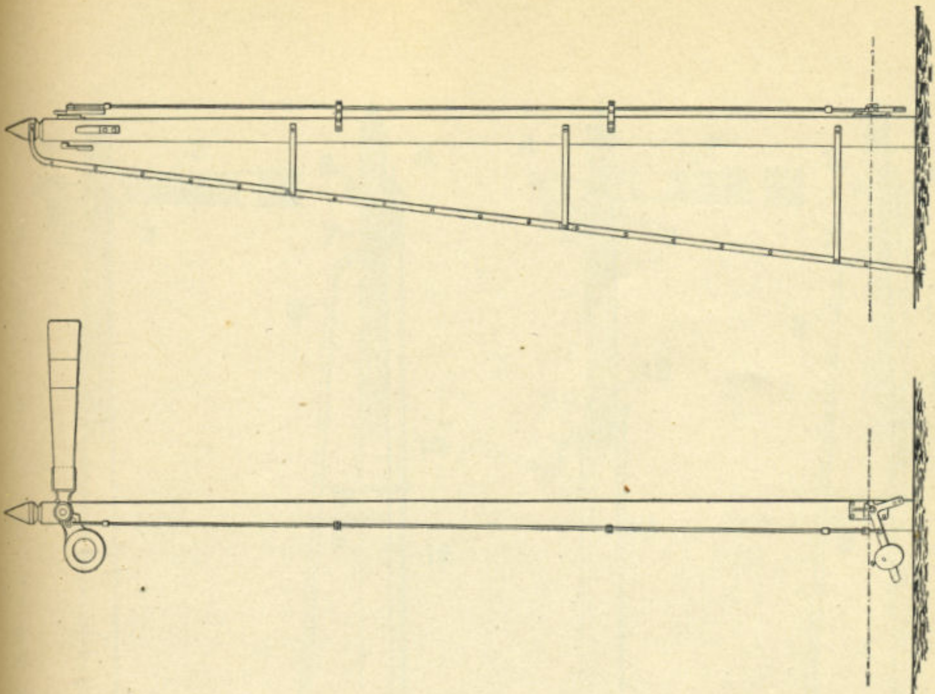
PLATES 28-33

crank at the middle point, this may be made to serve the purpose of a compensator. The pipes run on rollers or pipe carriers as they are frequently called, which it seems unnecessary to show here.

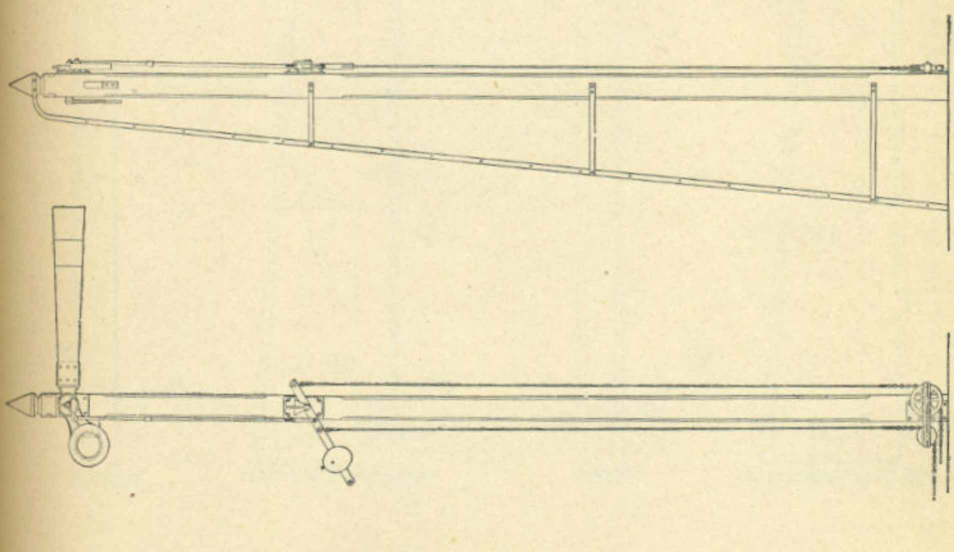
The connection from the signal post to the lever, is sometimes made by pipe, and this probably represents the best practice, although more expensive than is frequently thought desirable. More commonly the connection is made by wire. Wire, like pipe, expands and contracts with temperature. It has been found less simple to secure satisfactory compensators for wire, and many of the compensators introduced have failed to prove satisfactory. As a result there has been some indisposition to use them, and a few years ago, one prominent signal company advised dispensing with wire compensators, depending on the bending and kinking of the wire to take up slack and yet allow the lever to be pulled by straightening out the kinks. Among the forms of compensators used, and made, or recommended by good authorities are a post compensator at distant signal, shown in Plate 26, and by Plate 27 a compensator at the interlocking tower and also by the compensating dwarf signal shown in Plate 28.

Signals are sometimes operated by a single wire, which is used to bring the signal to the "clear" position, reliance being had upon the counterweight to return the signal to danger, when the wire is released. It appears to be recognized as much better practice to have a second or a return, wire to act positively upon the signal and assure that it will be pulled back to danger.

Plate 29 shows the arrangement of counterweight and wires for a wire connected semaphore signal and Plate 30 for a pipe connected signal, both of these as arranged by the Standard Signal Company. Plates 31 and 32 show similar arrangements for the Union Switch and



38AM



38AA

PLATES 29-30

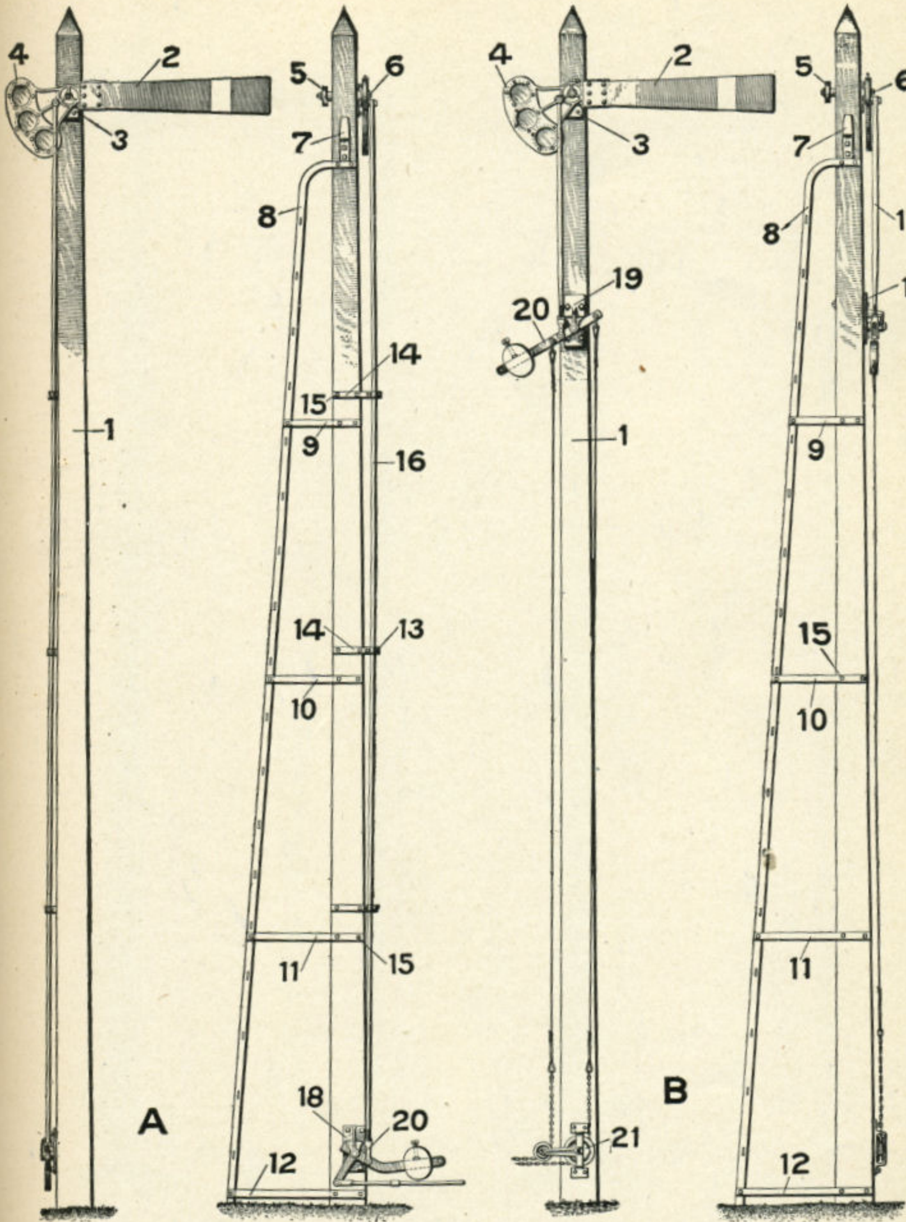
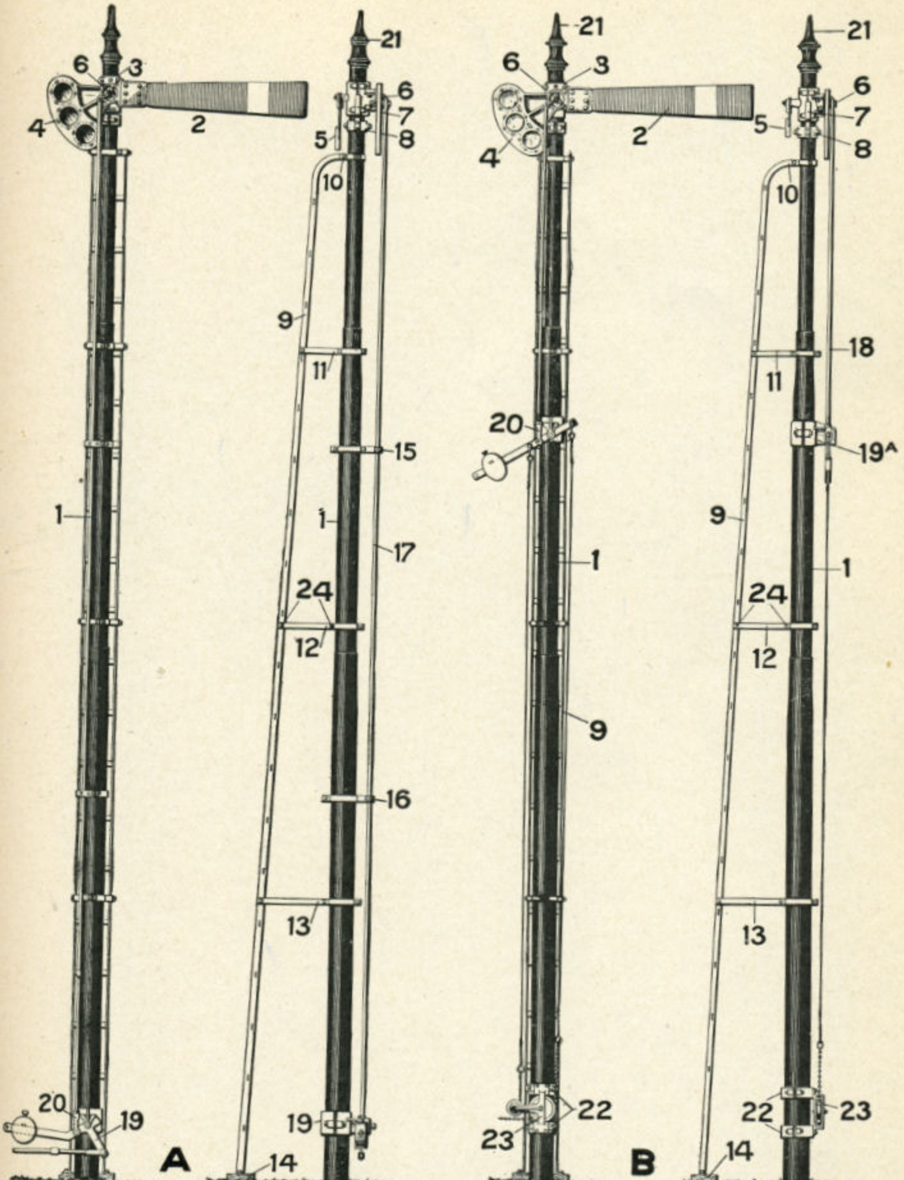


PLATE 31


6
3
4
2
1
20
19
A
21
6
7
5
8
10
9
11
15
1
17
24
12
16
13
19
14
21
6
3
4
2
20
1
9
22
23
B
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6
7
5
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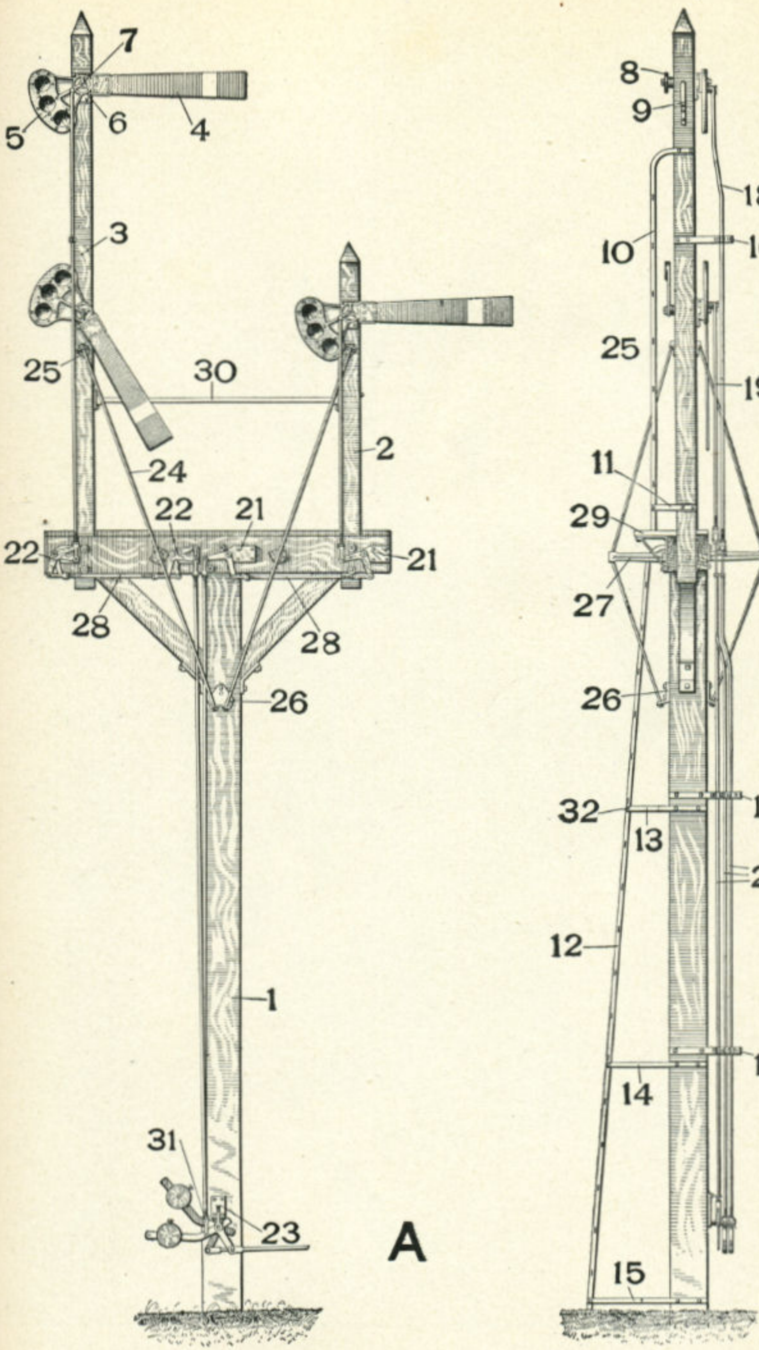
10
18
11
19^
9
1
24
12
13
22
23
14

PLATE 32


7
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25
30
24
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21
28
28
26
1
31
23
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15

A

PLATE 34

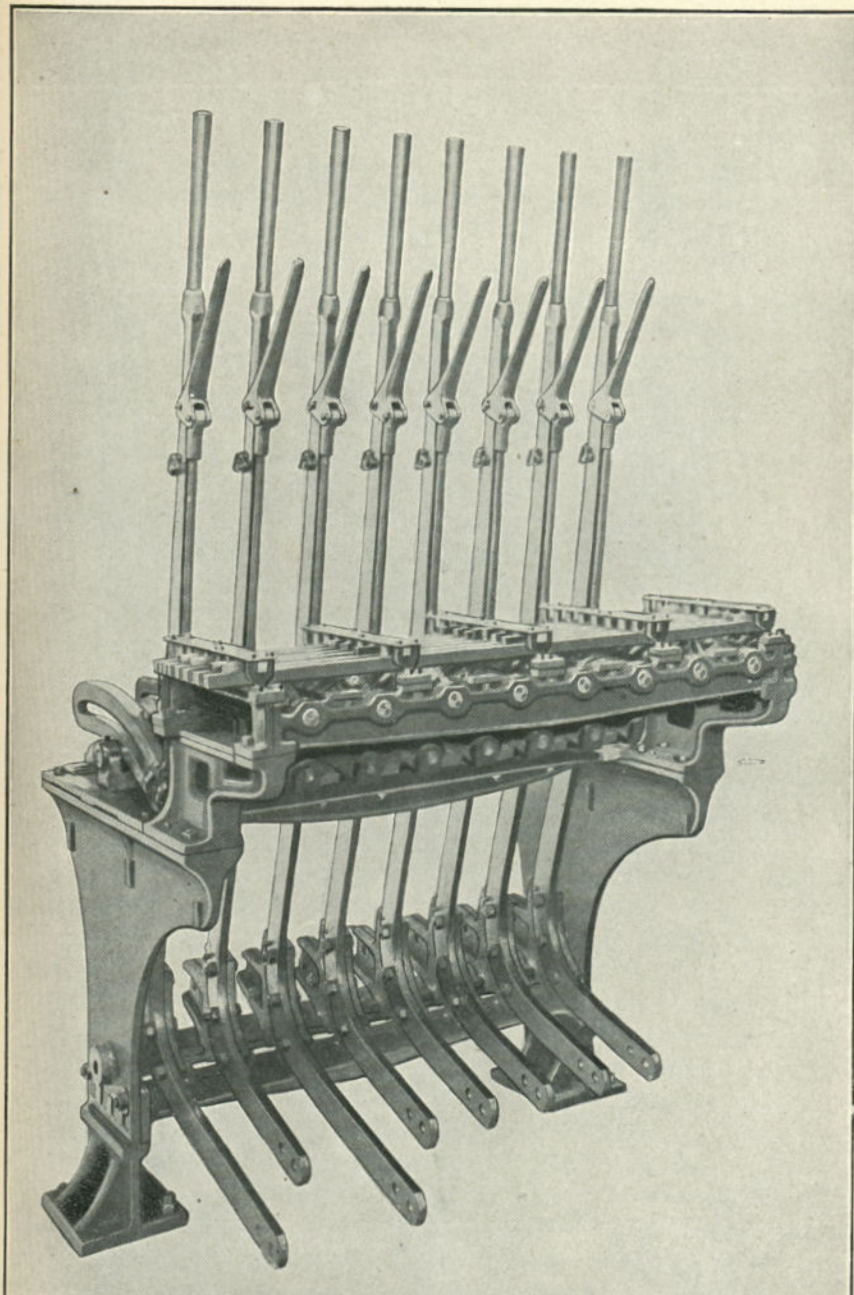


PLATE 35

Signal Company. Plates 33 and 34 show bracket signal, one for pipe connected and one for wire connected signals.

The levers with which the signals or switches or bolts are connected, are placed side by side, or in a row in an "interlocking machine" arranged in such a way that certain levers only can be moved at any time, depending on the position of other levers.

Plates 35 and 37 show different views of what is known as the "Saxby and Farmer" machine, as made by the Union Switch and Signal Company.

If the front of the machine be the side where the levers are placed, then the interlocking will be effected by the horizontal bars shown in Plate 35 at the top of the machine and back of the levers. Each of these bars is connected with one of the levers in such a way that when that lever is pulled outward, the bar is carried longitudinally a short distance, and is brought back to place when the lever is returned to place. Attached to each bar are certain lugs or "dogs" arranged in such a way that they interfere with the lugs or "dogs" on certain other bars, preventing these second bars from being moved after the first bars have been moved; since bars and levers move together the interference of lugs prevents movement of the second lever as well as movement of the second bar. Actually the "bars" are interlocked; practically the "levers" are interlocked which is the common way of expressing the idea. Referring to Plate 36 and 37, the lever cannot be moved until the latch is thrown as the latch rod bears against a shoulder as shown in Plate 38. Throwing the latch, however, raises the right hand end (and lowers the left hand end) of the rocking link (pivoted in the centre); a short connecting piece p reaches a crank arm, Plate 37, attached to a square rod which runs from front to back under the inter-

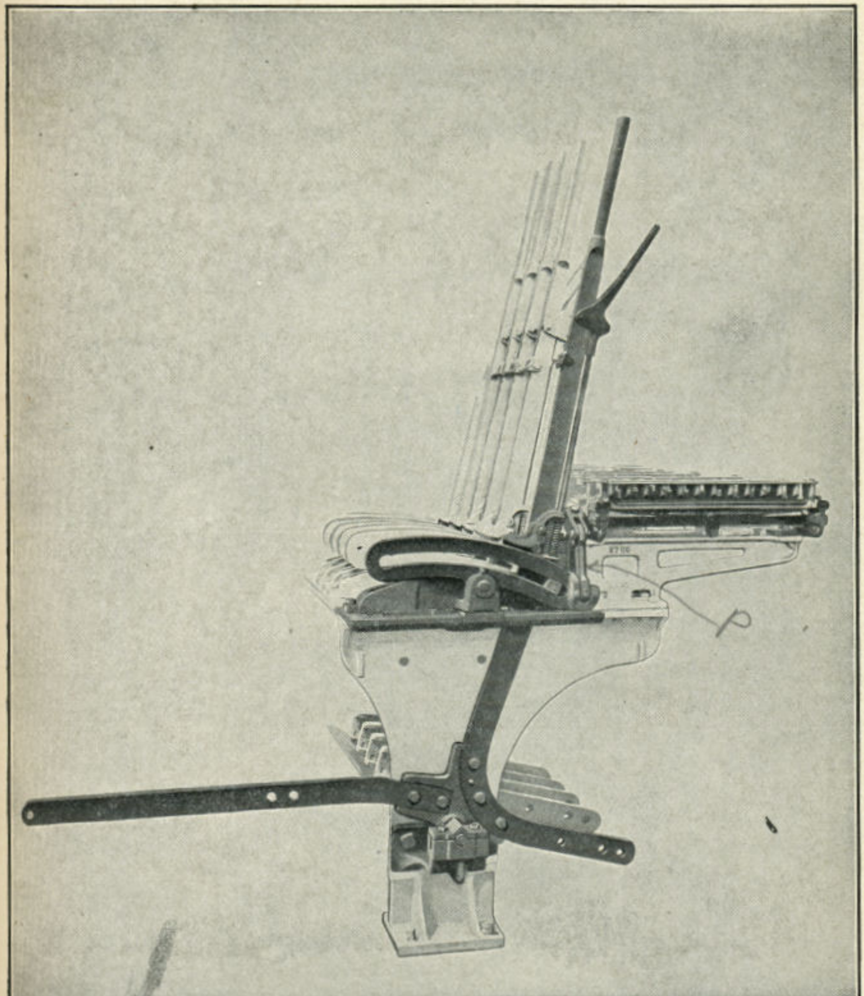


PLATE 37

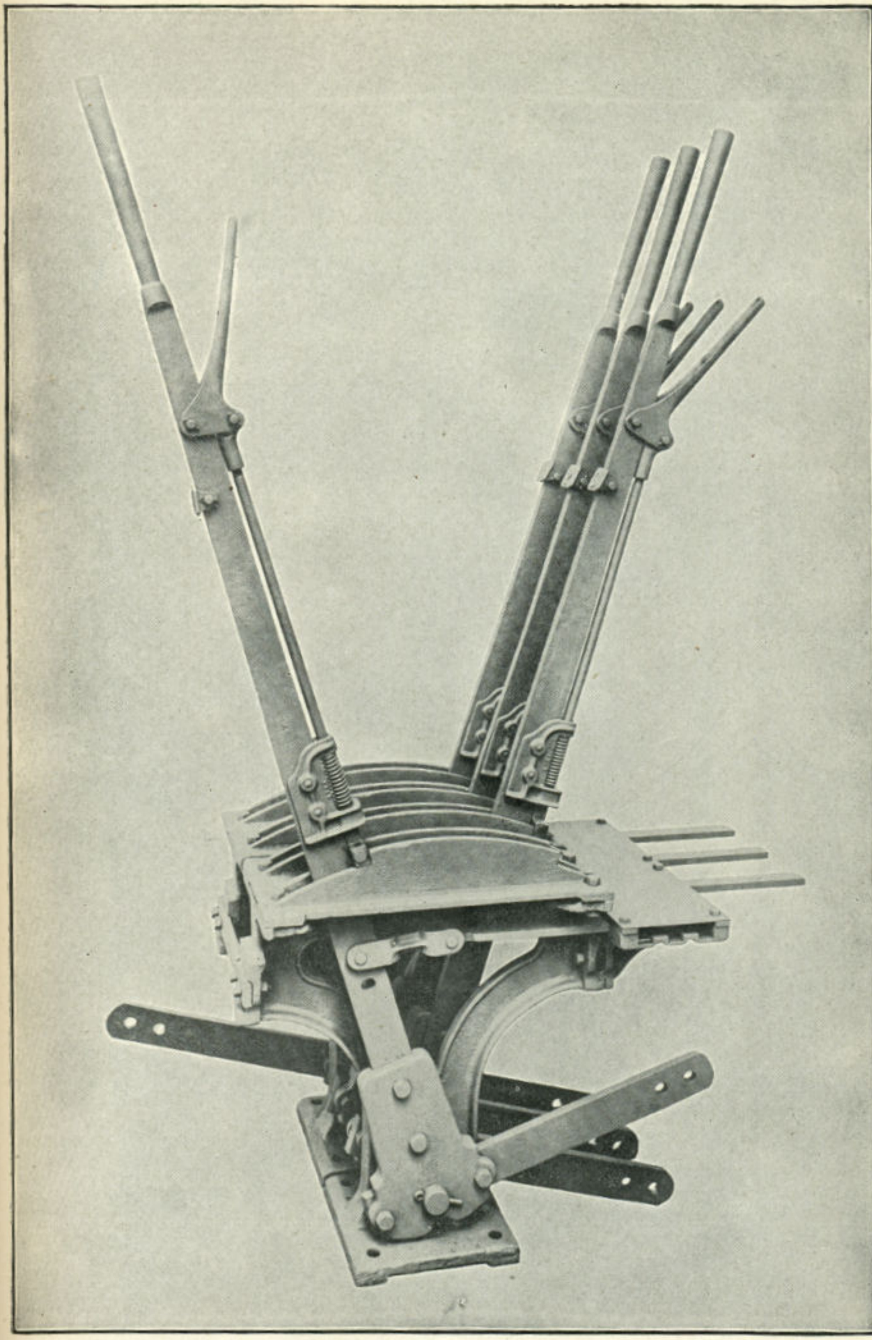


PLATE 38

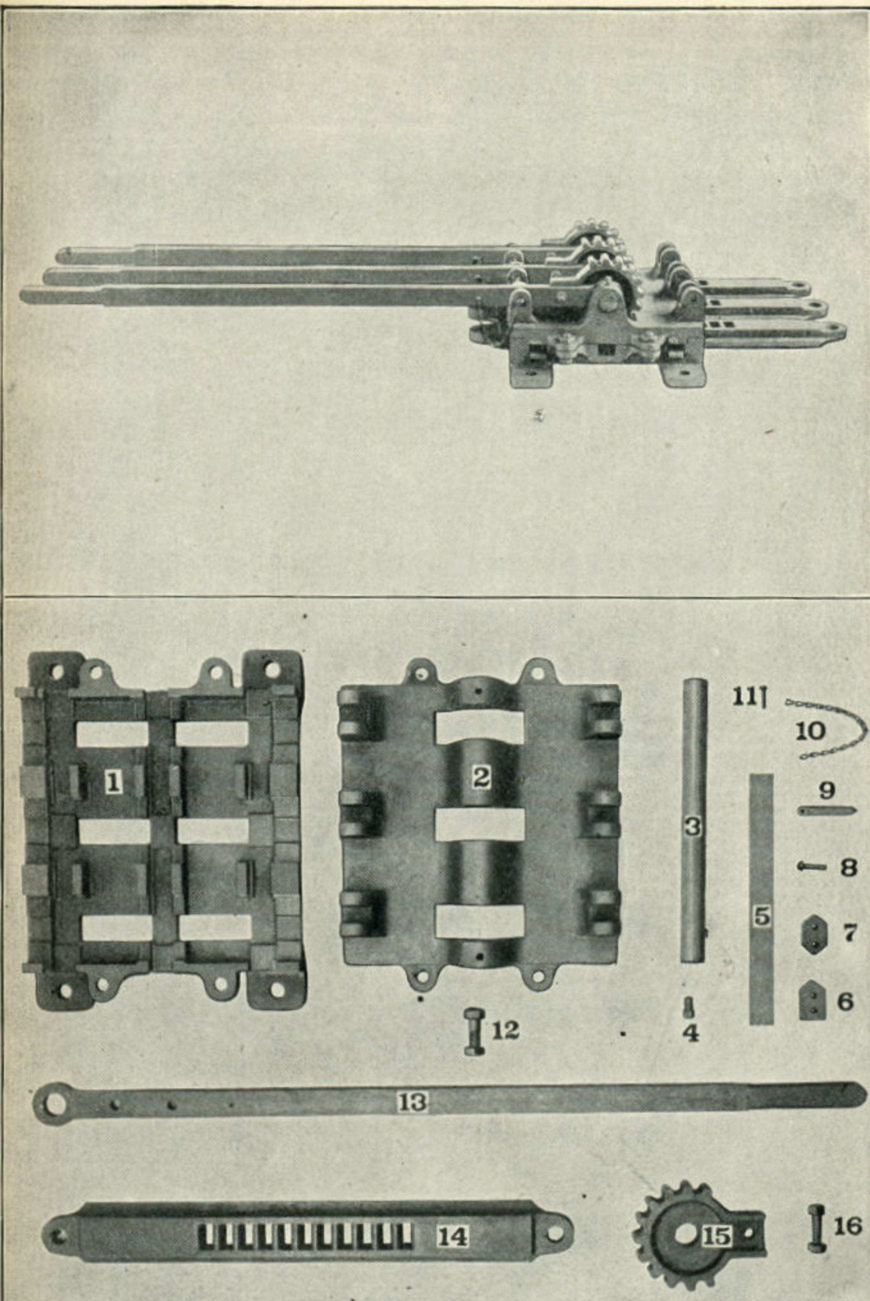
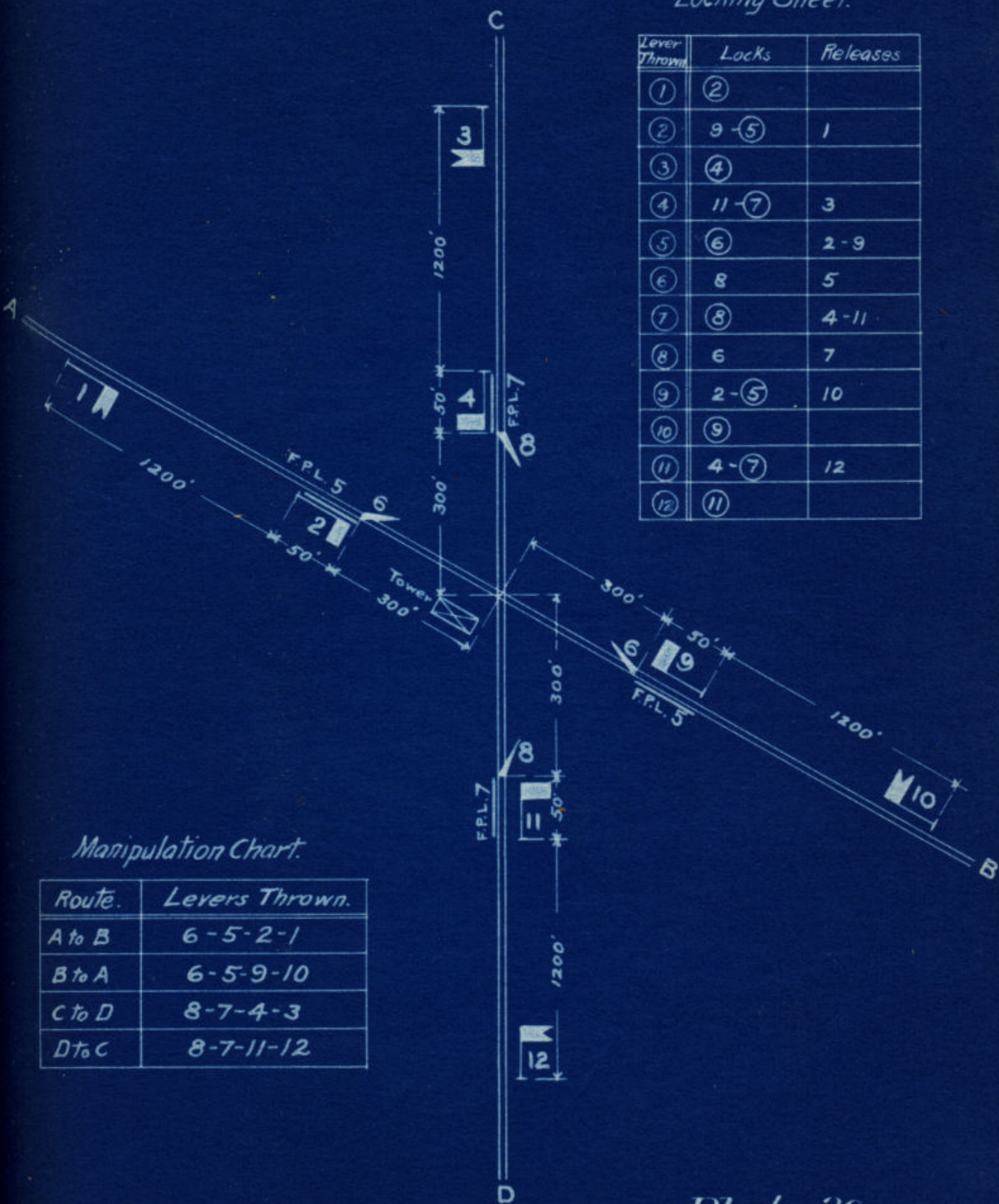


PLATE 38A

locking bars; lifting the piece p causes rotation in the rod which is connected to its appropriate bar and thus moves the bar along a short distance in which position it remains until the lever is fully thrown. During the travel of the lever the rocker is not further moved, but the release of the latch further depresses the left end of the rocker, and equally raises the right end of the rocker, throwing the interlocking bar further and completing the locking. It should be noted that the latch movement moves the bar far enough to interlock all bars whose levers conflict at all with the lever thrown, and it is not until the stroke of the lever is completed, and the latch down, that the result is accomplished not only of locking certain levers, but also of releasing certain other levers whose movement should follow (but never precede) that of the first lever. This latch movement accomplishing the result stated, is called "preliminary locking" which is valued in this country as an important feature from the safety standpoint. Plate 38 shows a form (The Stevens Machine) in which this feature is lacking, and which has the merit of greater economy and simplicity and makes it suitable for use for siding and yard work. For such purposes the machine is sometimes interlocked, sometimes not. The preliminary locking is considered essential for good practice in this country, but some very large and important installations have quite recently been made in Great Britain without this feature.

A somewhat better idea of the interlocking seems desirable and Plates 39- 40 - 41 - 42 show first a diagram of a single track crossing another single track, together with the "combination sheet" or "manipulation chart" and the "table of interlocking" or "locking sheet" on Plate 39. Next in order Plate 40 shows by single lines the levers, and also by single lines the bars with which they are connected each marked here by the same number as its lever, and with a small dot or

Sketch of a Single Track Crossing showing Arrangement of Signals for Interlocking



Locking Sheet.

Lever Thrown	Locks	Releases
1	2	
2	9 - 5	1
3	4	
4	11 - 7	3
5	6	2 - 9
6	8	5
7	8	4 - 11
8	6	7
9	2 - 5	10
10	9	
11	4 - 7	12
12	11	

Manipulation Chart.

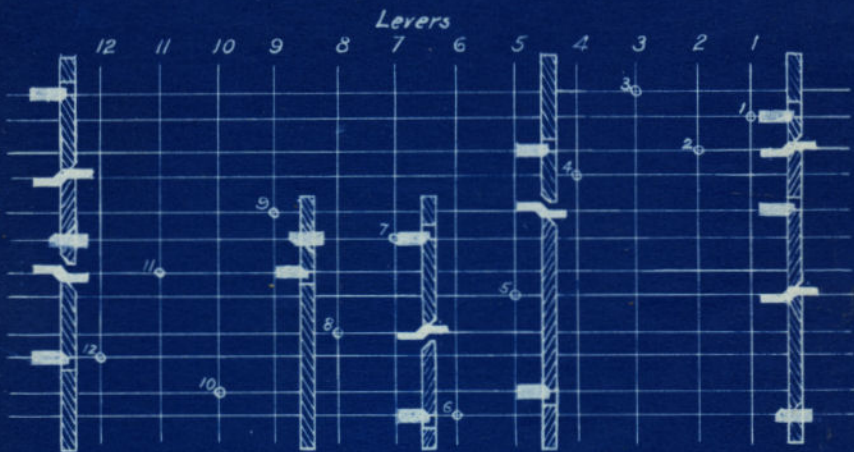
Route.	Levers Thrown.
A to B	6 - 5 - 2 - 1
B to A	6 - 5 - 9 - 10
C to D	8 - 7 - 4 - 3
D to C	8 - 7 - 11 - 12

Plate 39

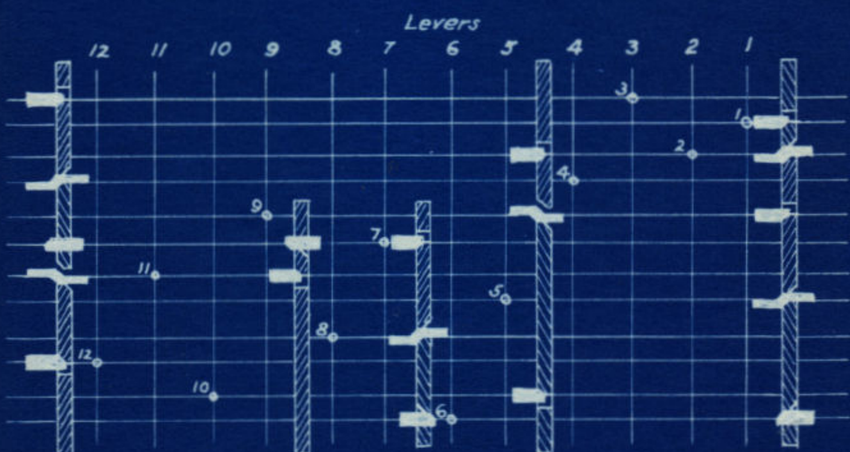
Saxby & Farmer Machine

DOG SHEETS

ROUTE A-B.



NORMAL



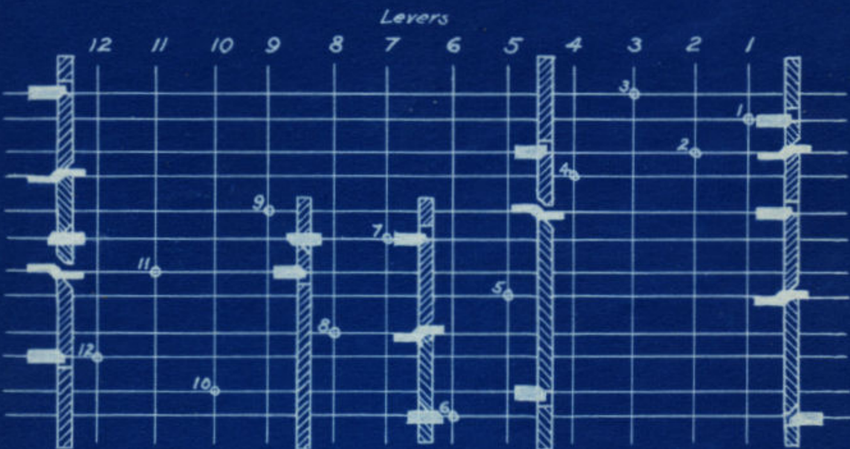
LEVER 6 HALF THROWN

Plate 40

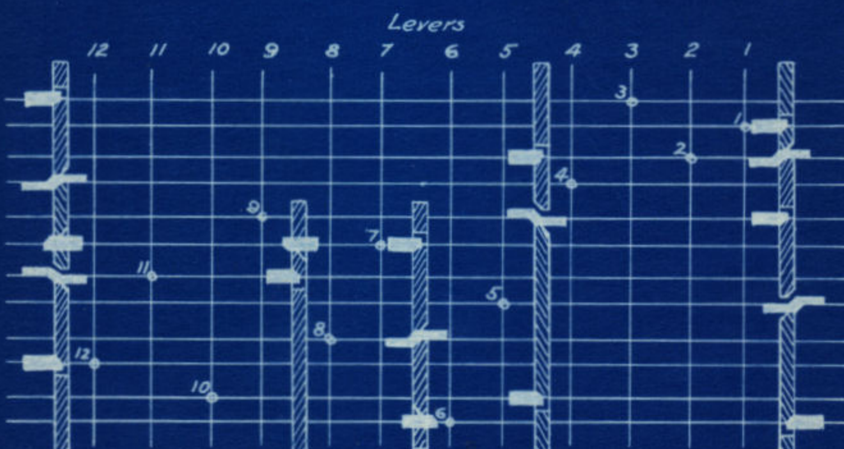
Saxby & Farmer Machine

DOG SHEETS

ROUTE A-B.



LEVER 6 THROWN



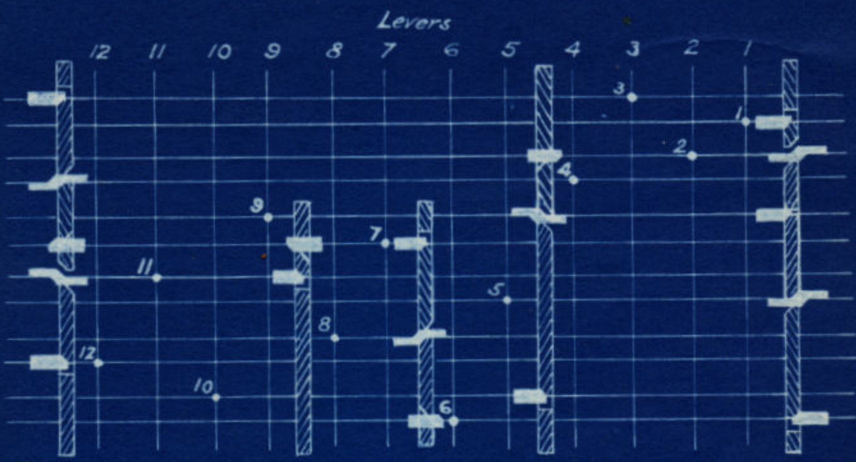
LEVERS 6 AND 5 THROWN

Plate 41

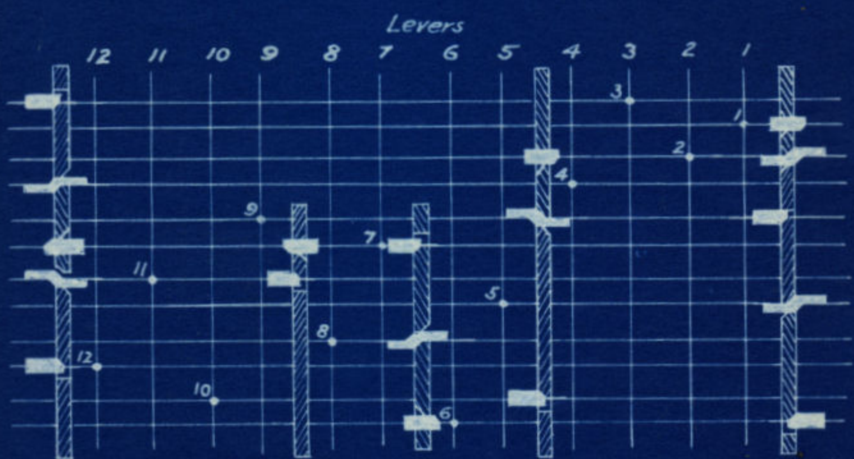
Saxby & Farmer Machine

DOG SHEETS

ROUTE A-B.

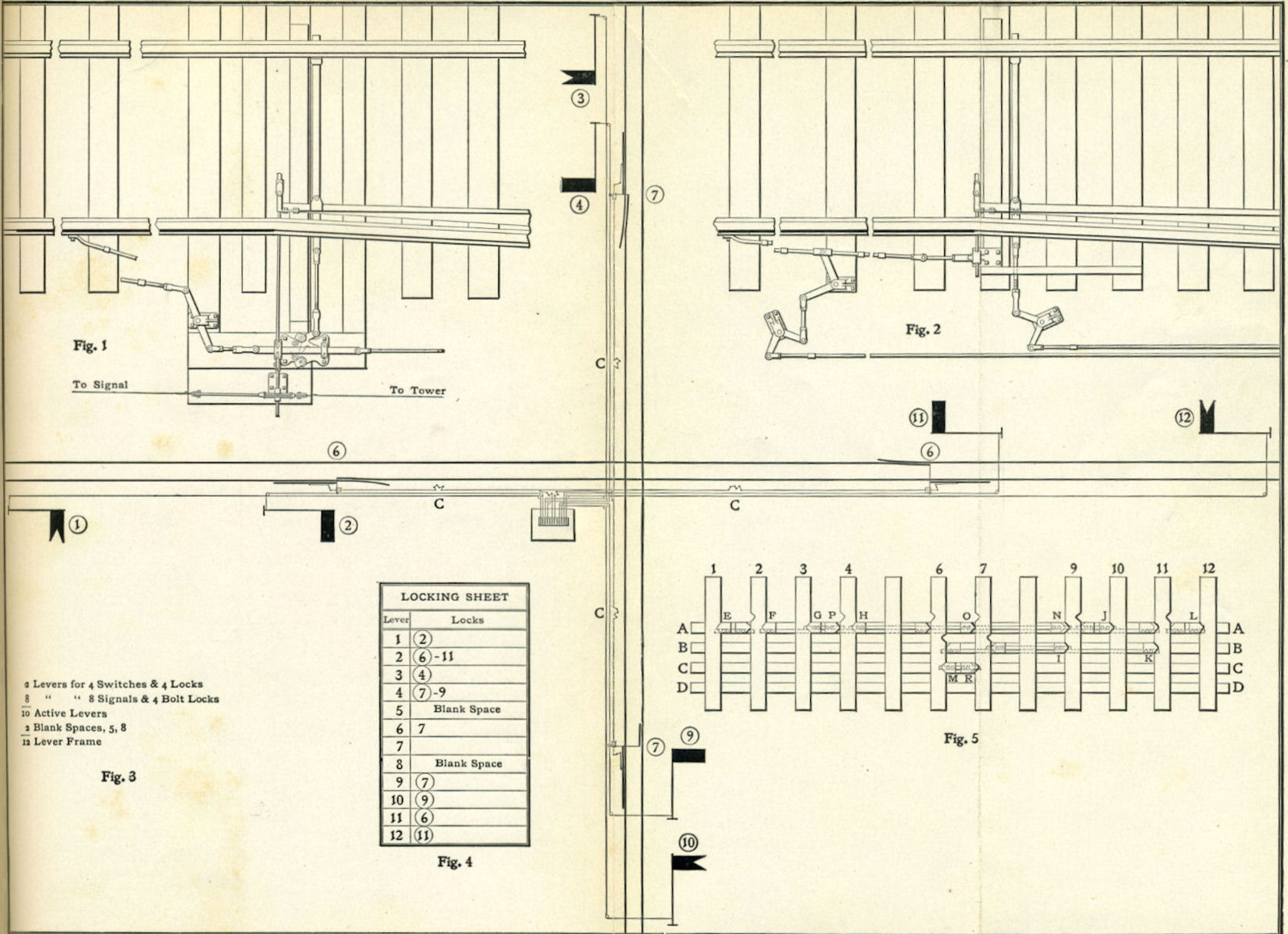


LEVERS 6,5 AND 2 THROWN



LEVERS 6,5,2 AND 1 THROWN

Plate 42



LOCKING SHEET

Lever	Locks
1	2
2	6 - 11
3	4
4	7 - 9
5	Blank Space
6	7
7	
8	Blank Space
9	7
10	9
11	6
12	11

Fig. 4

DIAGRAM A

circle where these lines intersect. The dog sheets made by the switch companies are essentially the same except that the bars are numbered consecutively from top to bottom so that lever 1 connects with bar 2, lever 2 with bar 3, lever 3 bar 1, etc.

Plate 40 shows the position of the lugs or "dogs" with relation to the cross pieces (AB - CD - EF, etc.) upon which the "dogs" act, these cross pieces moving backwards or forwards when acted upon by the inclined faces of the dogs attached to the bars. The positions in Plate 40 are (a) normal and (b) with lever 6 after the "preliminary locking".

Plate 41 shows again the position of the bars after lever 6 is fully thrown and the latch released (locking complete) and also shows position when lever 5 is also completely thrown.

Plate 42 shows position of bars after still further progress is made in throwing levers. The last position is that of the bars (or of the machine) after all movement have been made to allow a train to pass from A to B. In Plate 39 facing point locks are used, and the arrangement is that of the Union Switch and Signal Company in 1902. Plate 44 shows an arrangement with switch and lock movement for the same kind of crossing, and is taken from a catalogue of the same company published in 1889.

Convenience in handling the levers is secured in part by arranging the levers in suitable order, and in part by painting the levers (except the finished part of the handles) in characteristic colors. The color scheme adopted is as follows:

Switch Levers - Black.
Lock Levers - Blue.
Switch and Lock Levers - Black and Blue.
Home Signal Levers - Red.
Distant Signal Levers - Green.

For position in the machine the levers are numbered from left to right the Switch

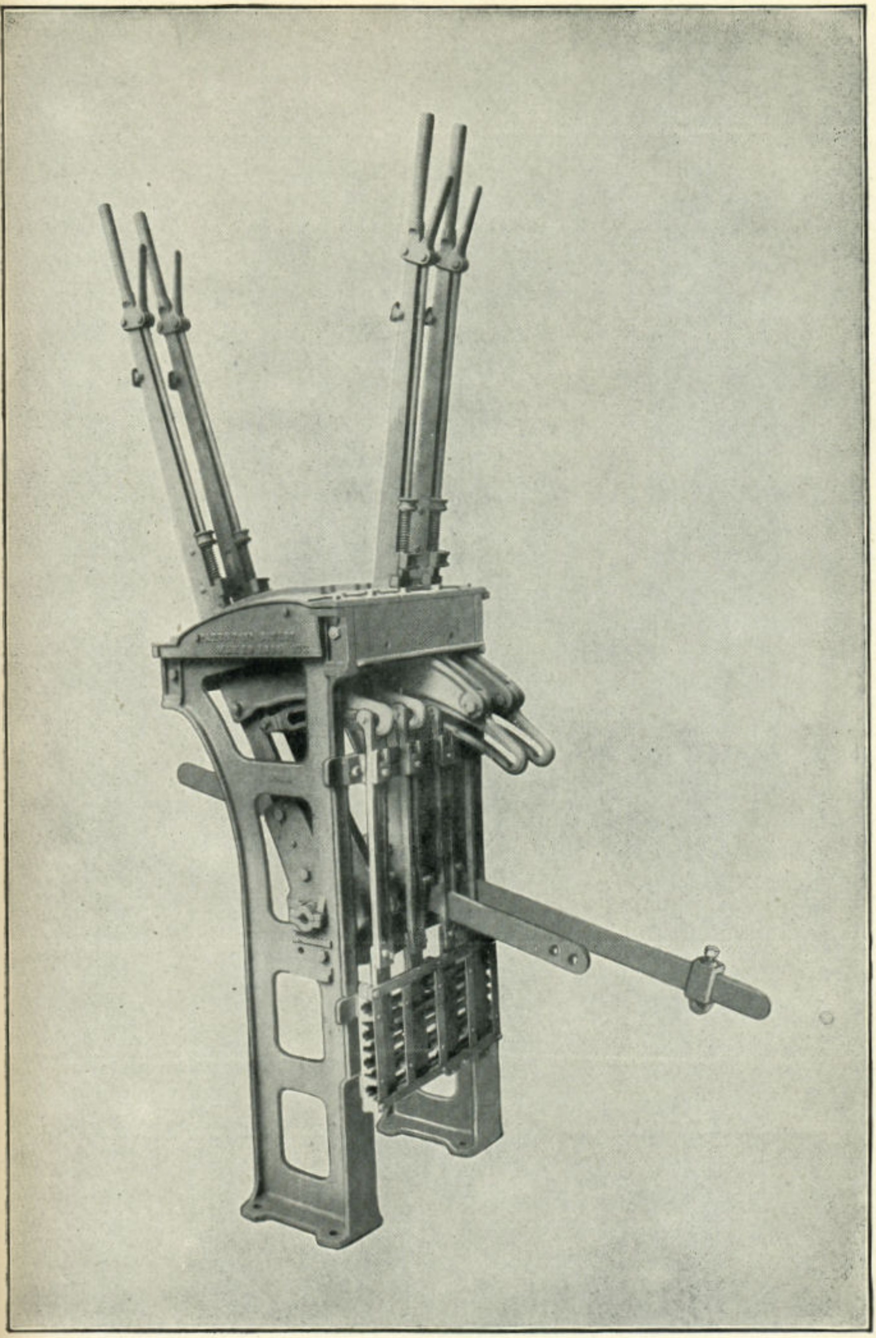


PLATE 45

Levers, the Lock Levers and the Switch and Lock Levers are placed in the middle. Spare spaces if any come next. Home Signal Levers are placed outside of these (right and left) and at the extremes (right and left) are placed the Distant Signal Levers. The levers for the Home and the Distant Signals which belong together are, of course, kept on the same side of the machine. Machines are made generally in groups either of four levers or of eight levers. A complete machine will thus have some multiple of four for the number of levers; there will often be spare levers as the result.

The Saxby and Farmer type of machine has locking bars lying in a horizontal plane and this arrangement is favorable for ease and lightness of working and consequent durability. When the signal tower is placed between tracks, and the space between tracks needs to be kept as small as possible, the horizontal arrangement of bars is wasteful of room, and there is a clear advantage in arranging the locking bars in a vertical plane. The Johnson type of machine is arranged in this way and Plate 45 shows two views of the Johnson machine. The preliminary locking is accomplished in much the same way although the rocker is set lower and moves with the lever. Plate 47 shows how the locking is effected, this plate showing a rear elevation and below the floor. The vertical bars are raised by the levers and push the horizontal locking bars to the right or left depending upon the arrangement of the "dogs" attached to them. This arrangement is sometimes referred to as "cross-locking".

The National Machine is similar in type to the Johnson and is probably less used, and is thought inferior to the Johnson by the Union Switch and Signal Company, makers of both. No cut of this is shown here. Plates 48 - 49 - 50 show a vertical plane machine as made by the Standard Railroad Signal Company. The diagram in Plate 50 shows the same arrangement of tracks as in Plate 47. The normal position of some of the switches is differ-

Johnson Machine

Locking Sheet.

Lever	Locks	Releases
1	2 - 4	
2	4 - 4 - 6 - 7 when 4	1
3	5 - 7	
4	1 - 7 when 5 - (2 B.S.)	5 - 6
5	4 - 8 - (7 B.S.)	3
6	2 - 4	
7	3 - 5 - 5	8
8	5 - 7	

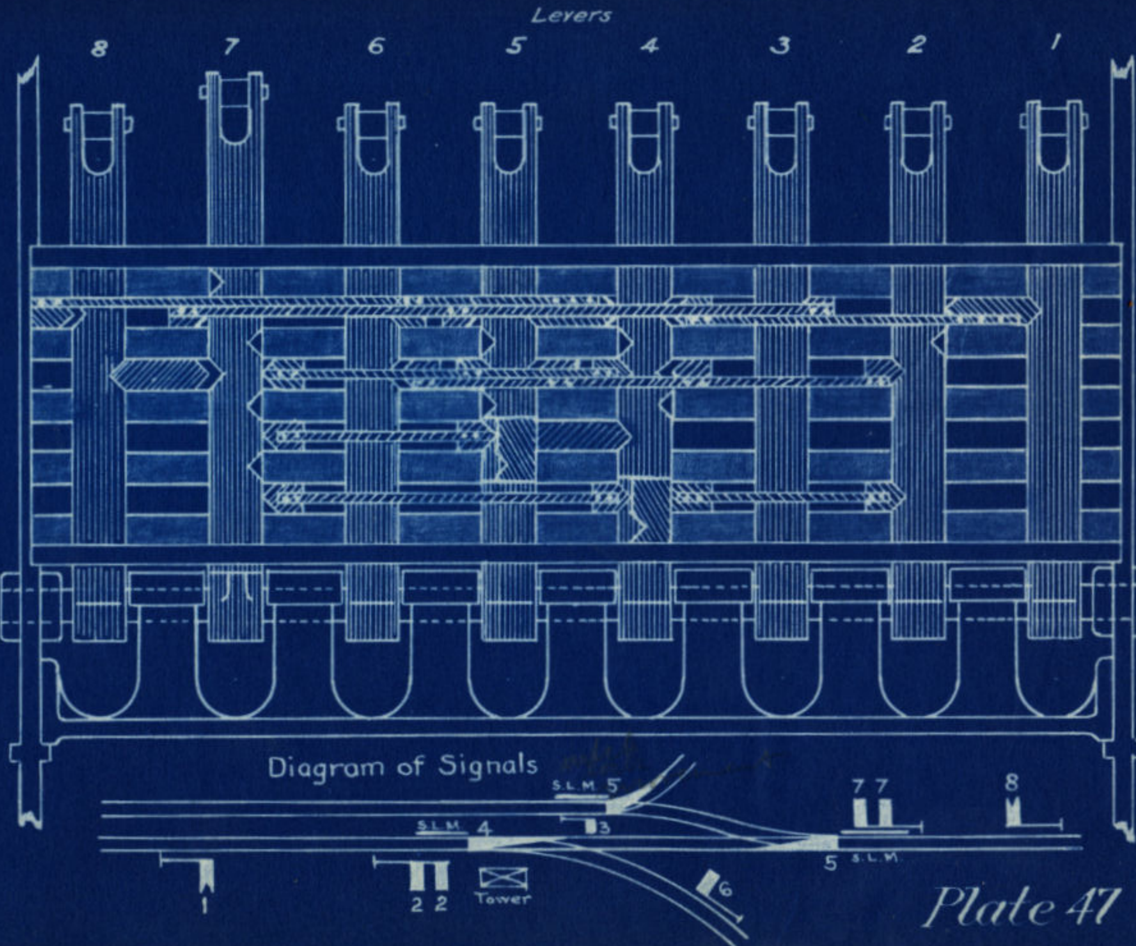
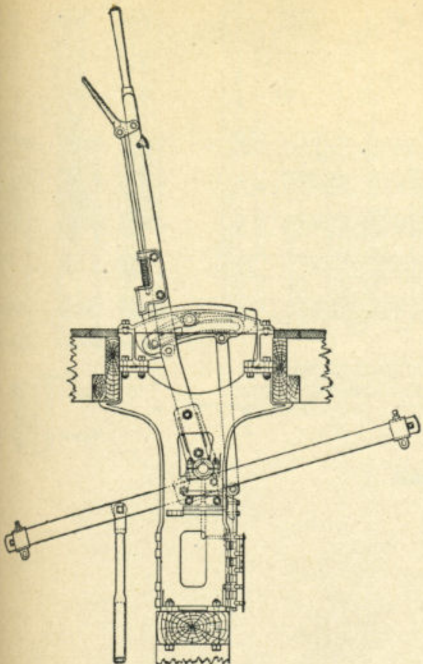
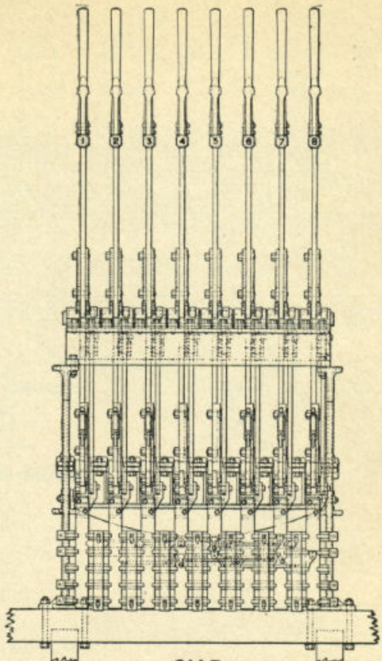
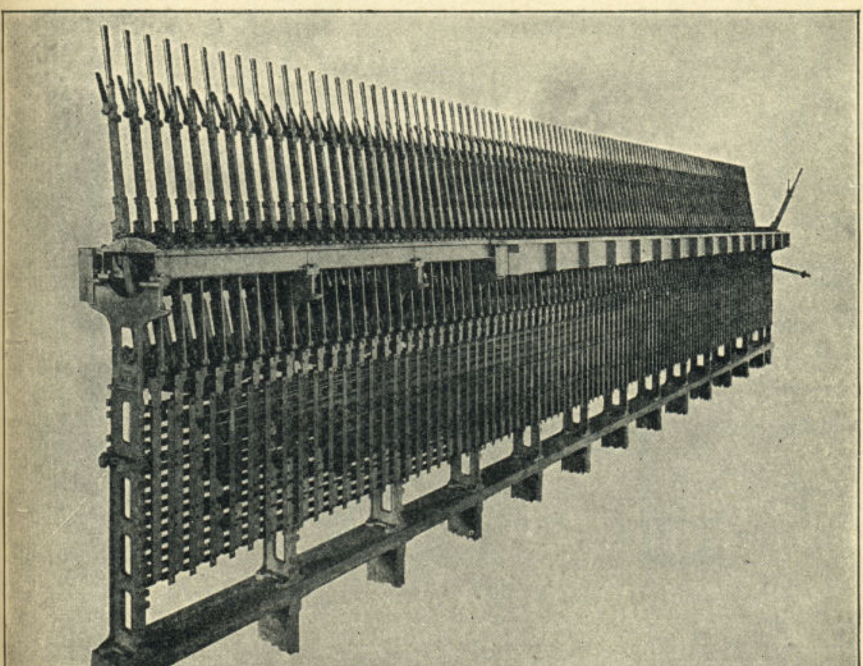


Plate 47





OIAB



PLATES 48-49

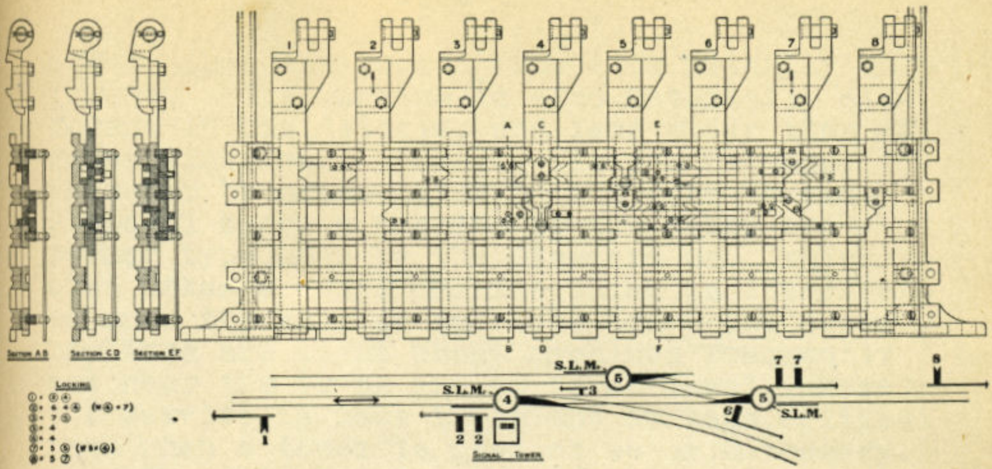
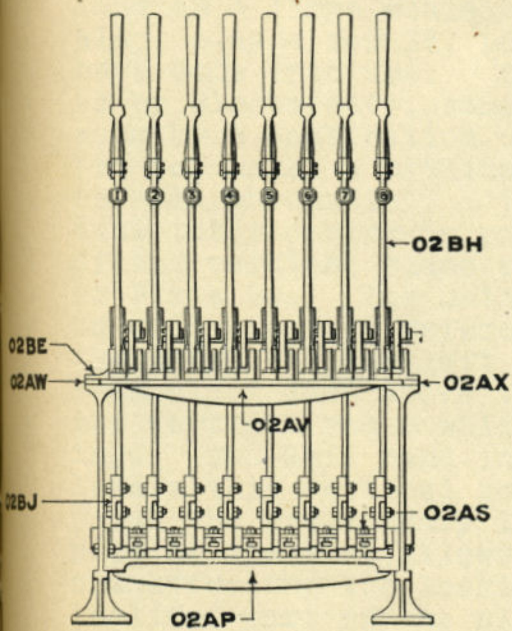
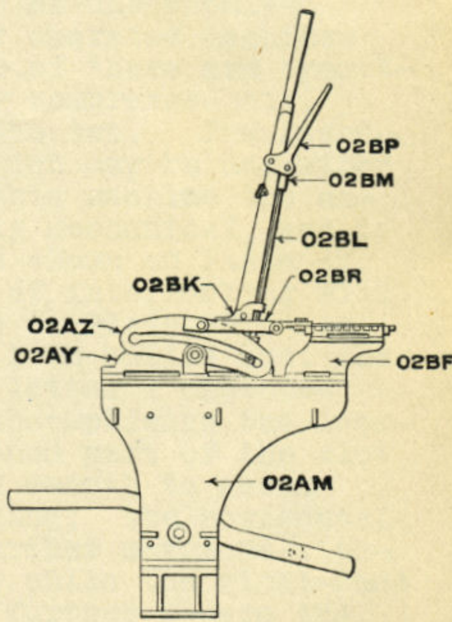


DIAGRAM OF SIGNALS

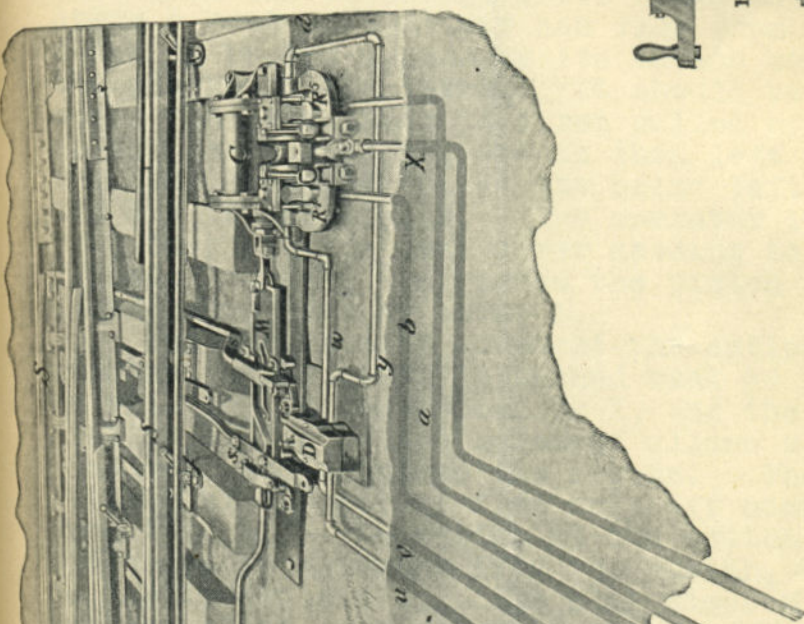


O2AB



ent so that the locking sheet is slightly different. The machine is also materially different in its details, and less clear than if fewer lines were shown. It can be made clearer by cross-hatching the dogs in red. Plate 51 shows a machine of the Saxby and Farmer type made by the Standard Co., which also makes a dwarf machine which is interlocked much the same as in Plate 50. The dwarf machines are light cheap machines frequently set near the track and at track level, where the service is less important or less critical than when a tower is used or seems necessary.

The interlocking thus far shown has been accomplished by levers pulled by hand by a man or several men in the tower. With very large or important installations, the work required becomes greater than can be satisfactorily performed by manual operation; the working by hand on a large scale becomes uneconomical also. As a result, power operated machines have come into use. Some of these are operated by electricity, some by compressed air, some by a combination of the two. The Standard Co. makes a machine which may be described as "all pneumatic". In this machine the actual interlocking is purely mechanical, and is of the vertical plane type shown on Plate 47 or Plate 50. The method of interlocking will be understood by reference to Plate 53. As the handle to the left of L is pulled out, the "cam-slot" just above the letter I operates the vertical rod H which accomplishes the locking. The left hand inclined part of the slot lowers this vertical rod H enough to accomplish the preliminary locking; the horizontal part of the slot allows further movement without affecting the locking, while the right-hand inclined part of the slot further lowers the rod H and completes the locking. The function of the compressed air is to operate the switch or the signal. The preliminary movement of the lever also arranges valve L^2 so that the air passes from the main supply X to



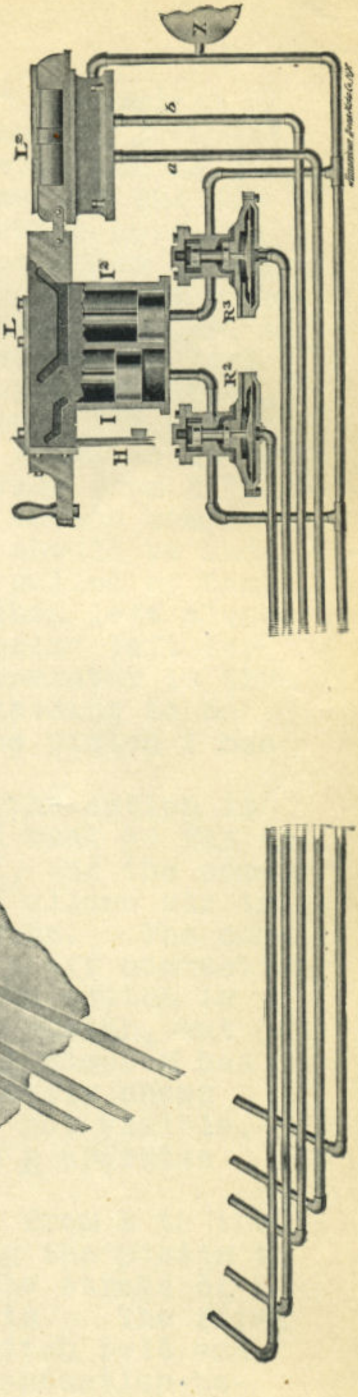


PLATE 53

the pipe a and through this to the switch where by suitable valves the switch movement is properly effected. The lever can be pulled out only so far as is allowed by the pin connected with the piston I^2 which moves in the horizontal part of the slot which is directly under the letter L. No further movement is possible until I^2 is free to move, and this happens only after the switch and lock movement (at the switch) has been completed, when a valve at the switch allows the air to pass into the diaphragm valve R^5 which in turn opens a port so that air can flow from X to I^2 which is pushed up and by its action completes the stroke of the lever. It should be understood that the lever is first pulled by hand as far as it will go, and is then left alone; the completion of the stroke being left for the air to accomplish. The operator is thus free to go to the next lever needing to be pulled. During the stroke the piston I has been pushed down by lever L.

For the reverse movement the action is similar. The lever is pushed back as far as it will go, is restrained by I, and the completion of the switch movement allows air to pass to I and complete the stroke. The completion of the stroke also cuts off connection from X to a. The action at the switch is not quite so apparent from the sketch, but can be easily explained. The slot piece M has two cam slots, one which is clearly shown operates the switch; another, not visible, operates the valve D. Air in a operates valve R^5, and opens connection from X to the right end of cylinder C pushing the piston to the left; M goes with it. The stroke of M may be considered in three parts. The first part serves to withdraw the switch bolt and also acts on valve D closing connection between w and y, while u and v are open to the atmosphere; the middle part of the stroke of M throws the switch but does not act upon the valve D; the third part of the stroke of M throws the bolt and locks the switch, and immediately following this it acts on the valve D to establish connection between v and y. The air in pipe a then flows through R^5, d,y, D,v, to R^3 where direct connection is made from X to I_2. The reverse motion is similar.

Pushing the lever establishes connection from X to b, the switch is thrown, and the return connection is b, c, w, u to R^2 where connection is established from X to I.

The signal movement is similar, as shown in Plate 54. Pulling the lever admits air to a and thus to R^3 which makes connection from X to piston A_2 which throws the semaphore to safety. It also acts on A_3 which cuts off connection from e (through B) to n. No return action of the air is necessary here as no accident will result if the signal remains at danger when it should go to safety. With the return stroke it is different. The signal must surely be at danger before other levers are pulled. Accordingly, on the return movement the lever cannot be pushed completely in, being held by I. The air flows through b to R^2, and thus from X through e to top of piston A_2 which restores semaphore to danger. There is no connection from e to n until A_3 is pulled down (by A_2) but when this is accomplished, then valve B allows air to pass from e through n to R' which completes the stroke. The action of the valves in detail is not very clearly shown by the sketches although these aid in giving a general idea of such action. Plate 55.

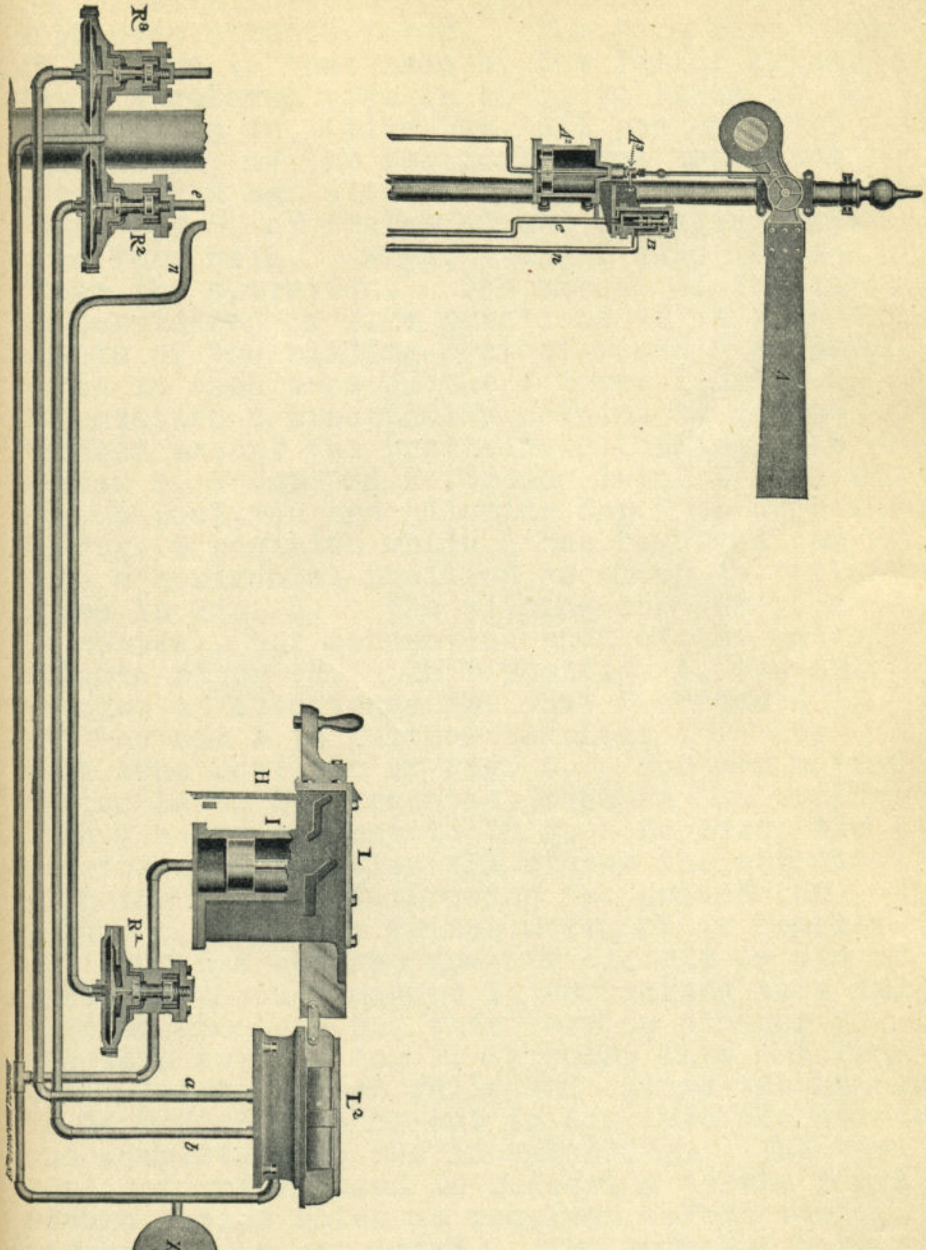
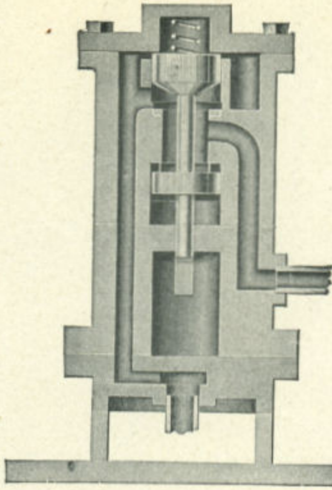


PLATE 54

The "All Electric" system has also met with considerable favor. The form best known at present is that made by the Taylor Signal Co. A general view is shown in Plate 56. The locking is, (like the "all pneumatic") mechanical, of the vertical plane type, and worked by a cam slot. Plate 57 together with Figs. 3,4,5, of Plates 58 and 59, illustrate this very well. Figs. 4 and 5 also illustrate the operation. The stroke of the lever is considered in five positions as is also the stroke of the sliding contact block Z as indicated in each case by the figures 1,2,3,4,5. At position 2 practically nothing is accomplished except the preliminary locking. At position 3, M acts on K forcing latch L into the Fig. 5 position and allowing dog P to drop into Fig. 5 position while Q has revolved cam N into a horizontal position as shown in dotted lines in Fig. 5. The sliding contact block Z is neutral, not connecting with either set of brushes XX or YY. In F position 4, the only changes of importance are that Z connects XX and the cam N is further revolved into its full line position of Fig. 5. Further motion of the lever is prevented, because the projection J bears against tooth Q. However, the electrical connection XZX closes the circuit, with the result of throwing the switch (or signal); when the switch movement is completed, (and not before) another circuit is closed, passsing through magnet I, energizing this and lifting armature T; this carries plunger R and this strikes dog P, throwing this out from under latch L which falls and allows the handle to be pulled further out to complete the stroke and complete also the interlocking. The term "indication" is used in referring to the final return action which is required before the stroke can be completed. The movement here resembles that of "all pneumatic" in that the stroke of the lever cannot be completed until the switch is completely thrown. In the electric machine, the completion of the stroke is



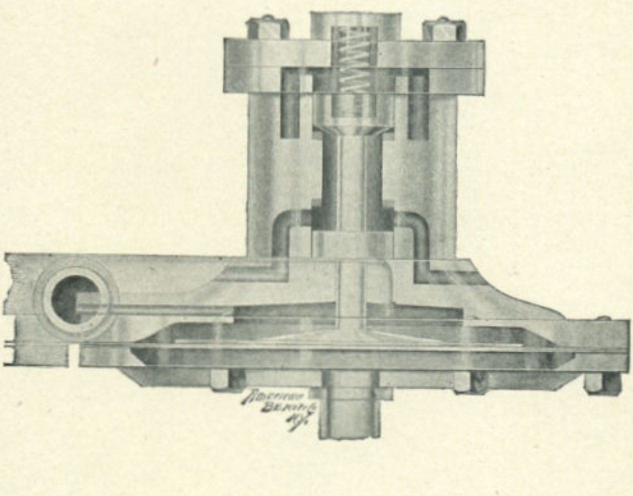


PLATE 55

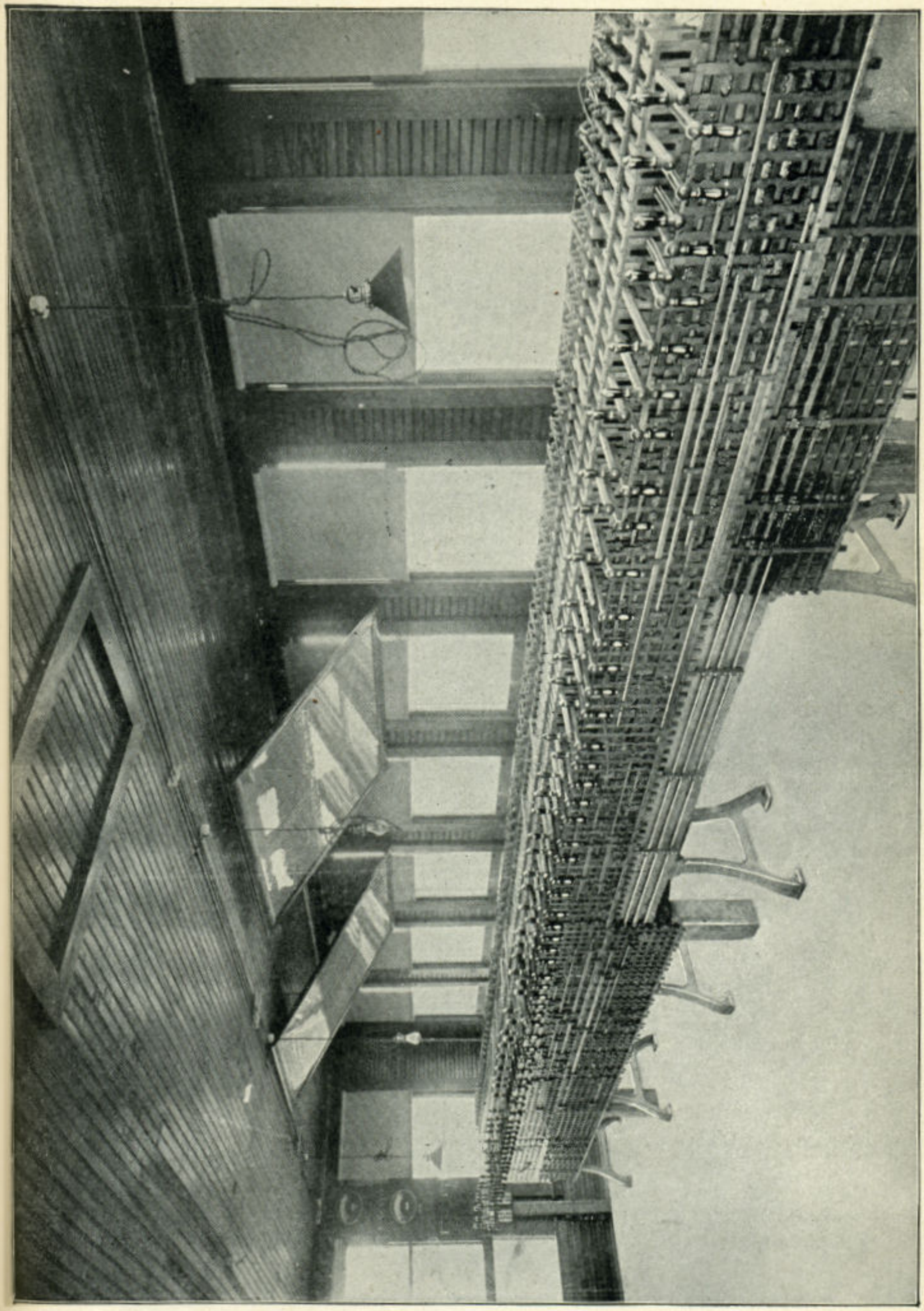


PLATE 56

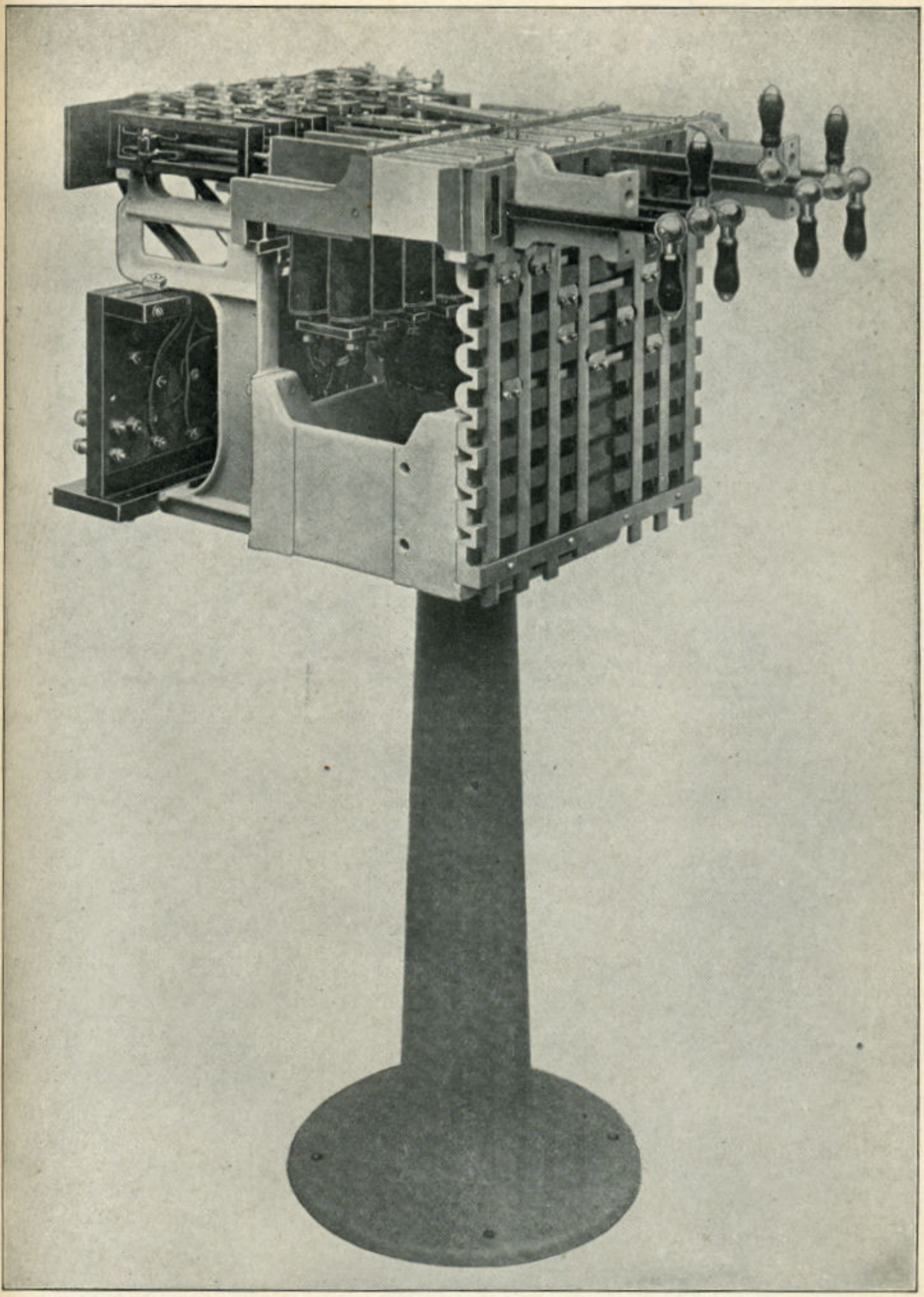


PLATE 57

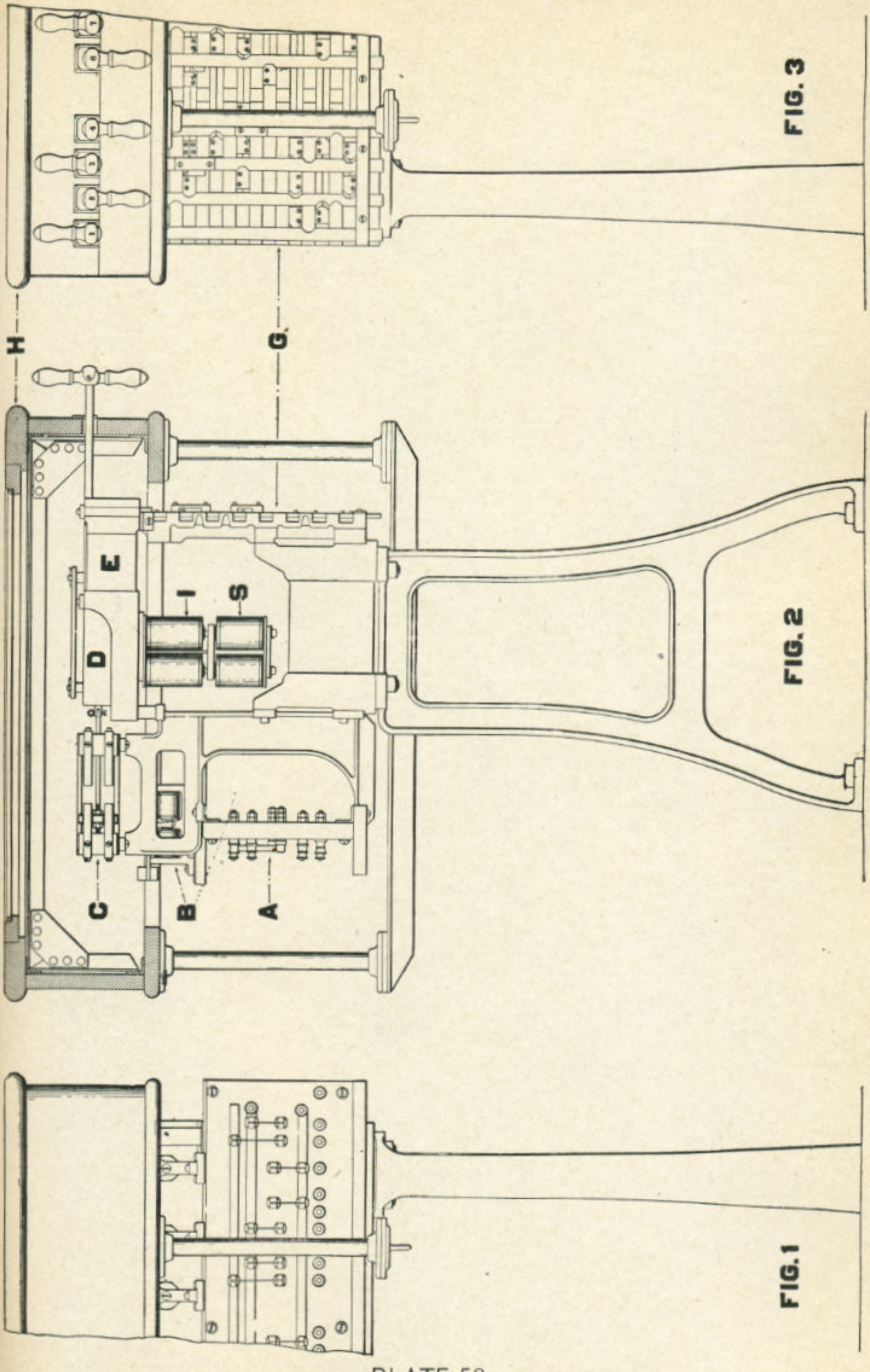


PLATE 58

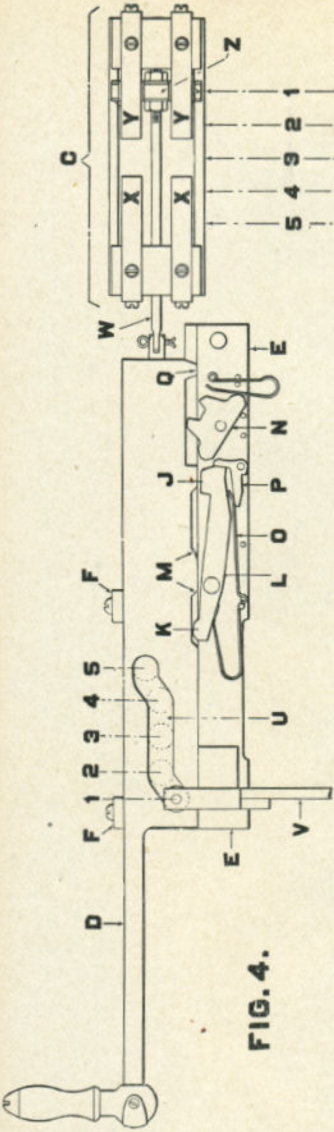


FIG. 4.

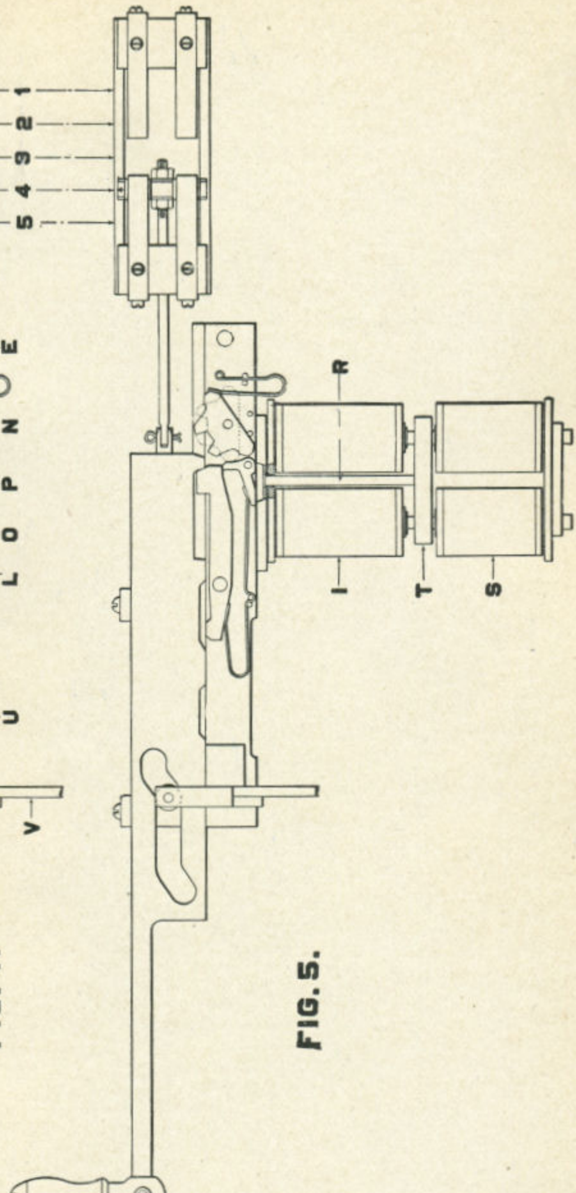
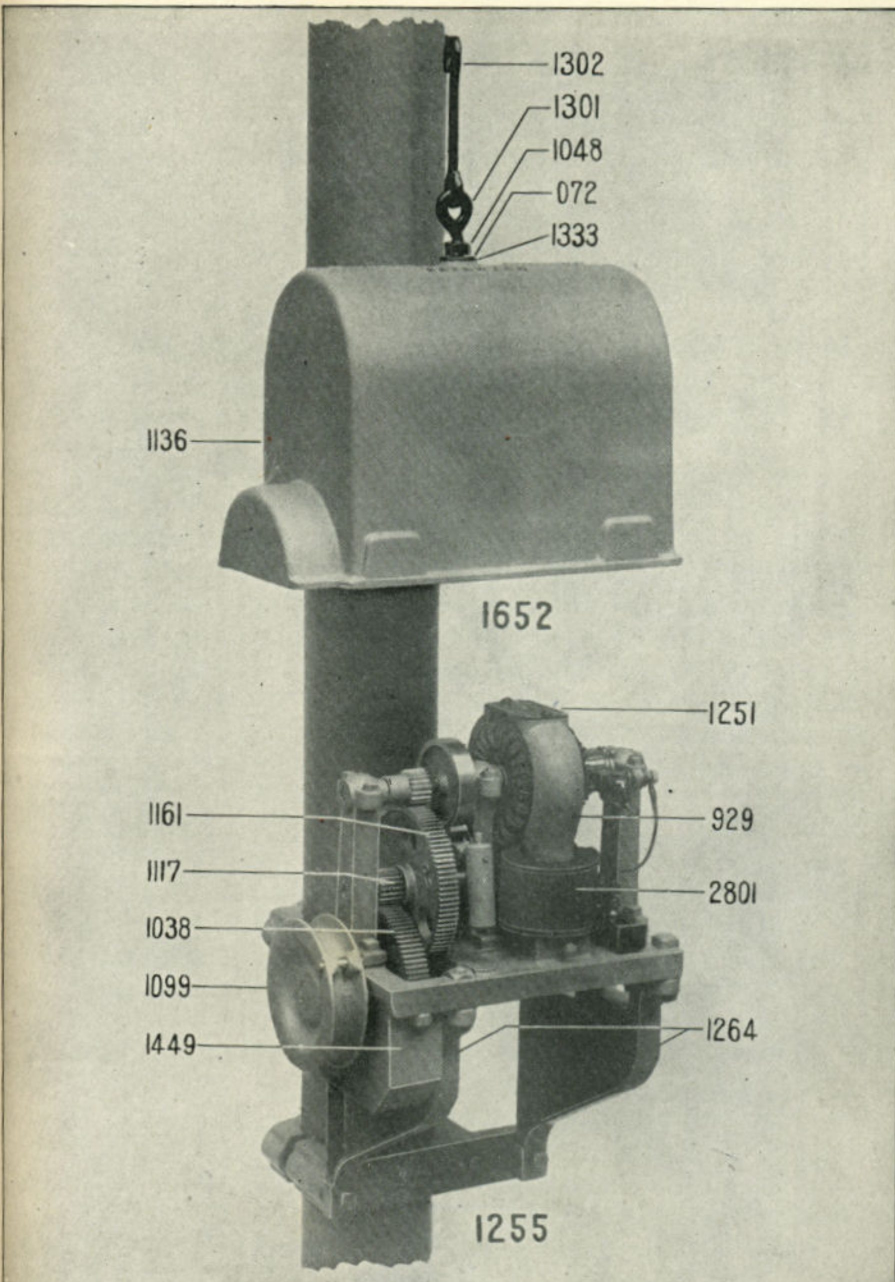


FIG. 5.

PLATE 59



1302
1301
1048
072
1333
1136
1652
1251
1161
929
1117
2801
1038
1099
1264
1449
1255

PLATE 59A

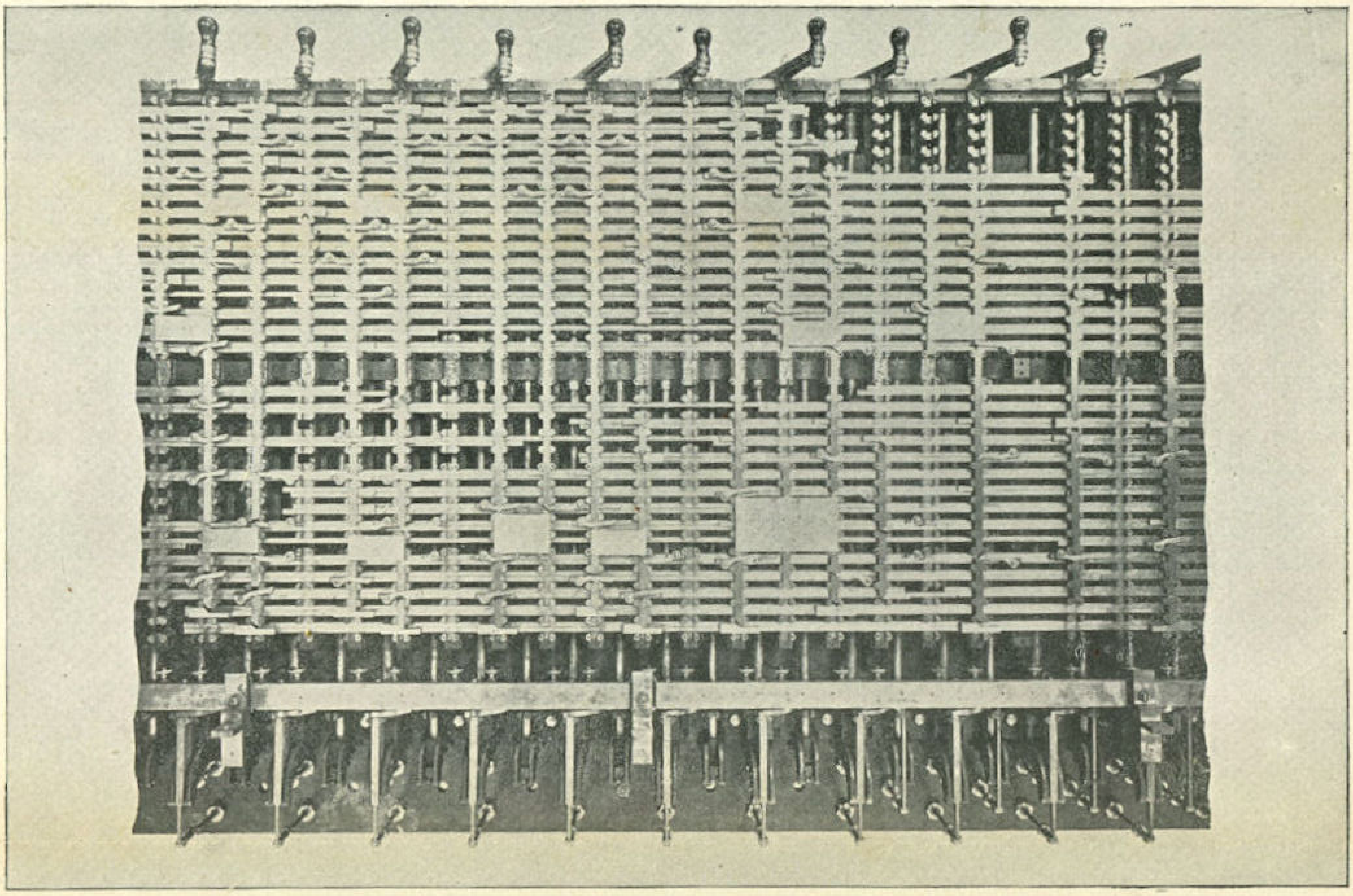
made by hand. In the pneumatic, the completion of the stroke is automatic. It appears hardly worth while at this time to take up the additional electrical arrangements connected with the machine or to describe in detail the electric motor placed at the switch; or at the signal post. Plate 59 shows a signal motor. A common method of providing the power for these is by a gasolene engine which drives a dynamo.

The Standard Co. and the Union Co. have, each of them, provided an "all electric" system which are too new to receive special attention (in 1904).

The "Electric-pneumatic" which is shown in Plates 60 - 61, has been in successful use longer than either the "all pnuematic" or the "all electric". The switches and the signals are operated by machines worked by compressed air and located close to the switches or signals. The valves regulating the air are operated by electricity; the electrical connections to any switch or signal are made in the tower by turning a handle in the machine to right or left (instead of pulling). The interlocking is purely mechanical.

The "push-button" machine is a similar machine for use where interlocking is not required; this is the case in distributing yards for instance, and in this case the simplicity of the push-button machine allows rapid movement. There is a row of buttons above and one below the number for any switch or signal movement. The upper button works the direct movement and the lower button the reverse movement for the same switch (or signal). Plate 62 serves to illustrate this.

The work of the machine and the number of levers necessary to secure a desired result have been reduced materially by the use of two devices, selectors and indicators. The action of the selector is this; when one of several switches, close together, has been thrown, the parts of the "selector" are also



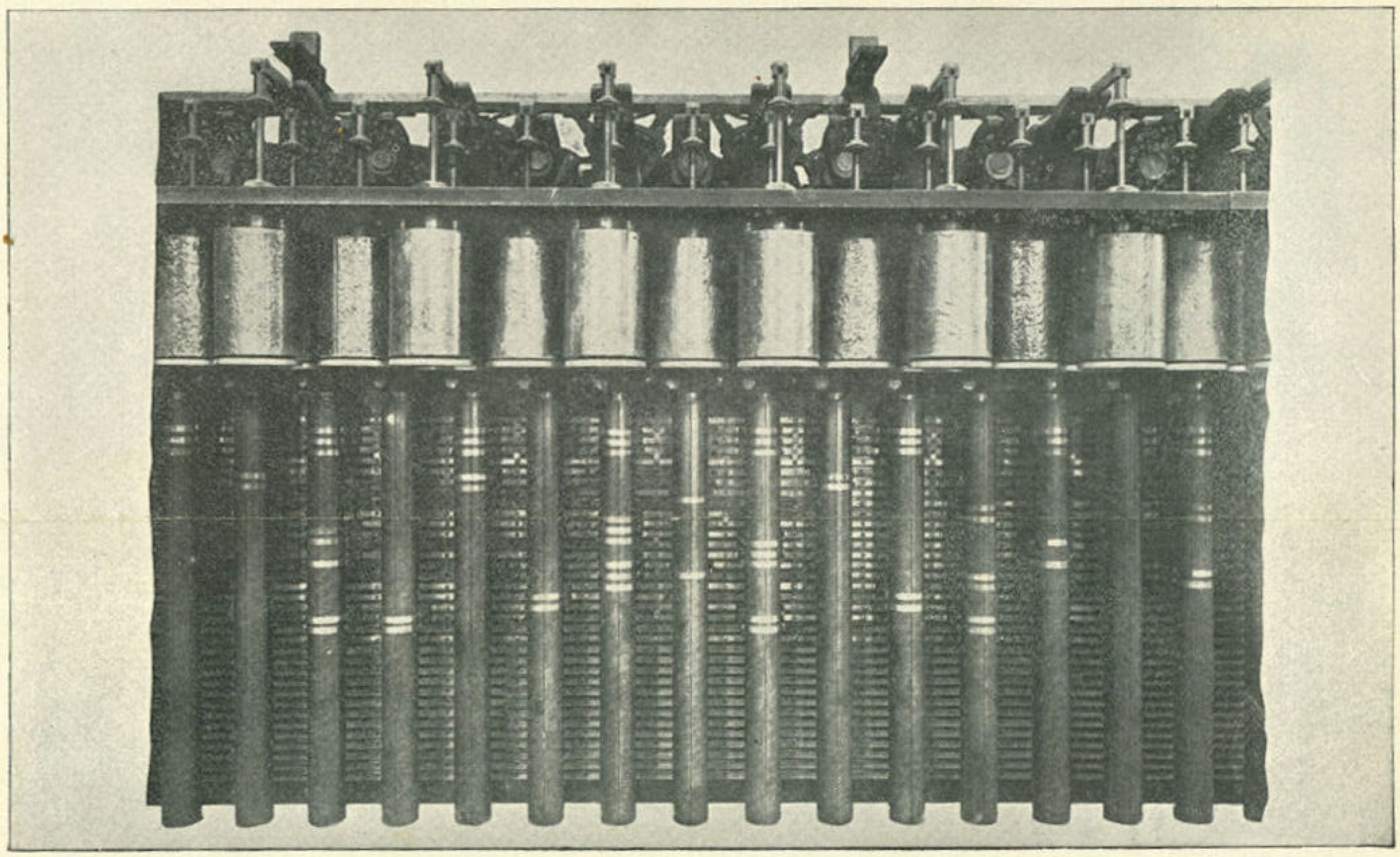
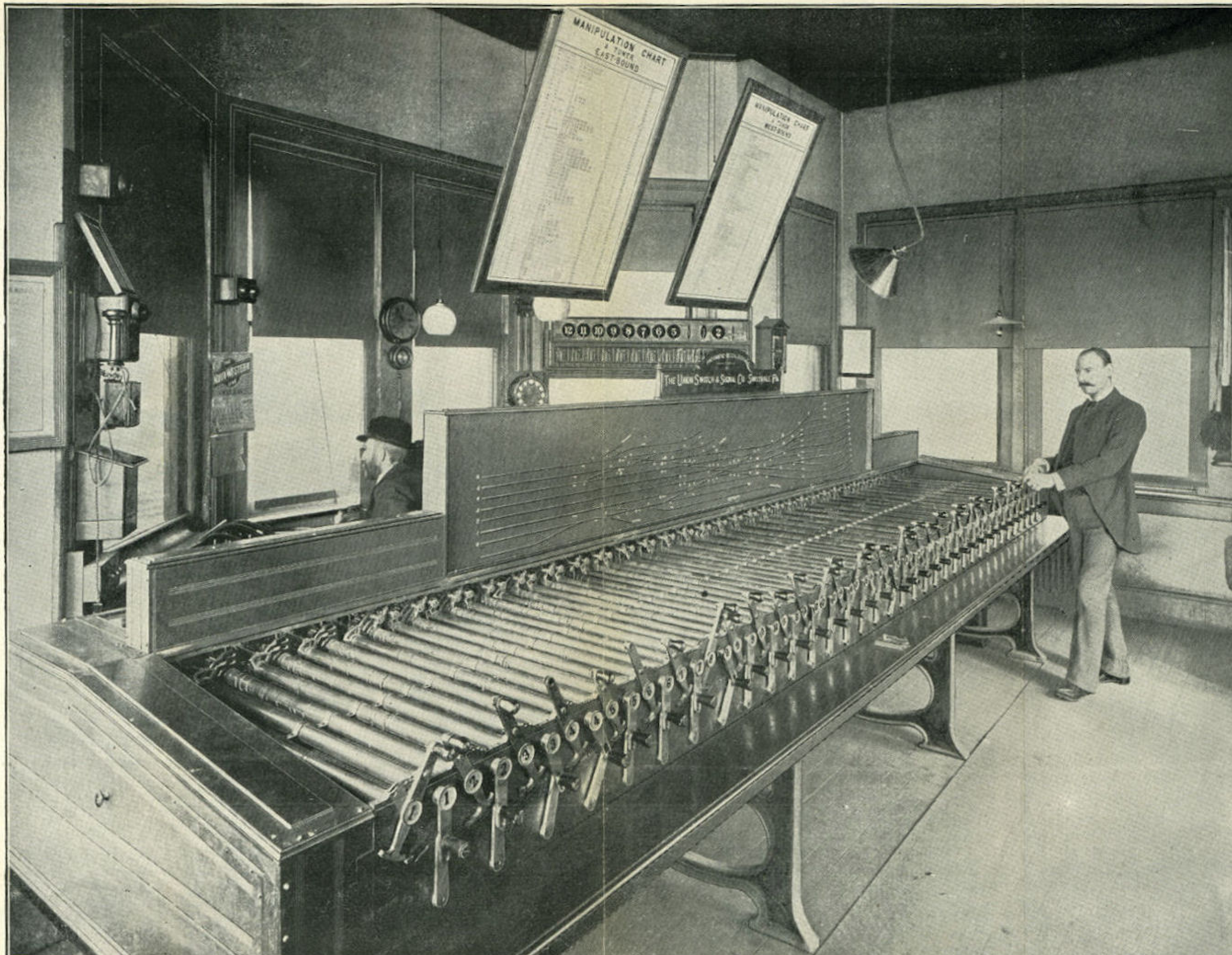


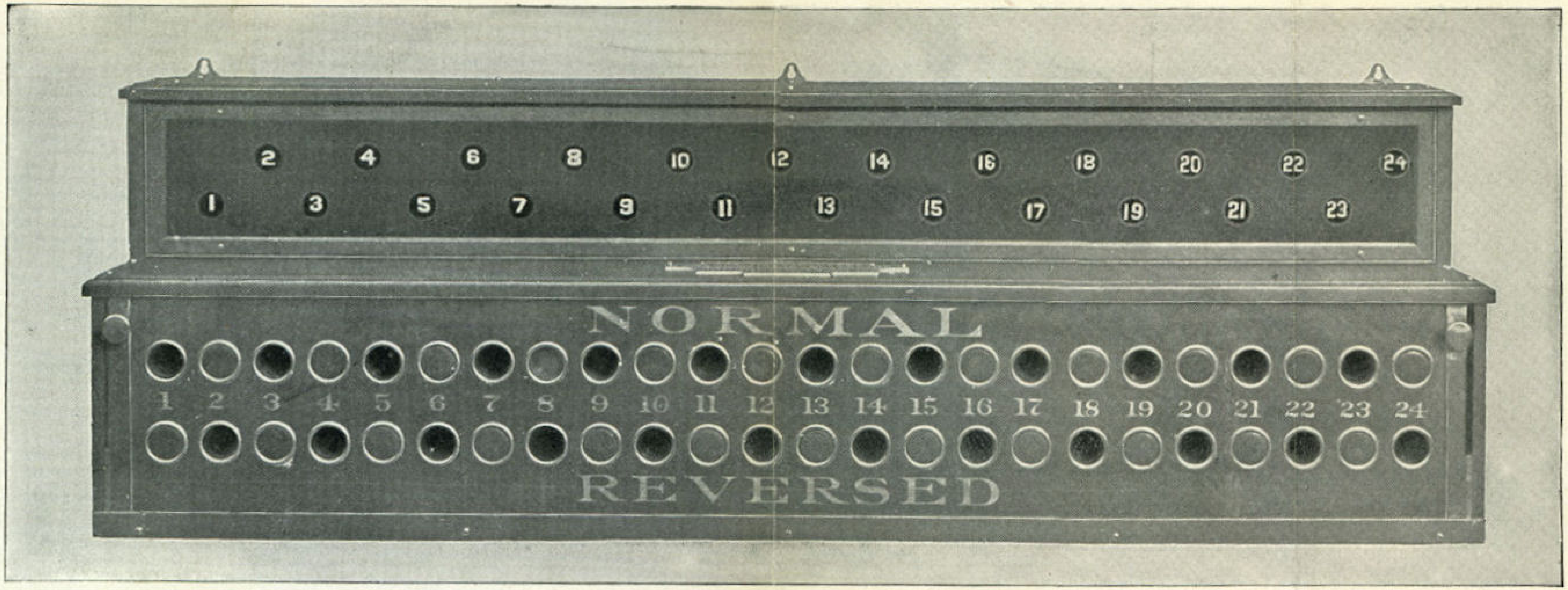
PLATE 61



acted upon and put in place so that the signal lever, when pulled will act upon the signal which goes with the switch already thrown; as each switch pipe when moved, arranges the parts of the selector in a different way, one signal lever will throw either one of several signals, dependent on the action of the selector. Several forms of selectors are shown in Plates 63 - 64 - 65.

The "indicator" is somewhat similar in its functions which may be described as follows: Where a turnout leads to several switches further on, a single signal at the main track will serve to show that the turnout is open but this signal will not alone show which of the further switches is ready for the train. These switches may be thrown by hand without connection with any machine. A connection is made with the signal, however, so that the pipe or wire which works the signal will also bring into view one of several plates each marked with a number to show which switch is open.

"Block Signalling" as has been stated is used to secure the result that a line of railroad shall be divided into a series of short sections or "blocks" and that no following train shall enter any "block" until the preceding train has passed to a point of safety without the "block." An "absolute" block system requires imperatively that the second train shall not enter the block until directed by signal to do so. A "permissive" block system allows the second train to enter the block under some circumstances, even when the signals indicate that the block is already occupied. A train entering a block under these circumstances must proceed with caution. One reason for the use of the "permissive" block system is the possibility of signals giving false information owing to defects of apparatus, a result to be expected occasionally, certainly with automatic signals and perhaps with others. The block system is a "space interval" system where trains are to be kept a defi-


2 4 6 8 10 12 14 16 18 20 22 24
1 3 5 7 9 11 13 15 17 19 21 23
NORMAL
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
REVERSED

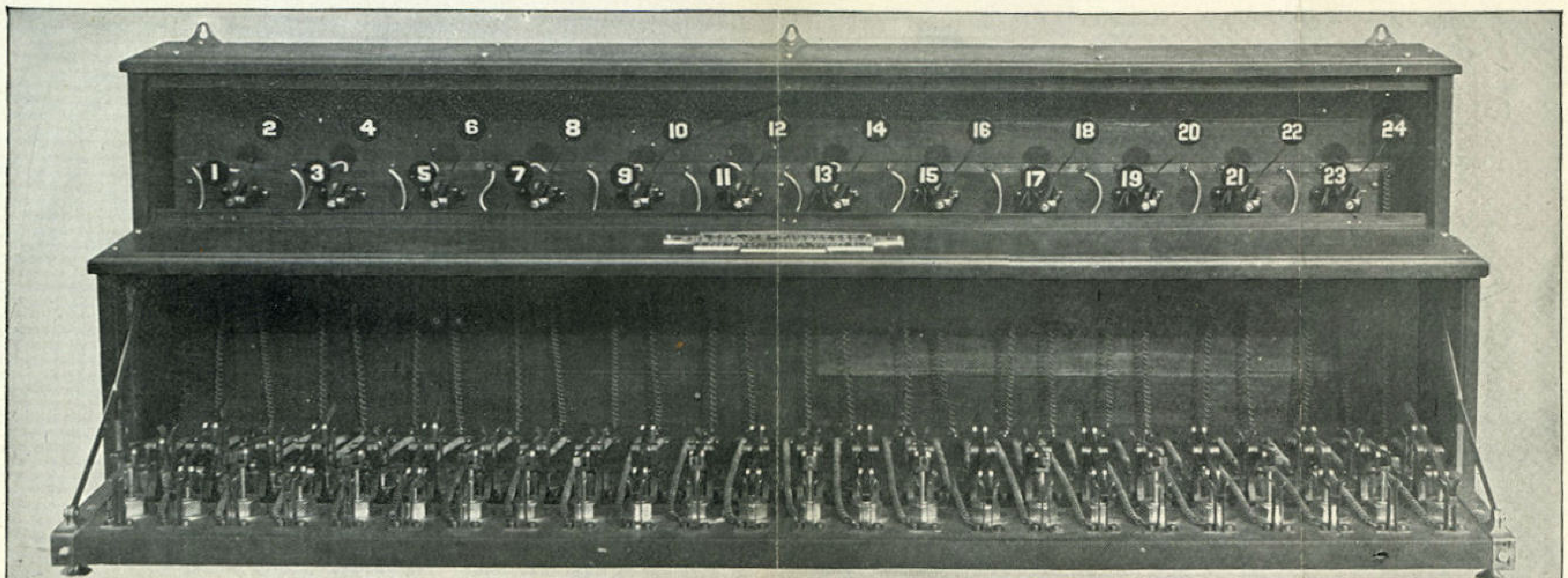
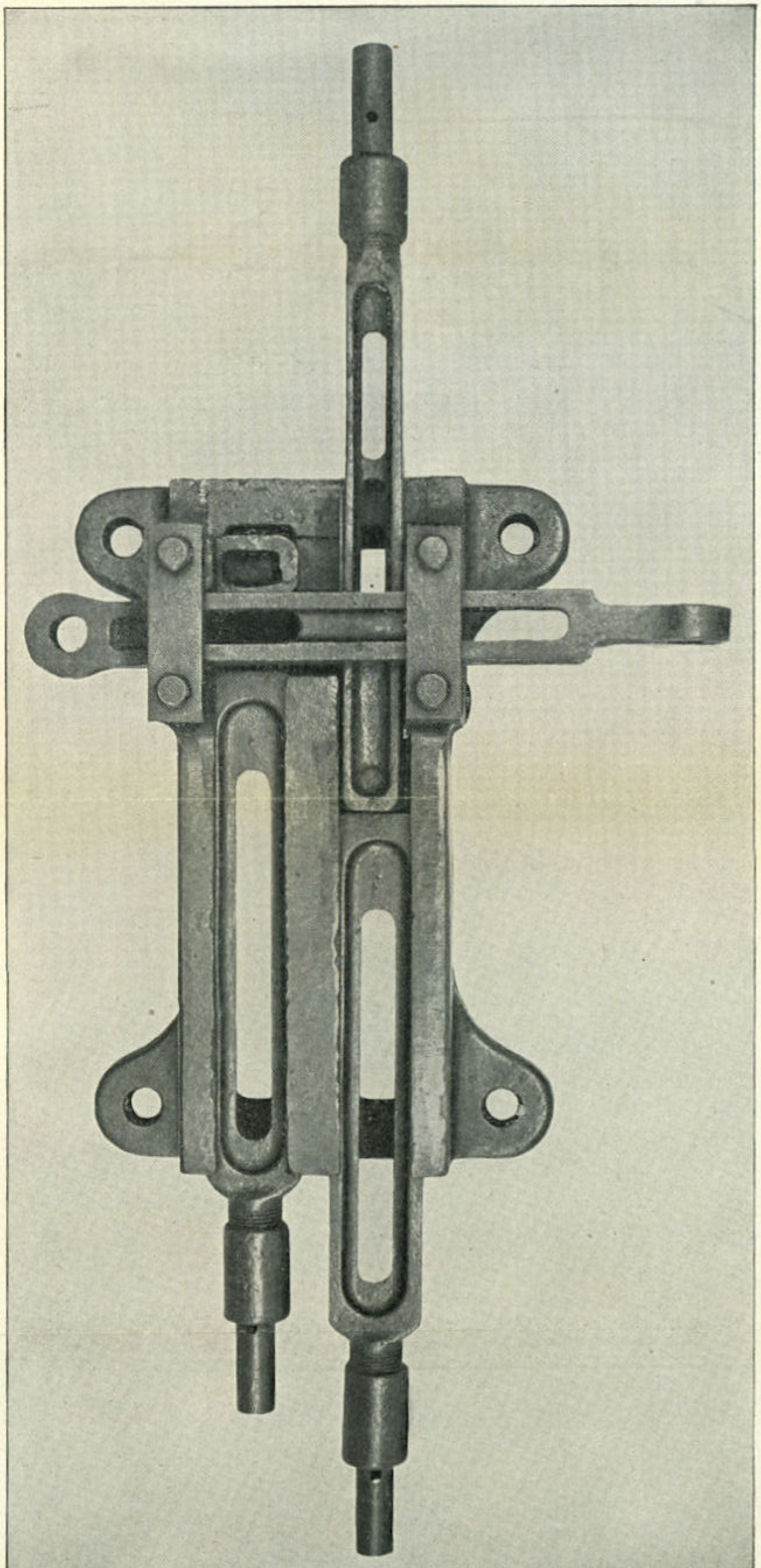
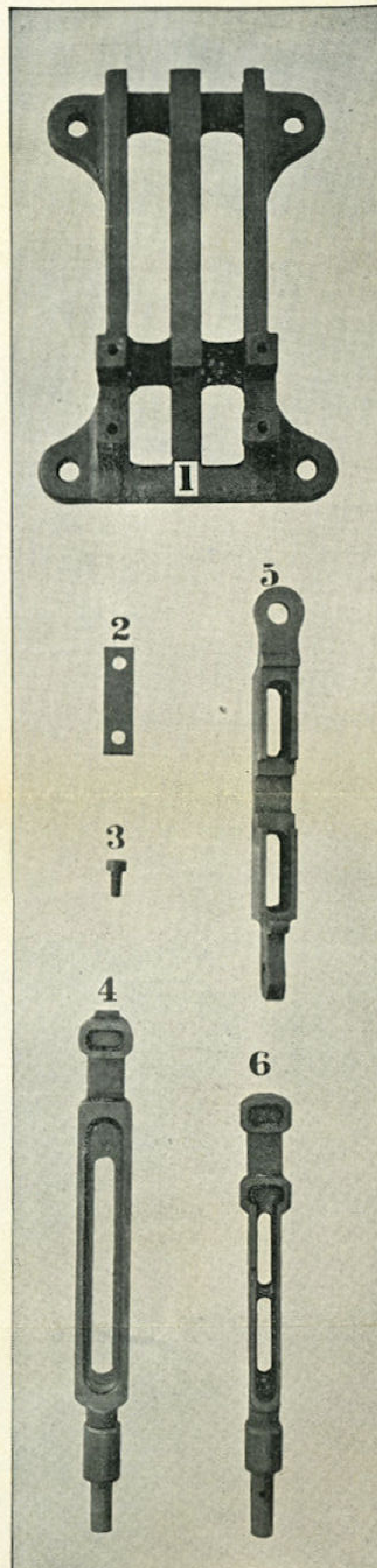
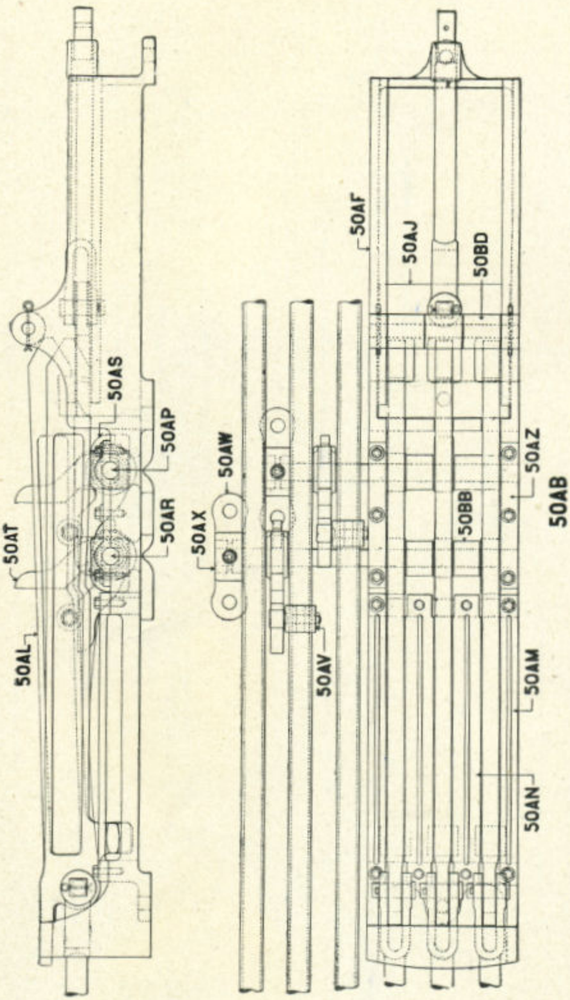

2 4 6 8 10 12 14 16 18 20 22 24
1 3 5 7 9 11 13 15 17 19 21 23

PLATE 62




1
2
3
4
5
6



50AS
50AP
50AR
50AT
50AL
50AW
50AX
50AV
50AF
50AJ
50BD
50AZ
50AB
50BB
50AM
50AN

PLATE 64

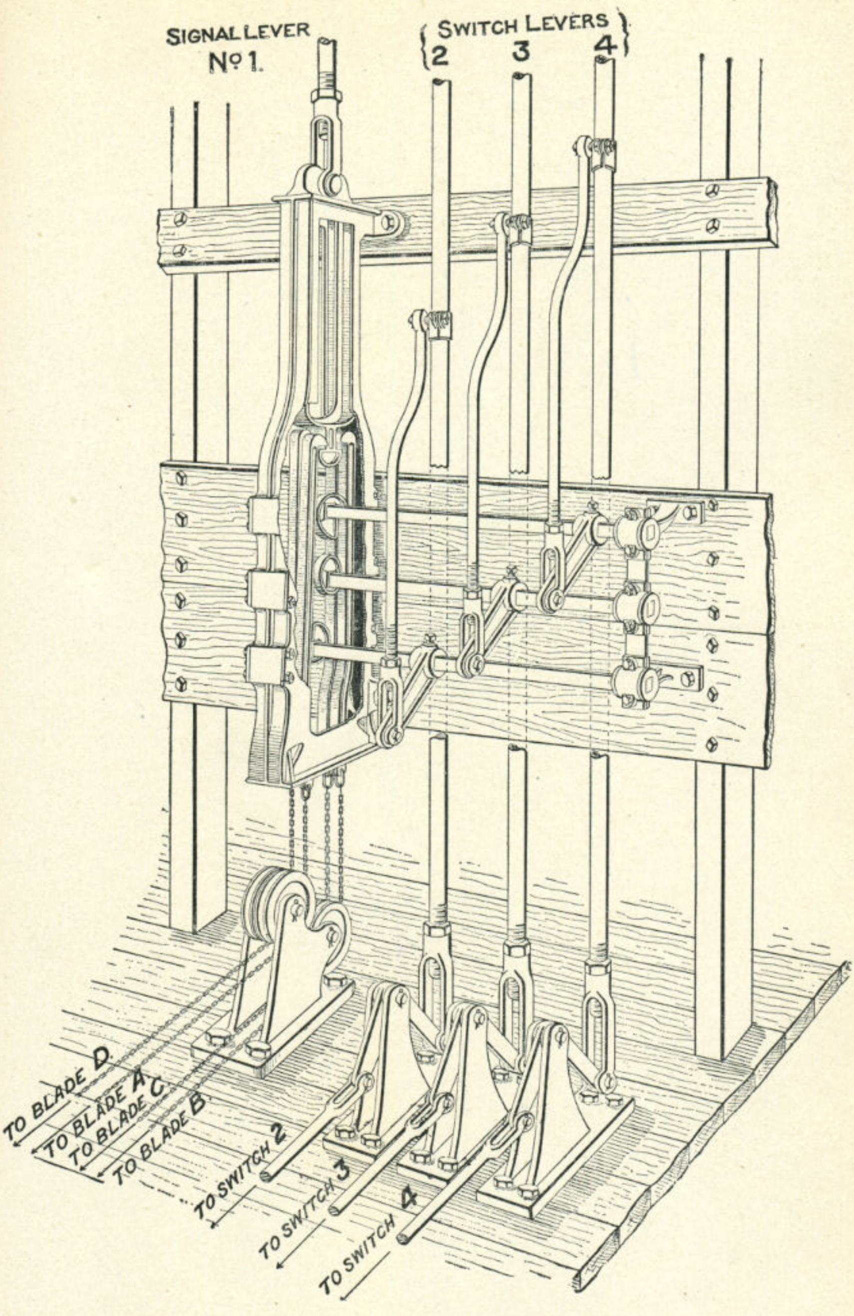

SIGNAL LEVER
No 1.
SWITCH LEVERS
2
3
4
TO BLADE D.
TO BLADE A
TO BLADE C
TO BLADE B
TO SWITCH 2
TO SWITCH 3
TO SWITCH 4

PLATE 65

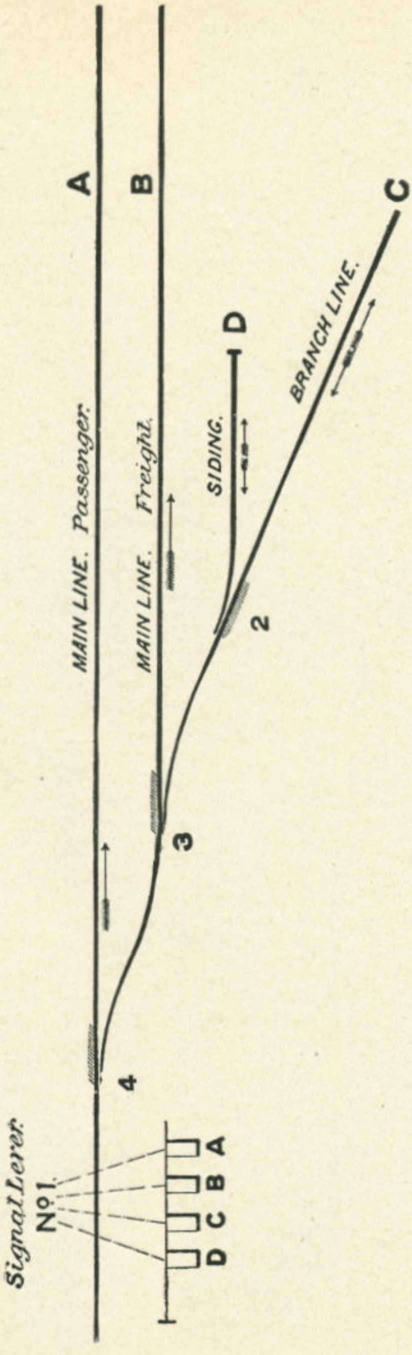

MAIN LINE. Passenger.
MAIN LINE. Freight.
SIDING.
BRANCH LINE.
A
B
C
D
2
3
4
Signal Lerer.
Nº1.
D C B A

PLATE 65A

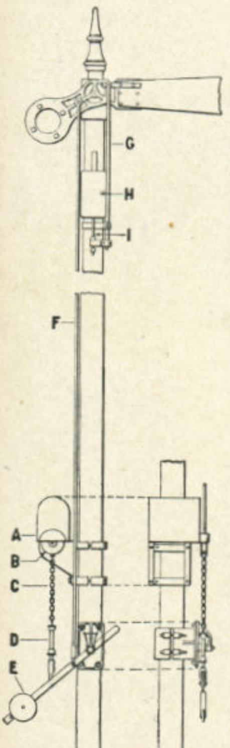


FIG 1

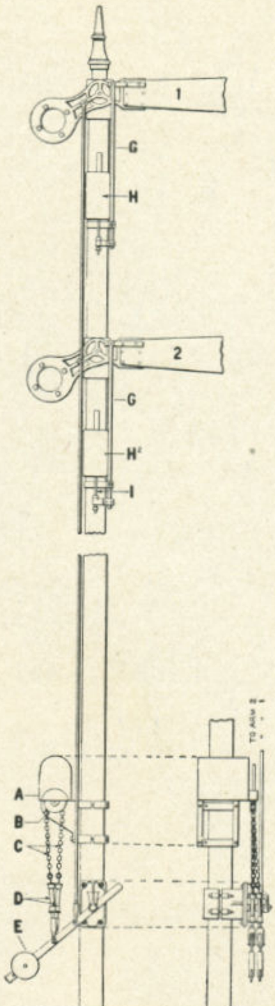


FIG 2

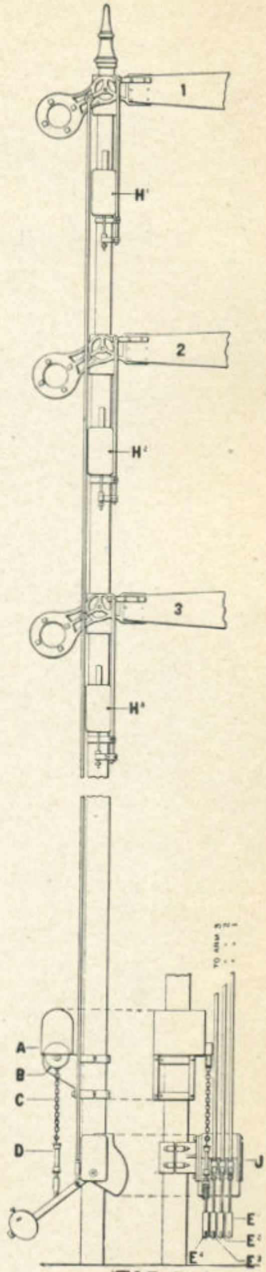
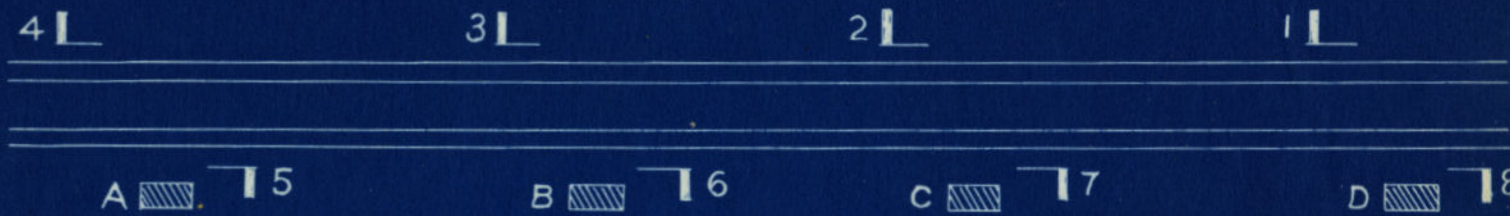


FIG 3

PLATE 65B

-nite distance apart; it differs from a "time interval" system, where a second train may pass a given point only when a specified time has elapsed after the passage of the first train. The time interval system is evidently not well adapted to secure safety and does not now meet with favor. It is not thought profitable to explain apparatus for giving time interval signals although some of these are ingenious and interesting.

The simplest form of "block signalling" is perhaps the ordinary case of manual blocking, where the length of the block is the distance between telegraph stations and the telegraph operators work the signals. When trains are infrequent a long block has little disadvantages The installations of block signals in this case involves little expense for the plant (the signal apparatus) and the expense of operating is increased by the wages of an increased number of operators together with a small allowance for repairs and deterioration of apparatus. (Night operators are necessary at every block station). The operation of a "manual block system" is as follows:- On the double track railroad shown in Plate 66, A B is a block as are also B C and C D. When an eastbound train approaches A (from W) the signalman at A, if there is no train in the block A B, sets signal 5 in the "all clear" position. The train proceeds as directed (or permitted) by the signal, and as soon as it has passed, the signalman puts his signal in the danger position, and notifies the signalman to the west that the train has passed. When the train approaches B the signalman gives a clear signal 6 if the block B C is clear, and when the train has passed B sets signal 6 again at danger and notifies signalman at A who then sets his signal 5 at "all clear" again, and is ready to pass the next train from the west when it comes. Each signalman has a blank on which he keeps a record of each train passing his station. Each train has a number



A.B.C. Ry.	Daily Record of Trains					
Meadowfield	Station	May 16-1904.				
Eastbound		Bk.	Hr.		Fd.	Rem.
Train	Engine	D.	A.	D.	D.	
14		1.37	1.44	1.47	2.01	
18		3.05	3.11	3.13	3.19	
	629	3.23	3.31	3.40	3.48	
26		4.50	4.55	4.57	5.04	
42		5.01	5.11	5.15	5.24	
12		5.16	5.22	5.25	5.37	
	536	5.27	5.35	5.39	5.46	
22		5.48	5.56	6.00	6.07	

Plate 66.

and each engine has a number and it is customary to enter both numbers in the record. Freight trains not regularly scheduled are not numbered and the engine number serves sufficiently to identify them.

The record or report may be in the form shown with Plate 66. The first column gives the train number; the second, the engine number; the third is headed with the name (or telegraph call symbol) of the station next west (as A), and shows the time of departure of train from that station; the fourth and fifth are headed by the name (or call) of the signalman's own station (as B), and the two columns show times of arrival and departure from that station; the sixth column is headed by the name(or call) of the station next east (as C) and shows the time of departure from that station.

The lever by which the signalman operates his signal, can be, and generally is, close by the table at which he works. The messages between stations A and B or between B and C or between C and D can be sent by telegraph by the common Morse alphabet, when the signalmen are telegraph operators, or by telephone. It is somewhat common in England, and now not altogether uncommon here to use bells for messages between signalmen and "bell codes" are arranged to cover all questions and answers necessary for operating the block signals. For instance -

1. Acknowledgement of any signal except as herein provided -
2. All right? Yes. 2-1 No.
3. Unlock my lever. 2-4 Has train cleared?
4 Train has entered block. 3-3-3 Train to you broken in two.
4-2 Train has cleared, etc.

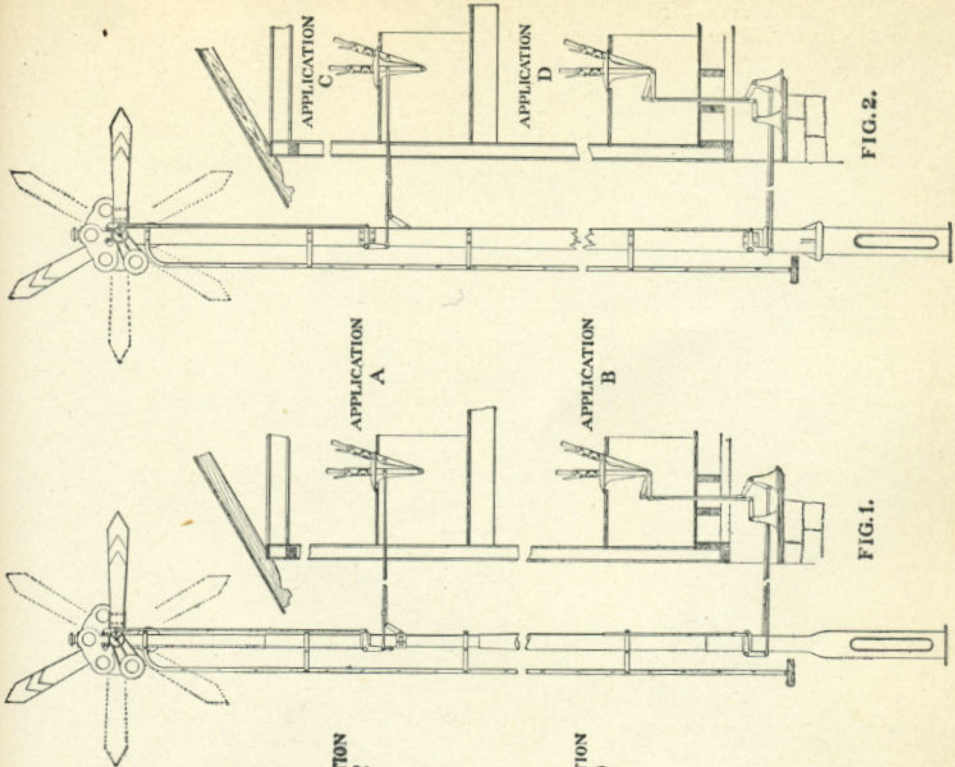
The advantage of the "bell code" is that an inexperienced man can learn the code more readily than he can learn telegraphing. Men able to operate by "bell code" can be more readily secured or more quickly educated and for less wages. A phrase is sent by a few rings of the bell which makes this system rather quicker also. An alternative is a dial with a needle whose pointer shows whether a train has passed the succeeding station or not; this is limited in scope.

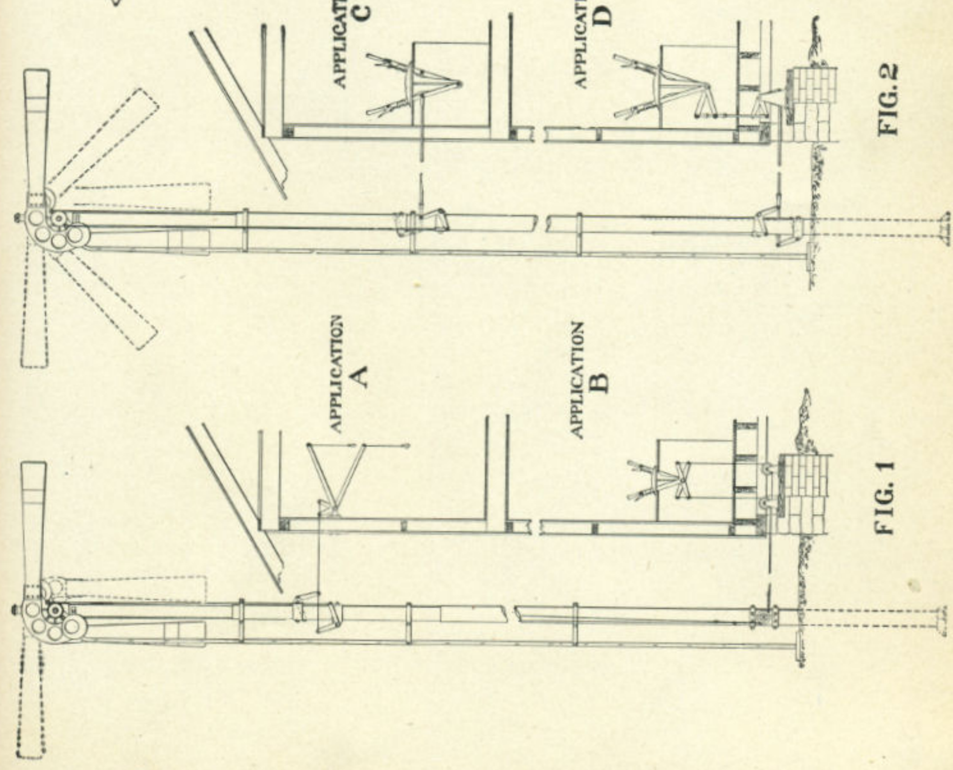
The method of communication between signal stations may then be (a) telegraph (Morse alphabet) (b) bell, (c) dial, (d) telephone.

With a "bell" or "dial" communication it is practically necessary that there should be special wires from station to station, and that the operation of the block system should be in the hands of the operators at the stations, thus fixing the responsibility closely upon the operator; when the Morse telegraph is used the arrangement may still be the same, and this represents good practice in this matter. Advantage may be taken, however, of the regular wire used by the train despatcher and by agents and operators for the general business of the railroad. In this case any message sent can be heard by any operator on that line, and the train despatcher can, if he wishes, have complete knowledge, or even exercise complete control, of all train movements from block to block. If this is done the system differs little from a "train order" system, where trains are run by telegraphic orders from the despatcher, and a train passes any station or stops at it depending mainly whether a "train order" signal is displayed or not. The "train order signal" on many roads is of a special form as shown in Plate 66, or of some other peculiar form which finds favor with the railroad using it. In some cases, or in many cases a semaphore is used, but this often differs in form somewhat from the semaphore used for interlocking or perhaps for general block signal work. Advanced practice asks for a train order signal uniform with the block signal, so that as the train order sys- [illegible]

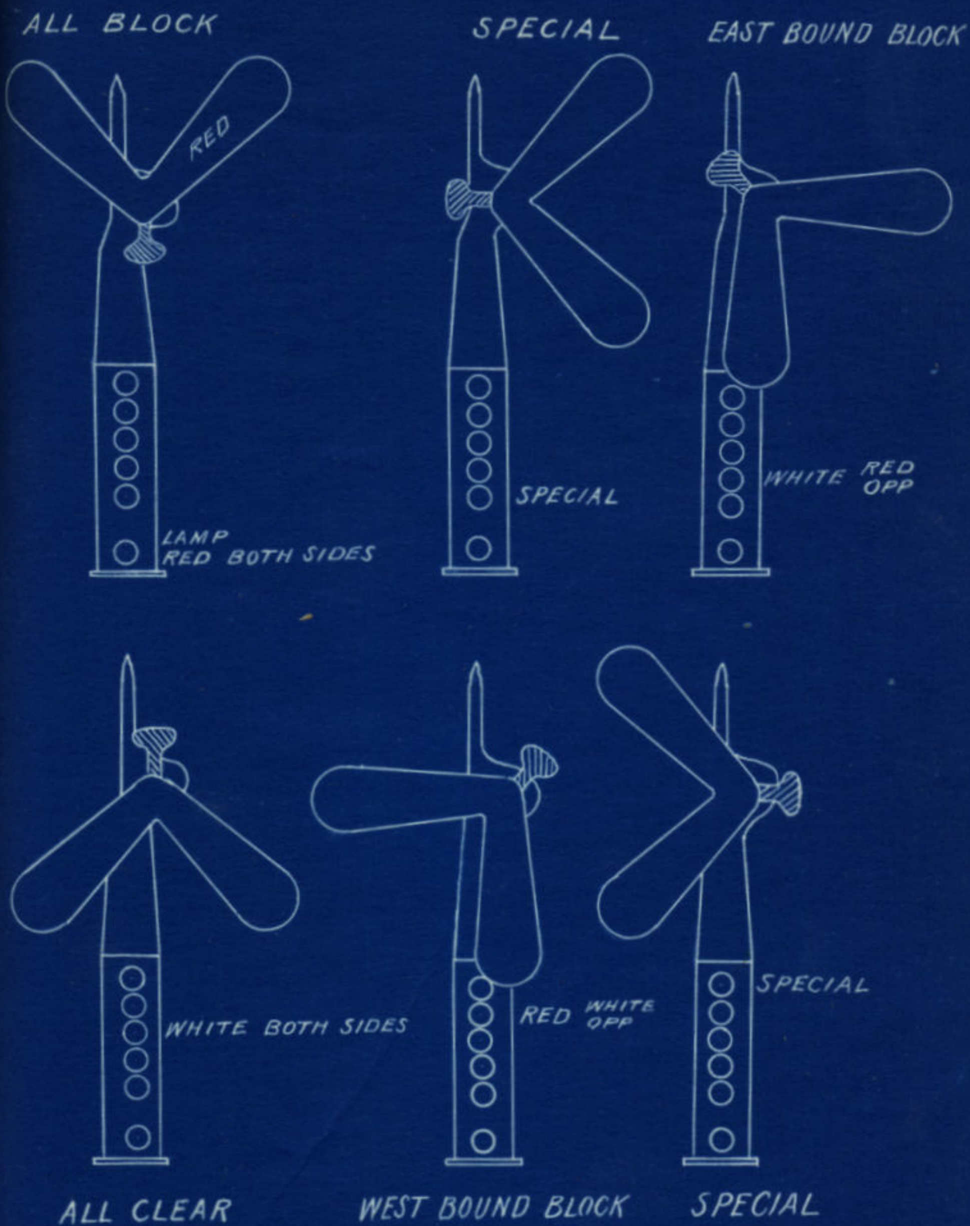
-tem either merges into a block system, or is abandoned for the block system the equipment in use can be utilized without change (or material expense) in fitting it into the new scheme. Plate 67 shows a form of semaphore in use on the A.T. & St. F. Ry. for Station Signals or for Block Signals. Plate 68 shows a peculiar form ("boot-jack") used on the L.S. & M.S. R.R. but this apparently is used for both Block and for Interlocking signals. The diagram explains itself sufficiently. Plate 69 shows the ordinary arrangement for connecting the levers in the station with the semaphores (one for each direction as east and west). Fig. 1 shows a wire connection; Fig. 2 a pipe connection. The levers are of different form depending upon whether the operator is on the ground floor or in the second story. In this case both signals are on one post directly in front of the station. A better arrangement for train movements is to have the signal for any train about a train length beyond the station, so that a train may stand opposite the platform while awaiting a clear signal. When used as a train order signal only it is sometimes arranged that the signal must stand at "danger" except while held at "safety" by the operator. Ways are frequently found for "beating such a scheme". In the simple system of blocking outlined, an element of danger arises from the fact of human fallibility. While in general it works well, occasionally an operator has been found to display a clear signal before the train has left the block ahead. This has come about sometimes through carelessness (or recklessness), sometimes through misunderstanding between the signalmen.

The "Controlled Manual Block System" came into use for the purpose of curing this difficulty; in this system not only must the signalman No. 1, ask the signalman ahead No. 2, if the block is clear but he must also move the proper lever (or similar device) in his ma-


APPLICATION C
APPLICATION D
FIG. 2.
APPLICATION A
APPLICATION B
FIG. 1.


APPLICATION C
APPLICATION D
FIG. 2
APPLICATION A
APPLICATION B
FIG. 1

PLATES 67-69



LAKE SHORE & MICHIGAN SOUTHERN

Plate 68.

chine and by electrical connection act on the signal of signalman No. 1., and release a lock on it; signalman No. 1 is powerless to clear the signal until this is done.

In order to make the safeguards more complete, in some quite modern instruments it is made impossible for signalman No. 2 to unlock signal No. 1 until the block is actually clear, that is until after the train has passed signal No. 2, and until the train has by electrical connections effected a release of a lock in the machine of signalman No. 2. A further refinement allows signalman No. 2 to unlock signal No. 1 only during the time when signalman No. 1 is holding his machine in readiness to be unlocked by signalman No. 2. The machines used for these purposes most commonly are the "Sykes" the "Patenall" and the "Coleman" machines, the latter being the latest and most elaborate. A detailed description of this may be found in the book "The Block System" by B. B. Adams, published by the Railroad Gazette, N. Y. Another excellent book on the subject of signals is "Block and Interlocking Signals" by W. H. Elliott, published by Locomotive Engineering. N. Y. The details of the electrical and mechanical arrangements to secure the results outlined above, are too elaborate and complicated to be advantageously described here.

Where the traffic is large the signal stations must be correspondingly close together, and signal towers will necessarily be provided, which will be used only for signalling purposes, and the expense for installation, for operation and for maintenance will all becomes items of consequence, but may easily be warranted either on the score of safety, or without this, purely on the basis of the increased capacity for traffic. It will be understood that in this system, the signals are operated by the signalman by mechanical connections, but are controlled (to secure safety) by electrical connections operated in part by the trains themselves.

The "Automatic System" might with propriety be named the "Electric Automatic System" since its feature or characteristic is that the train itself establishes electrical connections which reach the proper signals, and control them so that they take the proper position "safety" "caution" or "danger", the work of moving the signals being accomplished by weights, by gas pressure, or by electric devices (magnets or motors) or some other force conveniently arranged. The signals are moved, however, without any direct or immediate manual application, the system being thus "automatic".

Automatic signals have the electrical connections established (by the train itself) through (a) Track instruments, or
(b) Track circuits.

The track instrument is shown in Plate 70, and is simply a lever one end of which is depressed as the wheel tread presses on it; the other end through suitable devices, makes or breaks an electrical circuit which effects the desired change in the position of the signal. The lever L depressed by wheel lifts (or kicks) piston S upwards, air in the cylinder passes from above to below S through opening Y and post X, when S covers Y further lifting is resisted by the air cushion above. As S falls its action is retarded by the air below it whose escape seems to be regulated for that purpose. The upper right hand figure shows that S in rising, by means of its conical top presses against the roller of A and revolves this swinging arm so as to result in the spring B pressing against its anvil C making a closed circuit from button 1 to button 2. Apparently this instrument when acted on by the first wheel of a moving train will have the circuit closed (as shown here) and the piston S will fall slowly enough so that the contact of B and C will not be broken between the time of passage of two consecutive wheels

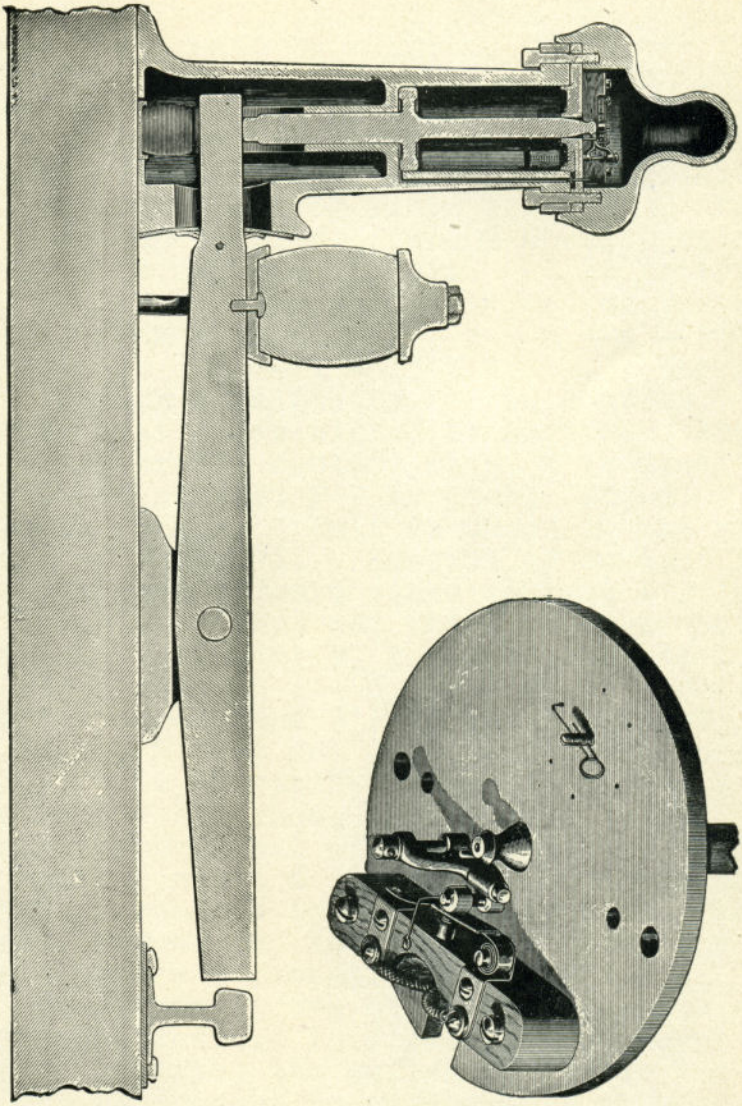


PLATE 70

of a moving train.

Plate 71 shows a simple application of the track instrument. S shows the signal (a disc) operated by magnets; D is the track instrument opposite it, whose function is to throw the signal to danger. B is a similar track instrument to throw signal to "clear" when the train reaches B. The instrument B is like that shown on Plate 70. In D the normal position is closed, and a wheel passing serves to break the circuit. X is battery, R is relay. Normally (top view) closed circuit is from X through 5 - r - r - 4 - P'- P - - 3 - S - 2 - E - 1 - to X again. The current through R maintains P'P in contact, through S it holds signal at safety. When a car wheel breaks contact at E, R is demagnetized, and contact P'P is lost; signal S also drops to danger. This is shown in the middle figure of Plate 71. Renewal of contact E fails to open circuit since contact P'P is still lost. When car wheel makes contact C at track instrument B, a closed circuit is established through x - 5 - r - r - 6 - C - 1 to X again and contact P'P is reestablished. The signal S does not go to safety so long as contact C is maintained, because signal S offers much resistance, and relay R little. The current (nearly all of it) flows through C and not until contact C is broken, is there enough current through 3 to operate signal. The signal, therefore, is at danger until the wheels have all passed.

The lower figure of Plate 71, shows an additional feature in a switch instrument G. Apparently after the switch is thrown the signal can be brought to safety only through the action of B. Plate 72 shows a switch instrument.

The Hall Signal Co., has used track instruments in earlier installations, and Plates 70 and 71 are taken from their catalogue and the signal shown is of a type frequently used by them. It should be understood that Plate

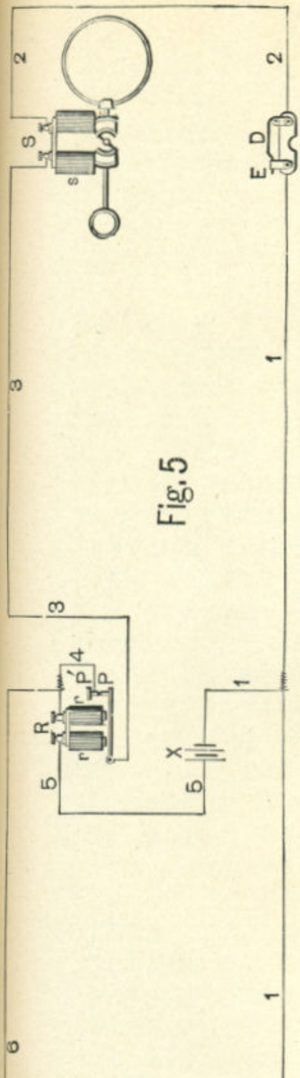


Fig. 5

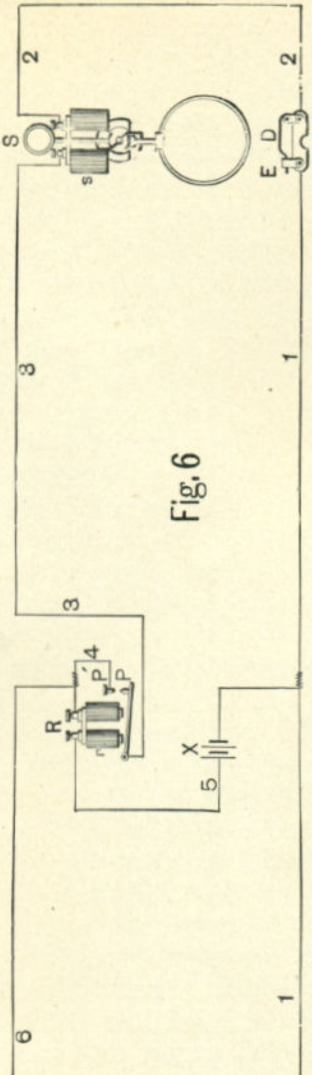


Fig. 6

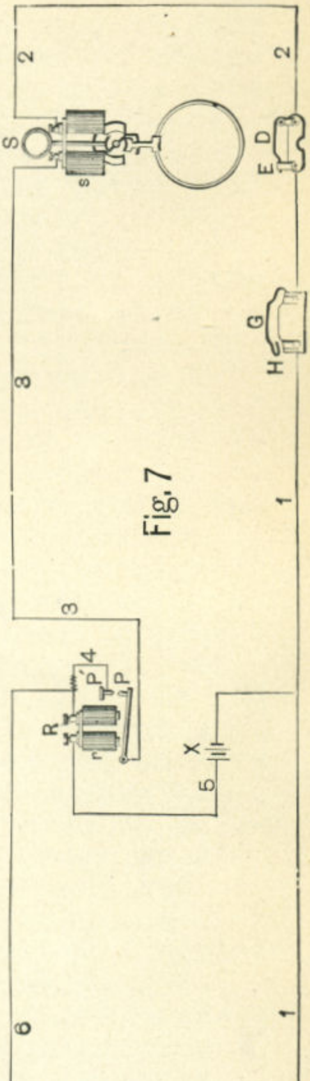


Fig. 7

PLATE 71

71 is shown by them and here also only to show simply in a preliminary way a scheme of operation that can be easily understood. The form of signal is better shown in Plates 73-74-75. The type is most properly known as a "disc" signal. A more common designation among railroad men in general is "banjo signal". No formal explanation seems necessary here.

The "Track Circuit" arrangement to accomplish a similar result can be understood by reference to Plate 76. In Fig. 16, there is a closed circuit from battery through lower rail, relay and upper rail back to battery. The relay allows the signal battery to hold the signal at safety. When connection is made between the two rails the relay fails to act on account of the short curcuit through the rails, the circuit from battery to signal is broken, and the signal goes to danger. A broken rail, or almost any defect of apparatus will have the effect of breaking the circuit and throwing the signal to danger which is considered a desirable feature in all signalling. An open switch can readily be arranged to have the same result. When the train passes out of the section, the signal again goes to safety. It will be observed that a break in the rails is shown at each end of the section. When the rail circuit system is used, the joints at each end of the section are "insulated" by interposing some non-conducting substance between the rails and the joint pieces, so that each section will be insulated from the other sections adjoining. To get good results in freedom from resistance, it is found necessary to connect two abutting rails within a section by means of wires (bond wires) generally of copper. The matter of insulation has been the cause of a good deal of study, and the bonding of rails is also a matter worthy of definite attention. Bond wires under heavy traffic tend to work loose. Plate 77 will give some idea of bonding and of insulation of joints.

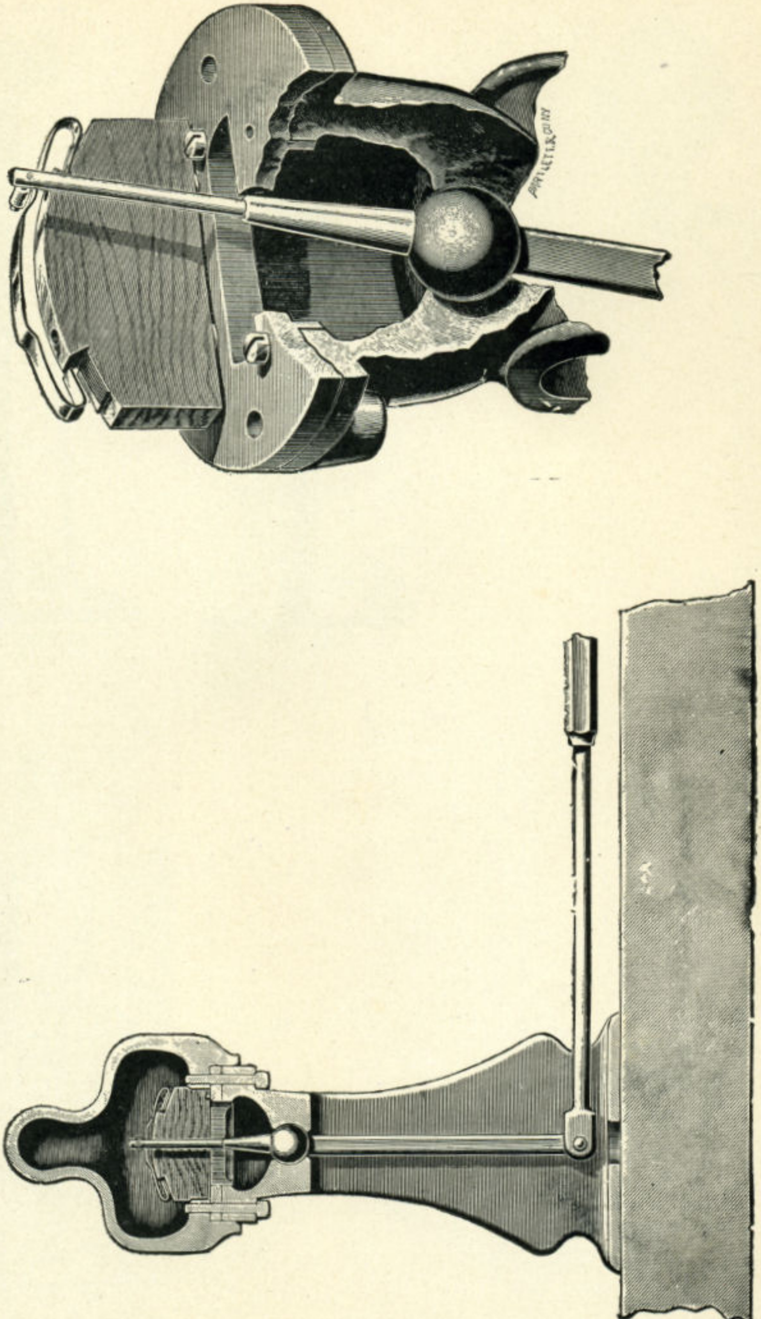
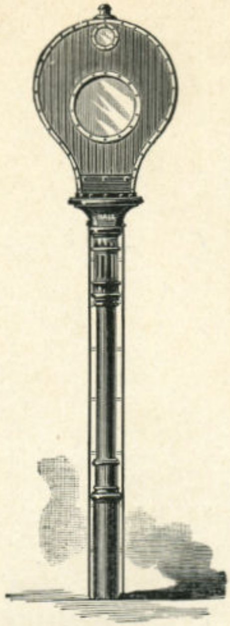
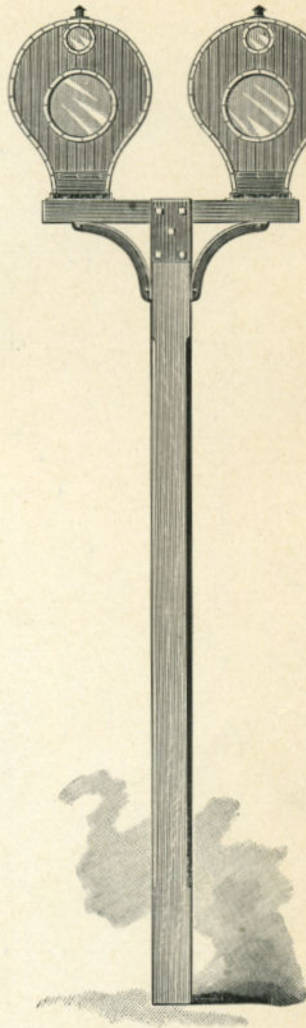
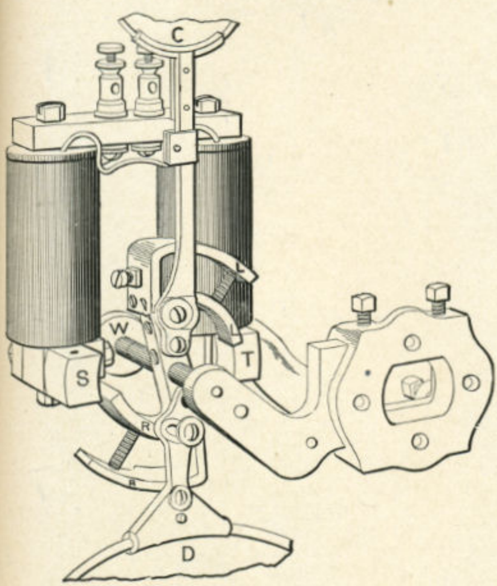


PLATE 72







PLATES 73-74-75

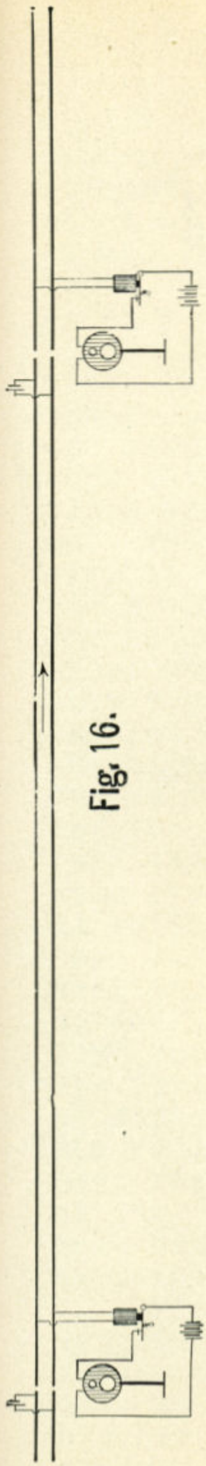
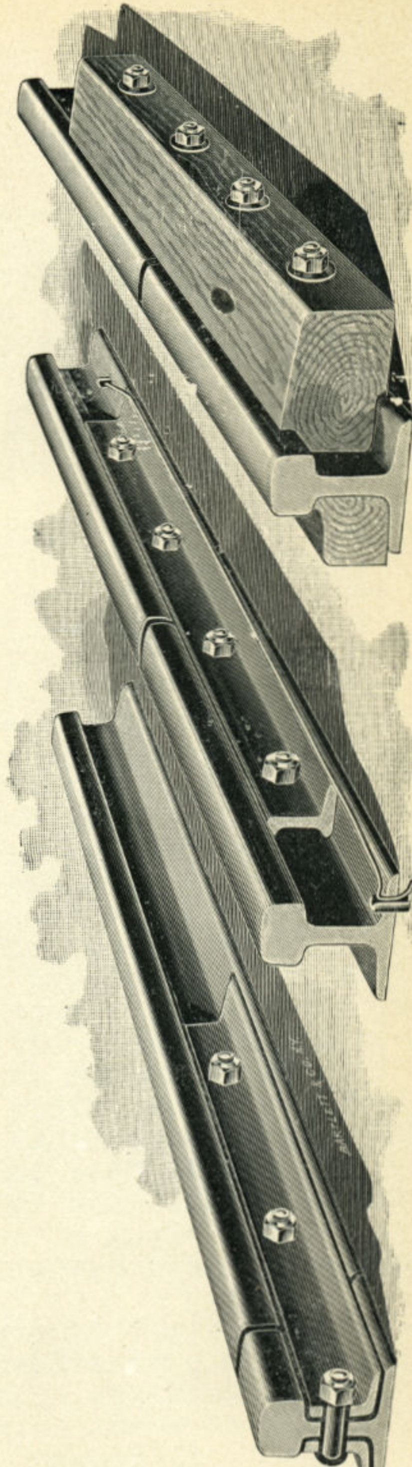
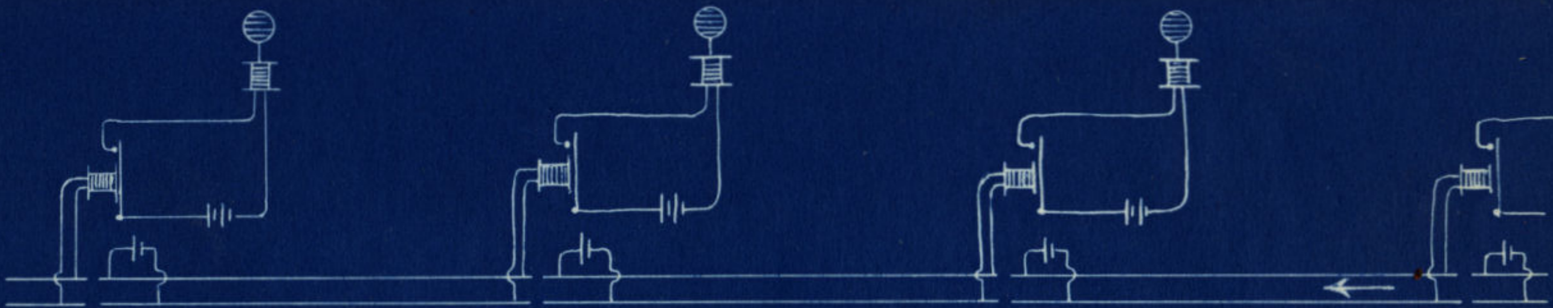


Fig. 16.

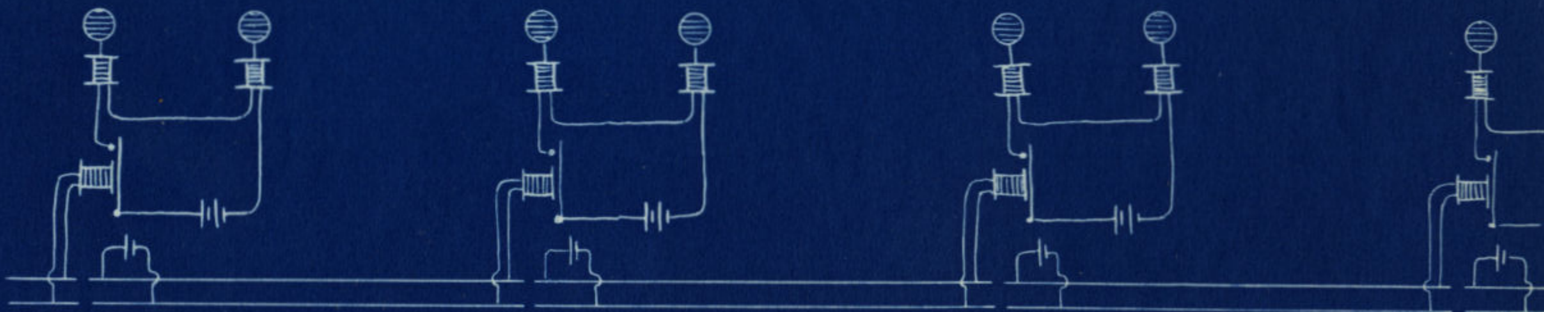


The simple arrangement shown either for the "Track Instrument" or the "Rail Circuit" system has serious defects. In the Track Instrument system, for instance, the forward wheel of a train just stopping may set the signal (behind it) to safety, and the whole train behind it will stand in the section for which a clear signal is shown. If a train breaks in two and the forward part runs to the track instrument, a clear signal results, although most of train may stand in the section and perhaps at some very dangerous point. The same thing is true even of a controlled manual block system, unless something of the rail circuit system is combined with it. The rail circuit system is not subject to these criticisms and appears to be accepted as superior for automatic signals. The simple system shown above is, however, subject to the defect that a train standing barely within the second section is in danger from a following train if the signal (nearly opposite the beginning of the section) cannot be seen soon enough to allow the following train to stop in time to avoid an accident. The remedy is to adopt some system which is necessarily more complicated so that the first train cannot free the back signal as soon as it passes into the next section; it must pass beyond to the length of an additional (short) section called an "overlap" before the back signal can be cleared. The train is then always protected by a signal at danger and far enough behind it to allow the following train to stop even if the engineer sees the danger signal only when abreast of it; as may be the case in fog, or under some other unfavorable circumstances of weather or perhaps of topography.

Plate 78 shows the wiring for such an arrangement. A serious disadvantage and also an element of danger in this arrangement exists in the fact that the engineer does not see his signal move as he passes it, because it does not move until the front of his train



SIMPLE OVERLAP



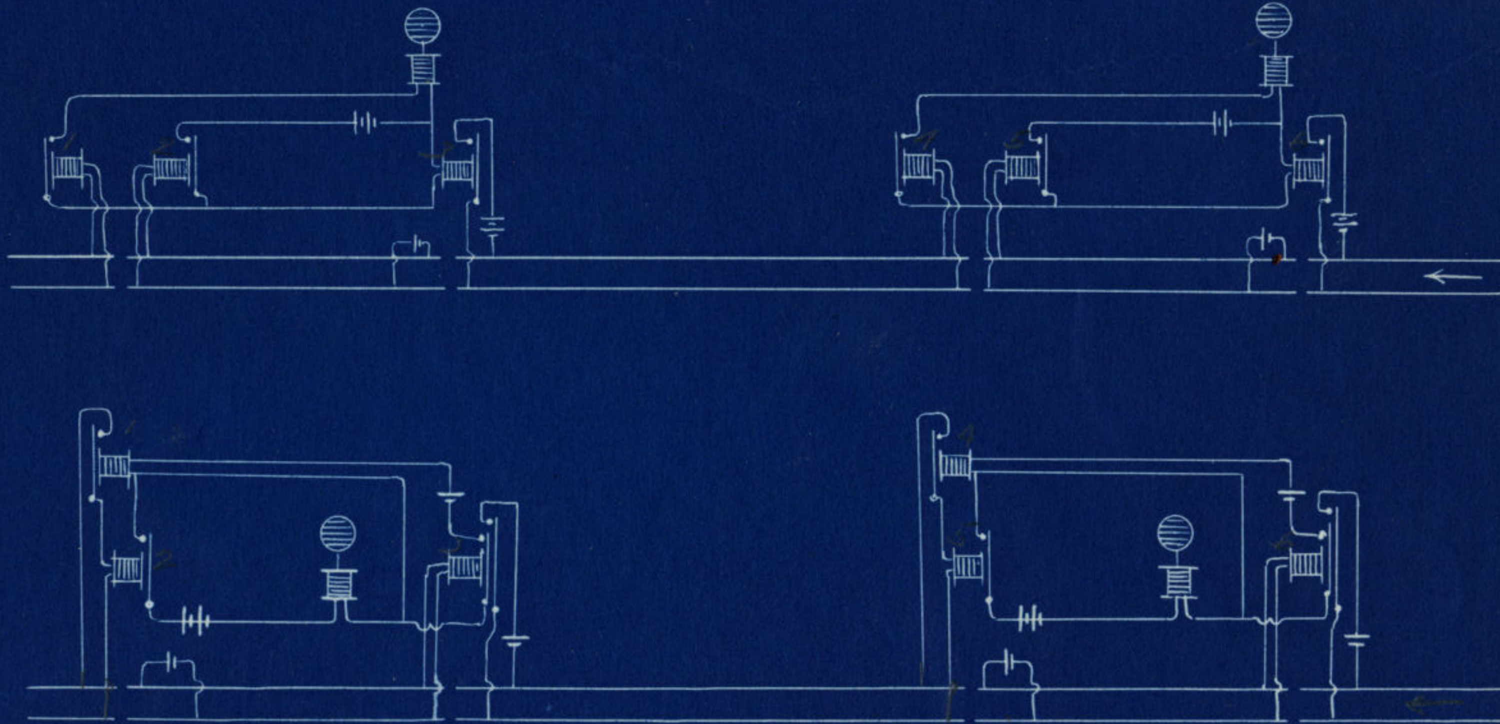
OVERLAP WITH TELLTALE

Plate 78.

is 1500 feet (or whatever may be the length of overlap) past the signal. The defect is cured in part by introducing another signal (telltale) at the end of the section. The engineer can see this move, and its position of danger behind the train is a protection as well as an indication of the position of the other signal. A still better arrangement is to have the "overlap" scheme more complete by the device of an overlap section, which is a complete section insulated like any other section. A train running over the line will then pass over the main section or block (of considerable length), then over the overlap section (only of sufficient length to safely stop a train), then over the next main block section then over the next overlap, and on in this order indefinitely. Plate 79 shows two methods of wiring which have been used by the Union Co. for track circuit and overlap block signalling, the lower scheme being thought more desirable. The arrangement and changes in circuits due to the passage of the train are not difficult, and are left as a study or problem instead of being explained here.

The upper figure in Plate 80 shows an older arrangement of the Hall Company for an overlap scheme, and the wiring includes a switch with its switch instrument. The lower figure shows an overlap scheme (an old one of the Hall Company) where track instruments are used. The arrangement is more elaborate than seems necessary for the track circuit scheme. An explanations of the circuits may be of advantage. B C represents the overlap. The signals 1 - 3 - 5 are all "clear" in the normal position shown in Plate 78. The normal circuit is battery X, wire 1, magnets E, point contact e'e, wire 2, magnets G, closed spring contact p_1 wire 4, instrument a, wire 5, signal 1 wire 6 connecting back to X; contacts e'e and p are dependent upon having a closed

Plate 79.



OVERLAP SECTIONS

TWO METHODS

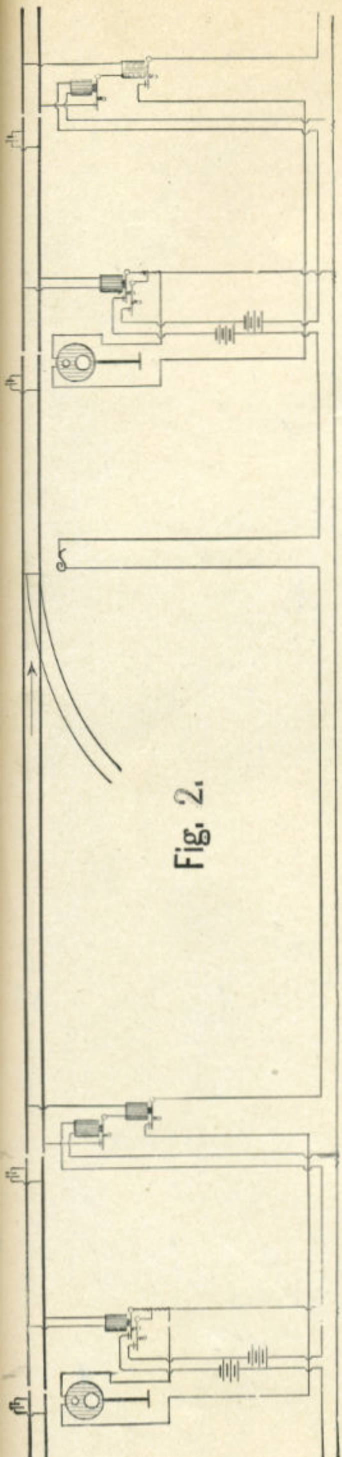


Fig. 2.

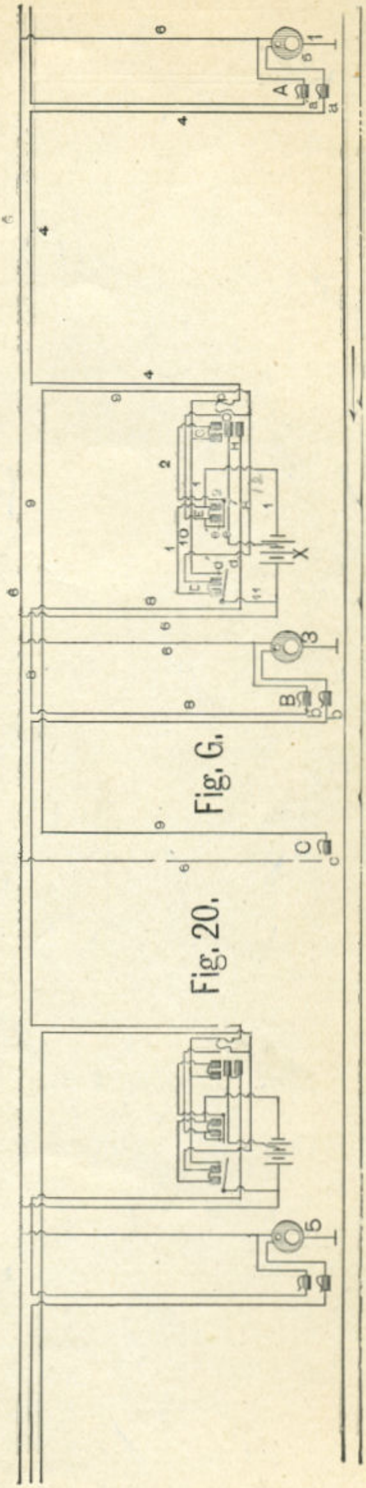


Fig. G.

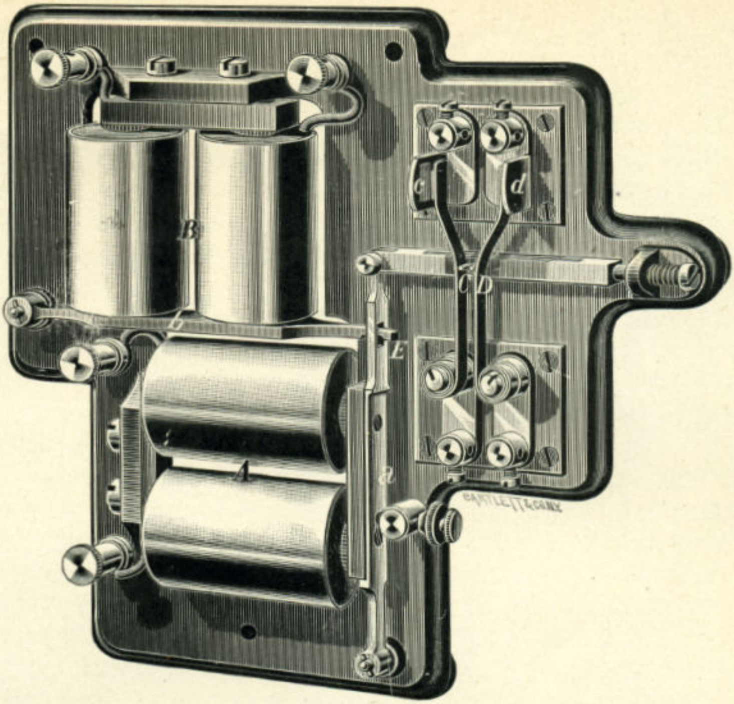
Fig. 20.

PLATES 80-81

circuit through E and G; if E is demagnetized contact e'e is destroyed; if G is demagnetized and in addition H is magnetized then contact p is lost and contact O is established. When train passes A, track instrument a' has contact established but the effect of this is felt only on the back section. Track instrument a has contact broken, the circuit through signal 1 is broken and the signal goes to danger. The breaking of the circuit demagnetizes E and G so that contact e'e is lost and p will later be lost as will be described later. When the train has passed A and the contact a is again established, signal 1 still remains at danger due to the loss of contact e'e. When train passes signal 3 contact b is lost, and signal 3 goes to danger. In addition to this contact b' is established. There is then a closed circuit as follows: battery X, wire 7, magnet H, wire 8, track instrument b', wire 6, back to X (passing end of wire 11). The magnetization of magnet H establishes contact O and destroys contact p. When the train has passed B the only permanent result is the establishment of contact O and the loss of contact p. When train reaches C at the end of the overlap, there is found a closed circuit from battery X through wire 1, magnet D, wire 12, wire 9, track instrument c, wire 6 return to battery. Another closed circuit also exists; battery X, wire 1, magnet E, contact O, wire 9, track instrument c and wire 6 back to X. The magnetization of magnet D establishes contact d'd and of magnet E, contact e'e. Now a closed circuit is in operation; battery X, wire 1, magnet E, contact e'e, wire 2, magnet G, contact d'd, wire 11 and back to X. For the time being the contact p does not exist, but as soon as G becomes magnetized (H was demagnetized when the train passed B) the contact O is destroyed, contact p is again established normally as in the beginning and signal 1 goes to safety again.

The interlocking relay instrument is shown in Plate 81 A one of these is the Hall and the other the Union type.

In all cases shown thus far the normal position of the signal has been "clear" and the signal has gone to danger as the train passed. With the track circuit systems, the circuit has been normally open and any accident to the line by short circuits produced by wires crossing would cause the signal to go to danger the same as if a train were on the track; a break in the wire, a break in any rail would break the circuit and the signal would go to danger. It is a general principle to be observed in signalling (as previously stated) that any defect of apparatus should lead to a "danger" position of the signal. One possible danger is that a signal left a long time at safety might, in a sleet storm, become frozen and fixed in the safety position. Furthermore there is some waste (in cost of battery) in maintaining a signal circuit as a closed circuit. This would be true especially where there are a few trains a day. As a result of these and perhaps other considerations, a system has been devised called a "Normal danger" system, as distinguished from the "normal clear" system such as have already been considered. Plate 82 shows from an early Hall Company's catalogue what is called then the "Wilson Self Indicating Track Circuit System", which is a "normal danger" system. It should be understood that in a normal danger system, the signal remains at danger only until the approaching train is one block away; the train then acts on a track circuit in such a way as to throw the signal ahead to clear, so that as the train more closely approaches, the signal gives the proper clear indication (unless the block ahead is occupied). The common arrangement as already suggested has been for an open circuit where no train is near. The approaching train in the "normal danger" system has the effect of closing the circuit, in which case the signal ahead is brought to safety. As a closed circuit is



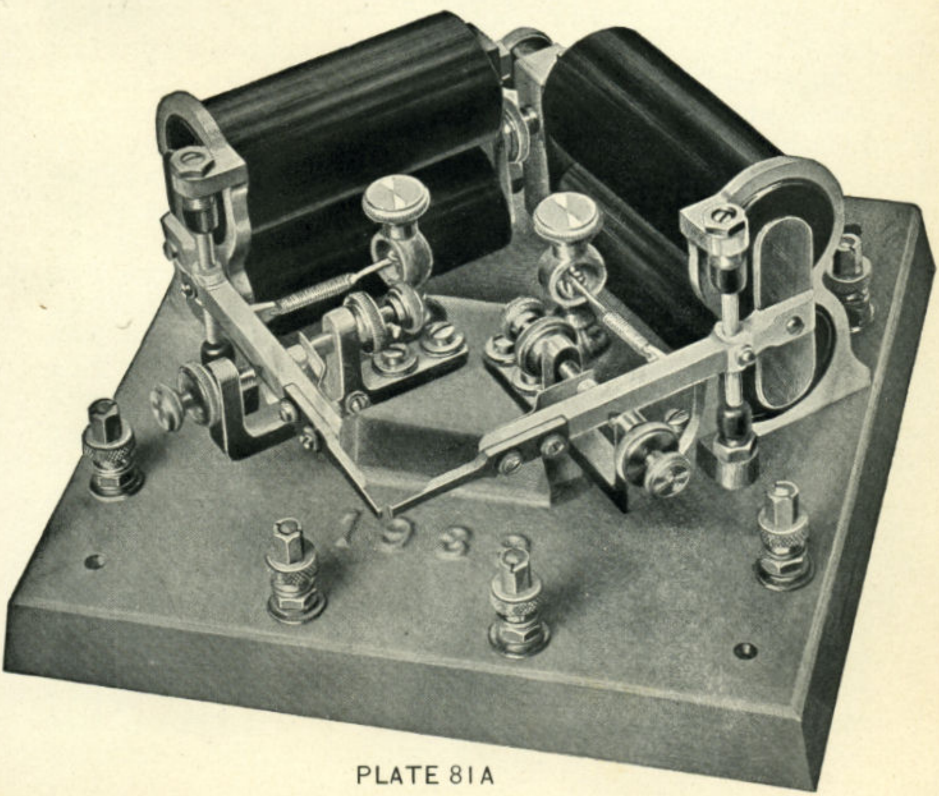


PLATE 81A

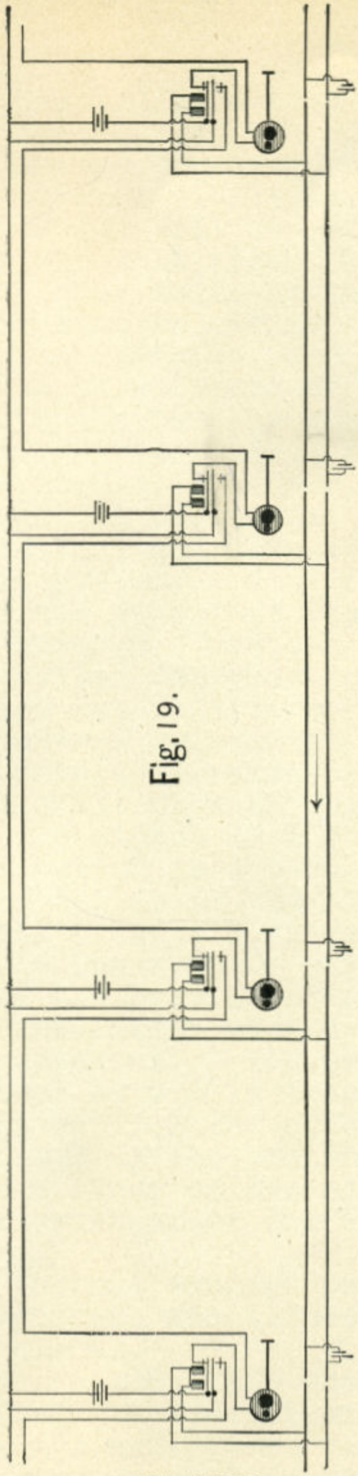


Fig. 19.

PLATE 82

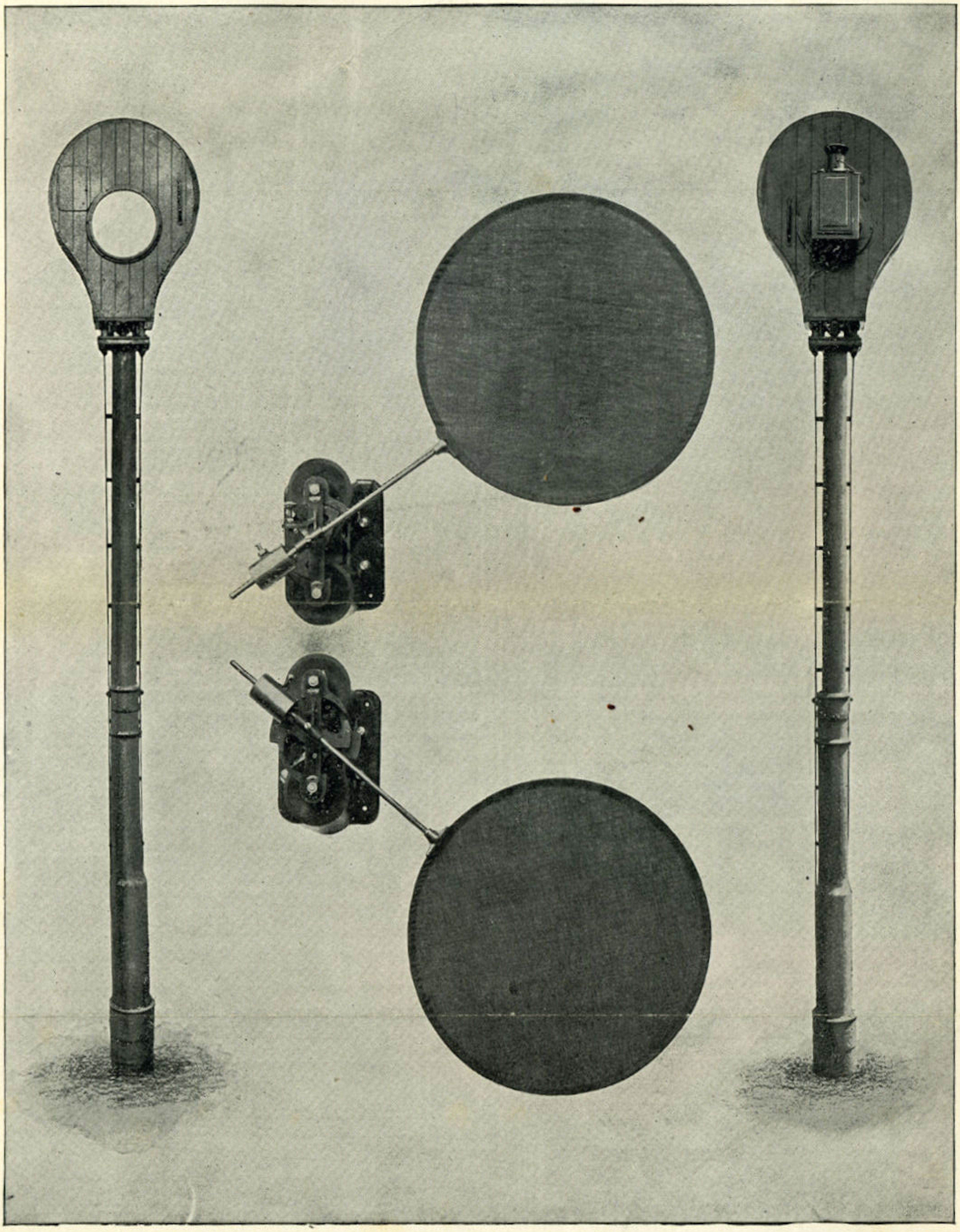
necessary for a safe signal, the general conditions of good signal practice are maintained, as any defect of apparatus may be expected to prevent a "clear" signal. Plate 82 shows the "Wilson system" referred to above. Its action does not require special explanation. The advantages and disadvantages of the "normal clear" and "normal danger" systems are a subject of discussion or controversy between signal companies and between signal engineers, and the advantage is not in all points in favor of either system.

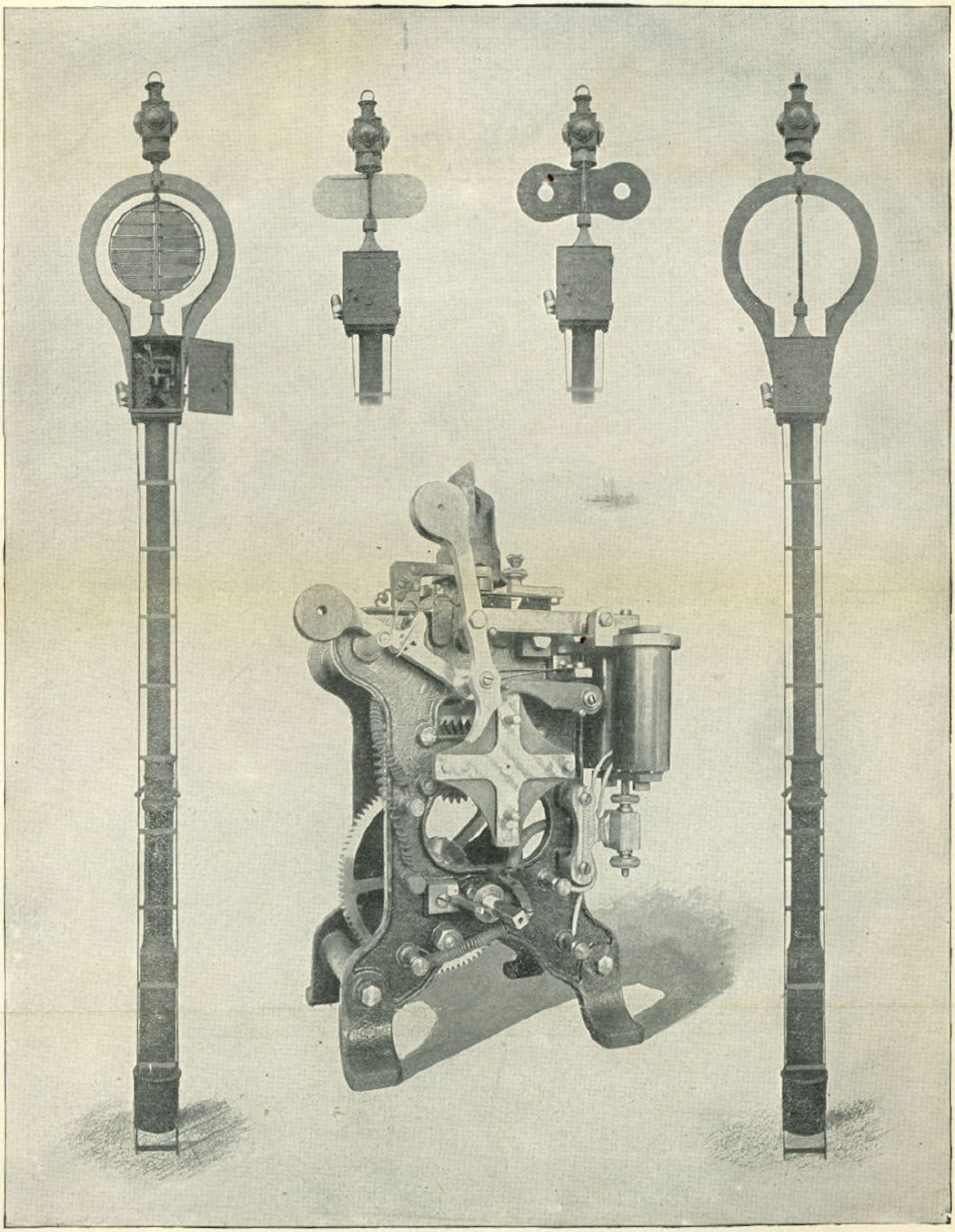
The systems described appear to have reached a point quite satisfactory looking from the standpoint of safety. Modern requirements on a road with many and especially with fast trains look hard at "convenience" of operation also, and from this standpoint, the engine runner needs earlier information than is given him by a single signal controlling a block. For fast trains, therefore, two signals are required for each block, the "home signal" at the beginning of the block and the "distant signal" at an appropriate distance preceding it. Where a line is divided into a series of blocks each consisting of (a) a long main section (insulated) and (b) a shorter overlap section (separately insulated), a common arrangement is to place the distant signal at the beginning of the short (overlap) section and the home signal at the end of the overlap and beginning of the longer main section. The early assurance of a clear route for some distance ahead, which is given by a distant signal is of considerable advantage in fast running; a block not clear is protected by two signals, one of which (the distant) is a warning only and does not demand an immediate stop; the second (home) indicates a train close by, in advance;. any train passing a home signal at danger (if the rules allow this) must expect to catch sight of the earlier train at any moment, and must be under very complete control for a sudden stop.

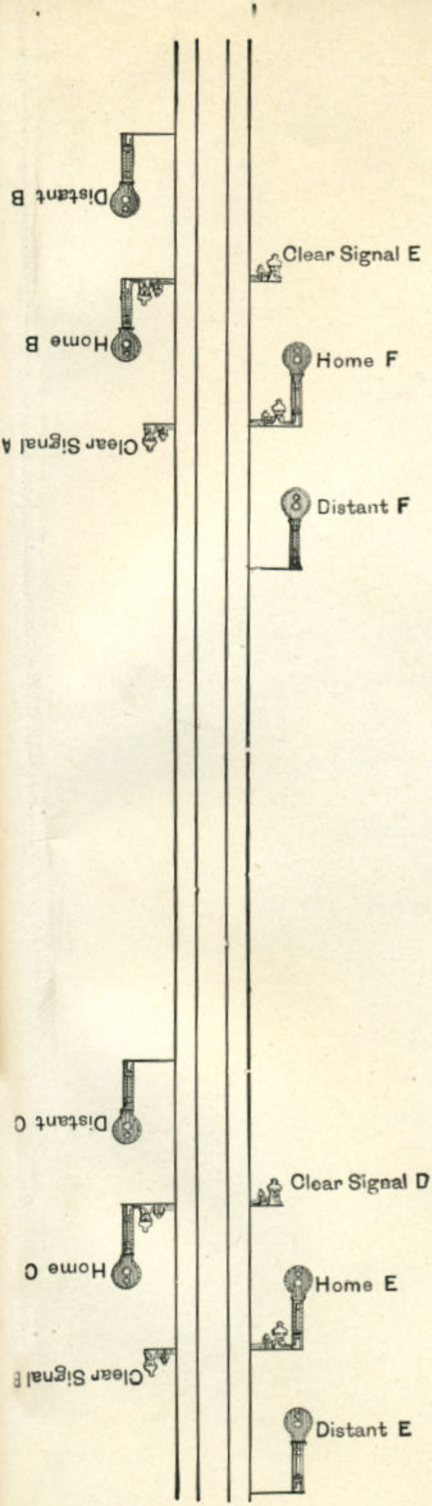
Plate 35 gives some idea of the positions of home and distant signals of the Hall type. The general sketch shows track instruments, while the sketch of wiring is arranged for track circuits and will be referred to later. The forms of the Hall signal have been shown in Plate 73. The Union Switch and Signal Co. have somewhat similar signals in the Banner Signal shown in Plate 84, and the Disc Signal shown in Plate 83. Plate 87 from the Catalogue of the Union Company shows various arrangements of signal systems and of signals; A shows disc signal, B banner, and C semaphore signals in various positions. D shows a track with switch, and with wiring for ordinary track circuit system. This differs from the Hall only in the fact that the Hall carries the circuit through a switch instrument. Some of the Switch Companies claim that throwing the switch may fail to make good enough connection between switch rail and stock rail. Unless the contact is reasonbly good, enough current will still flow through the relay magnet to hold the signal in the clear position although the switch is thrown and constitutes an element of danger in the block. Referring still to Plate 87 line 1 shows a "normal danger" system. The symbols for the insulation at the end of the main block and the other symbol for the insulation at the end of the overlap will be apparent. The gap within the block just back of S 6 is intended to represent a broken rail. The effect of the various trains and of the broken rail will be evident from a study of the diagram. Line 2 is a similar arrangement for a "normal clear" system.

Line 3 "normal danger" and line 4 "normal clear" go together, and illustrate the use of the distant signal.

When the "blocks" are short, as they will be where a frequent traffic must be provided for, two signals are put in the same post, the home signal for one section and the distant






Distant B
Clear Signal E
Home B
Home F
Clear Signal A
Distant F
Distant C
Clear Signal D
Home C
Home E
Distant E

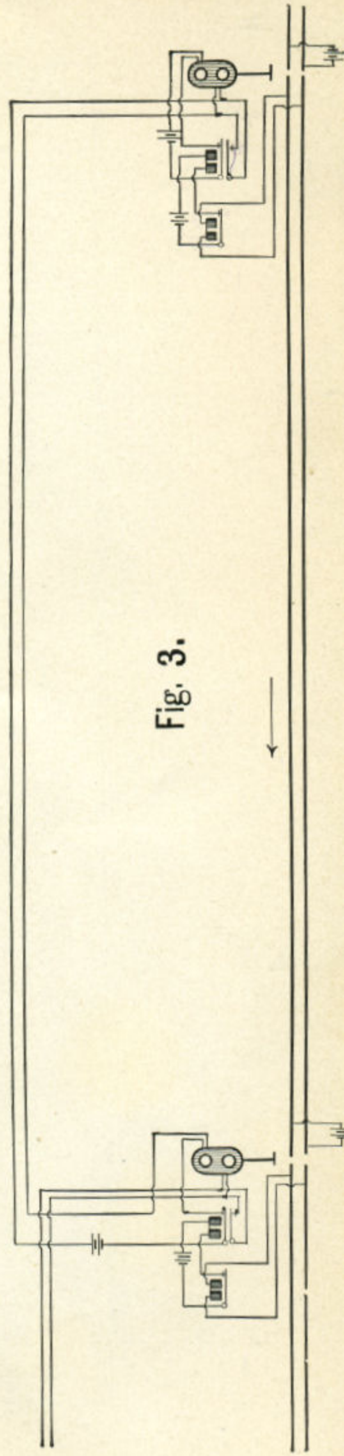
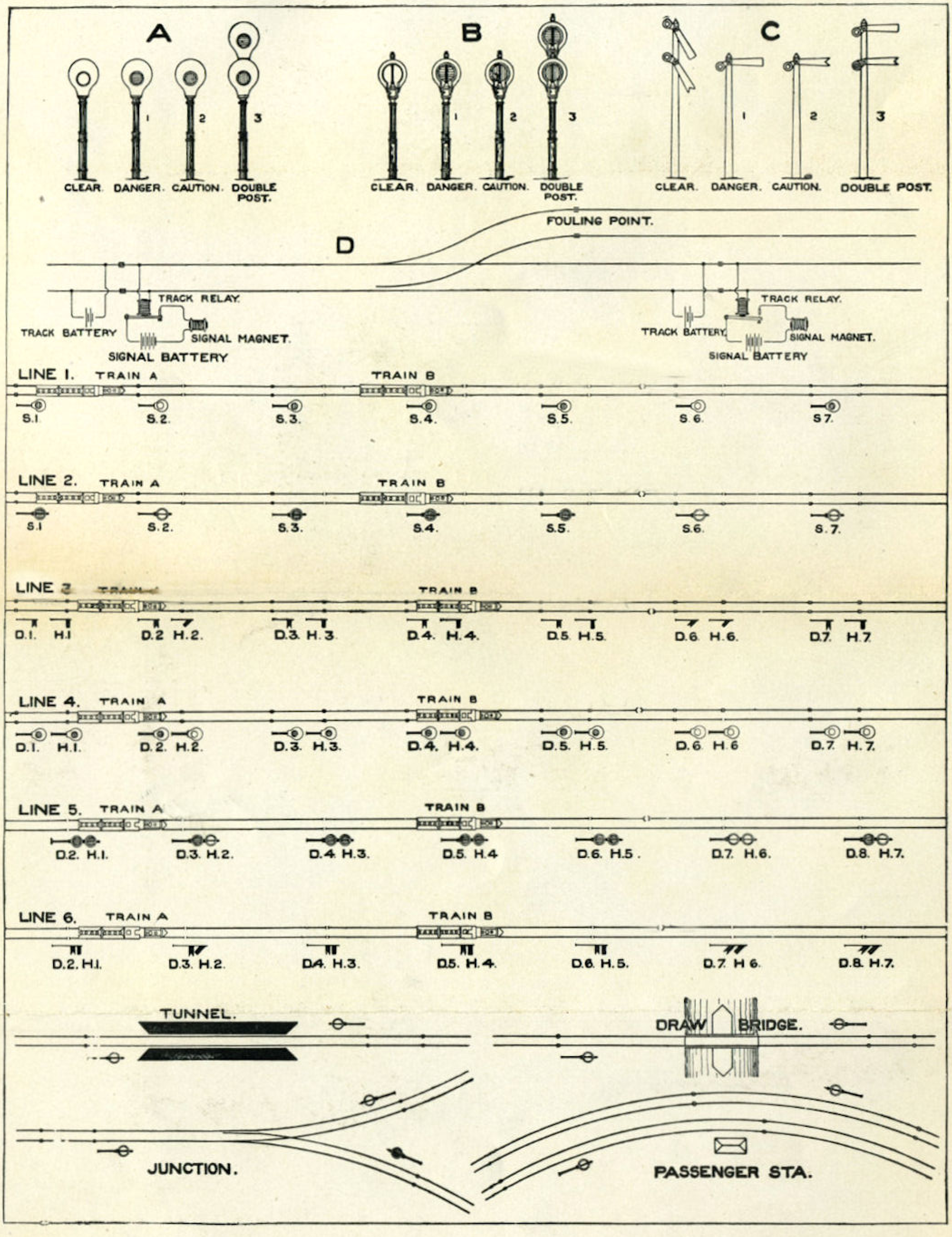


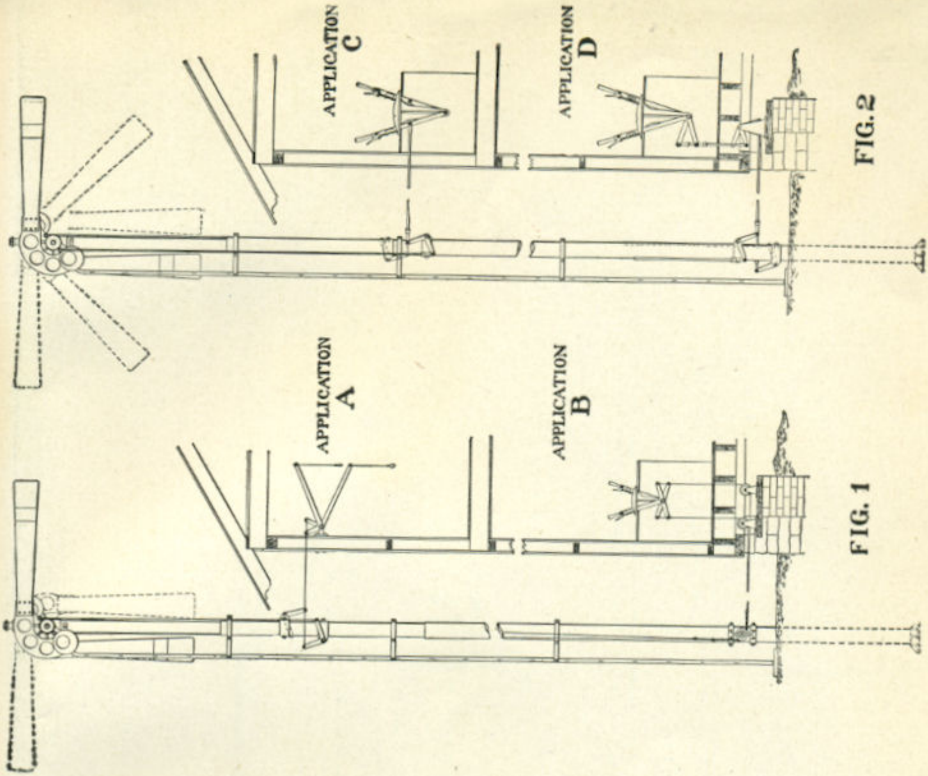
Fig. 3.

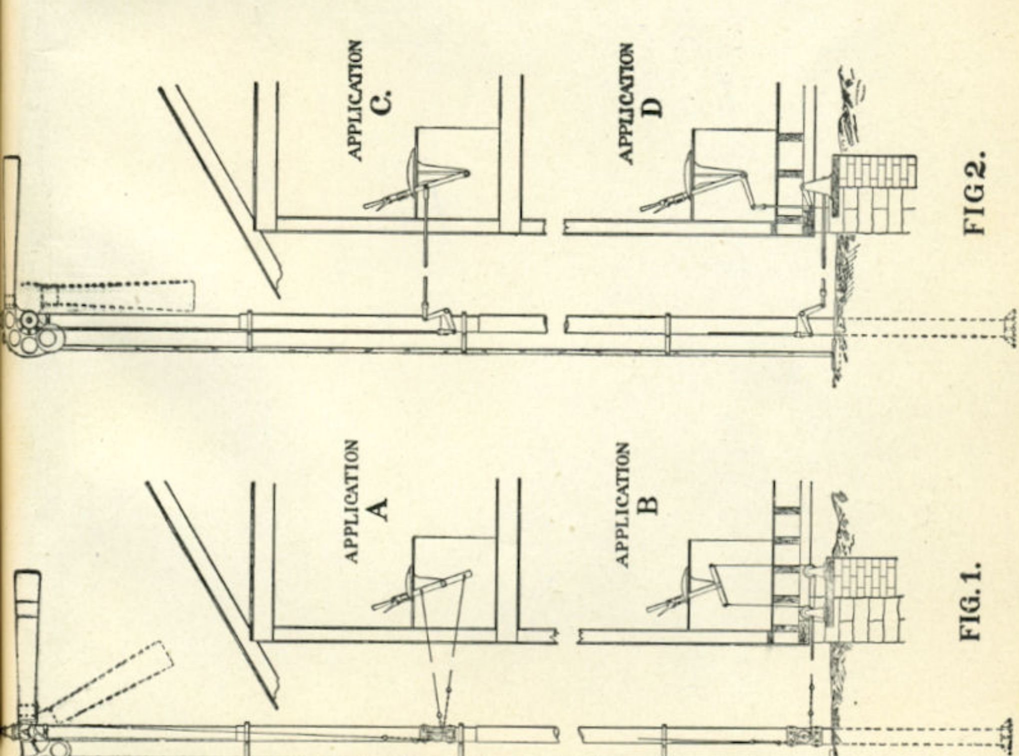

A
CLEAR. DANGER. CAUTION. DOUBLE POST.
1 2 3
B
CLEAR. DANGER. CAUTION. DOUBLE POST.
1 2 3
C
CLEAR. DANGER. CAUTION. DOUBLE POST.
1 2 3
D
FOULING POINT.
TRACK RELAY.
TRACK BATTERY
SIGNAL MAGNET.
SIGNAL BATTERY
LINE 1. TRAIN A TRAIN B
S.1 S.2. S.3. S.4. S.5. S.6. S.7.
LINE 2. TRAIN A TRAIN B
S.1 S.2. S.3. S.4. S.5. S.6. S.7.
LINE 3 TRAIN B
D.1. H.1 D.2 H.2. D.3. H.3. D.4. H.4. D.5. H.5. D.6. H.6. D.7. H.7.
LINE 4. TRAIN A TRAIN B
D.1. H.1. D.2. H.2. D.3. H.3. D.4. H.4. D.5. H.5. D.6 H.6 D.7 H.7.
LINE 5. TRAIN A TRAIN B
D.2. H.1. D.3. H.2. D.4. H.3. D.5. H.4 D.6. H.5. D.7. H.6. D.8. H.7.
LINE 6. TRAIN A TRAIN B
D.2. H.1. D.3. H.2. D.4. H.3. D.5. H.4. D.6. H.5. D.7. H 6. D.8. H.7.
TUNNEL.
DRAW BRIDGE.
JUNCTION.
PASSENGER STA.

signal for the home signal next ahead. The "main block" and the "overlap" cease to exist separately as every block is used as the overlap for the block next to it. Lines 5 (normal danger) and 6 (normal clear) illustrate this case, which is the case shown in Plate 86 (Hall Co.), which requires but little explanation. It is evident that a train entering (at right end of block) will put both home and distant signals at danger. When the train passes into next station to left, the first home signal will go to safety but not the first distant signal, which is on the same circuit with the second home signal and must remain at danger whenever that does. Plate 87 fails, however, to show still another system somewhat similar in character, and which meets with great favor with some signal engineers and which is shown in Plate 89. Here one signal only is shown on a post, every "block" is also used as an "overlap" and the single signal on the post is a "three position" signal, being used alternately (to all intents and purposes) as home and distant signal. Plate 88 shows the three positions; danger horizontal; caution inclined; safety vertical. While strongly advocated by some excellent signal engineers, this system does not yet (1904) receive either general endorsement or very serious disapprobation.

The American Railway Engineering and Maintenance of Way Association's report of Signal Committee, with the discussion following, seems to indicate that opinion is somewhat evenly divided as to the vertical or the inclined position of the semaphore to indicate safety. The vertical safety position means a drop of 90° and this seems necessary if the three position scheme is to be adopted with caution and safety both shown by dropping the blade. Horizontal danger; 45° caution; 90° safety seem pretty nearly dictated if this scheme is to be carried out.

It has not seemed desirable in these notes


APPLICATION C
APPLICATION D
FIG.2
APPLICATION A
APPLICATION B
FIG. 1


APPLICATION C.
APPLICATION D
FIG 2.
APPLICATION A
APPLICATION B
FIG. 1.

PLATES 88-89

to include sketches for the wiring of all the various systems shown in Plates 88 - 89. Different signal companies adopt different schemes, and some railroads are likely to arrange special schemes of their own. Further than this a scheme in use this year may give way to a new one next year. Enough has been shown to give an idea of what is needed, and a further idea of what measures have been taken to meet the needs. Of the forms of signals, disc, banner, semaphore, it is thought by many that there is an advantage in having a form for block signalling different from that used for interlocking, With interlocking signals, no train should be allowed to pass any home signal at danger. Where signals are out of order, hand signals will supersede them. In block signalling the opportunity for derangement of automatic signals is sufficient so that the system must be made "permissive" a train being allowed after a stated interval of time, to enter a block where the signal is at danger, but slowly and with continued caution. The disc in the "banjo" signal is very light in weight and can be operated very easily and is well protected from the weather, and meets with much favor. The semaphore is superior in visibility and is likely to continue in favor with very many railroad and signal men. The electric circuits in automatic signals is not usually relied on to directly furnish the power to operate the signals. Some of these are worked by clockwork as shown in Plate 84 for the banner signal of the Union Company. The weight is wound up by hand from time to time, and the signal movements are effected by the release of the weight in the instrument, brought about by the electric circuit. In other plants compressed air does the work the electric circuits controlling the valves for the air. In other cases, a special current from a dynamo acting on a motor at the signal, takes the place of the compressed air. The Hall Company is just now making a specialty of

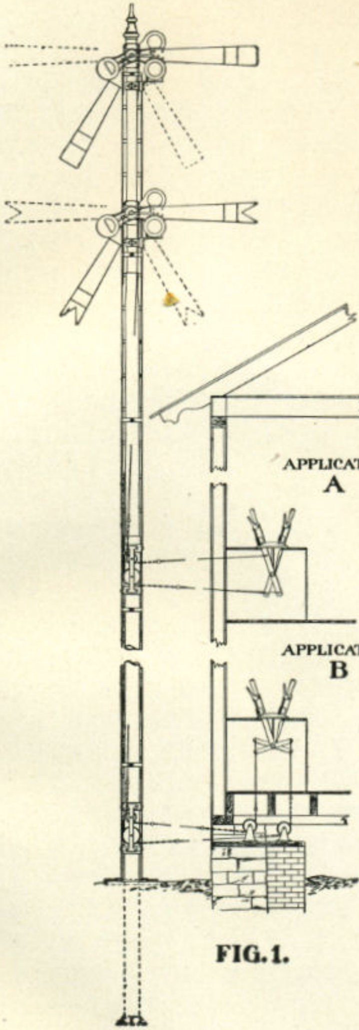


FIG. 1.

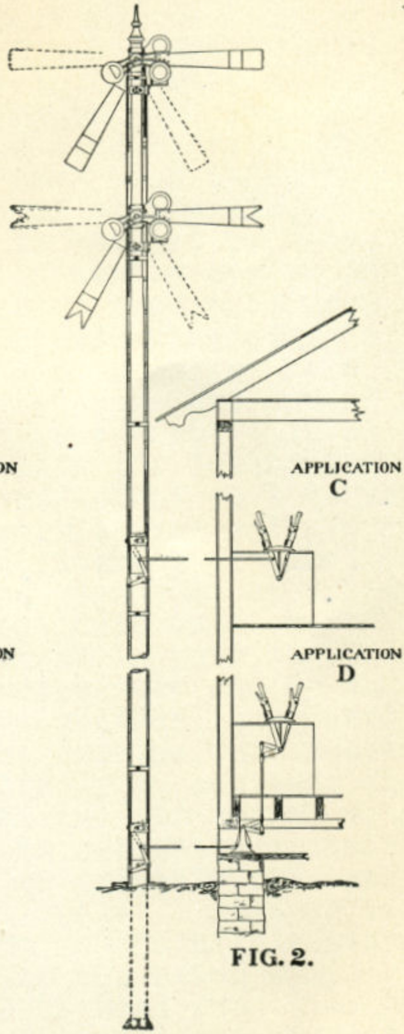
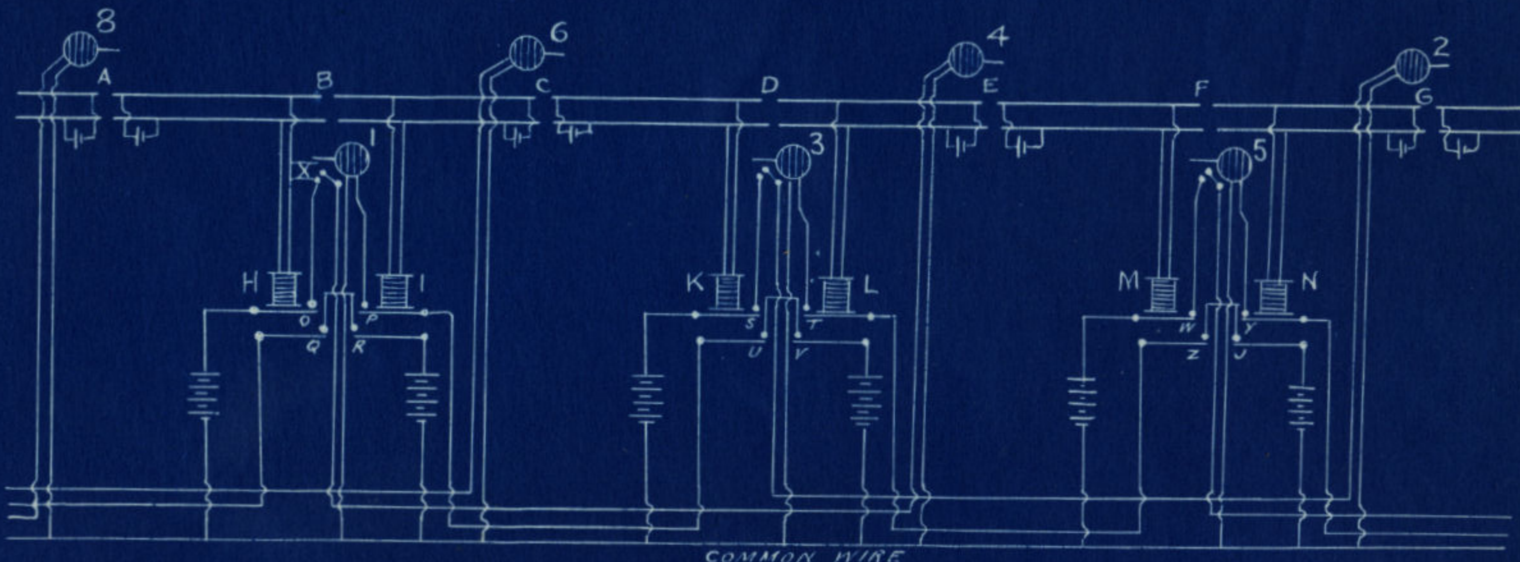


FIG. 2.

carbonic acid gas to work the signals. This is sent out in cylinders under high compression. The Boston and Albany Railroad has recently (1903 - 1904) equipped part of its line in this way. The details in all these cases do not seem to be matters desirable for explanation here.

The several systems of automatic signals shown have been applicable to double track railroad only. Several railroads have adopted automatic block signals for single track lines, and Plate 93 shows a form of wiring that has been used by the Hall Company. Detailed understanding of its working can easily be studied out. Many signal engineers object to any system of automatic block signals for single track lines, and there would appear to be good reason for objection. In an automatic system, the signals are not under the immediate control of any operator, and a derangement of apparatus must occur occasionally and will not be known until reported by the train men. The train in such case must enter ("permissive block") a block whose signal is at danger. This may be done with comparative safety on double track lines. On single track line two trains occupying a block at the same time may be approaching each other, and under some circumstances at considerable speed; a crooked road, fog, or other unfavorable conditions furnish the other elements necessary for a head-on collision. Where the signals have been giving trouble and both engineers know this, (the signals for both trains are probably out of order together) the engineers are likely to run by with less caution than is necessary, as they depend somewhat on the fact that the danger signal doesn't mean much as it is generally out of order. For single track line, the device best recommended is the "train staff" or the"train tablet". In England many years since it was customary for a "pilot" to go with any train which used the block upon which he worked. As he could be



SINGLE TRACK AUTOMATIC BLOCK SIGNALS

Plate 92.

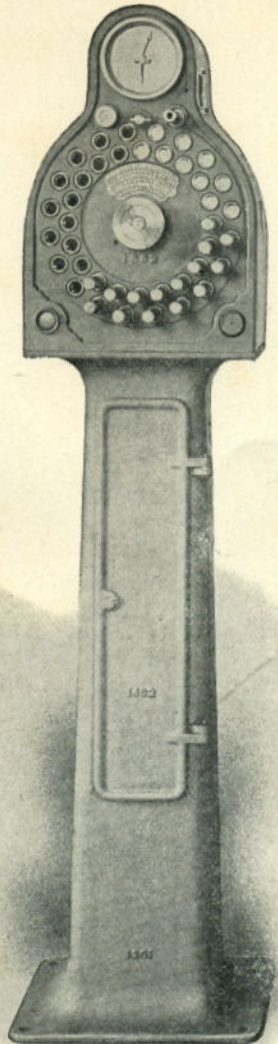


PLATE 92

on one train only at a time, safety was secured. Where several trains run (for instance) east before a train returned running west, the pilot issued tickets for the first and second trains, but went himself with the third and last train. No train could come in the opposite direction as no ticket could be handed out except by the one pilot. If a fourth train came bound east, it must wait until the pilot returned, on horse back if all return trains were cut off by accident or other unsuspected delay. A later development was to send a "train staff" instead of the man. This was a rod of convenient length, and saved the wages of the "pilot". Tickets for first or second trains could be furnished from a pocket in the hollow end of the staff. Improvements have been made from time to time until now, the operation of the train staff system is substantially this; No train can enter the block without the staff, or without a staff. As several trains may pass station A bound east before any train passes station A bound west, more than one train staff must be kept at each station. A staff machine or staff holder is placed at each end of every block, and these two machines should be duplicates. Each station will thus have two machines, one for the east block, one for the west block. These will not be alike. Each machine has several staffs. Any staff will fit its machine (or duplicate machine) only. The two machines at the two ends of any block, are electrically interlocked. When a staff is taken from one machine, no other staff can be taken from either machine until the first staff is replaced in one machine or the other. Train 1 bound east takes its staff; train 2 bound east arrives but cannot get another staff until train 1 has reached the next station, has delivered its staff, and the staff has been placed in the machine there. Then one staff may be taken from either machine, but the staff taken from either, at once locks both. The tablet machine is entirely similar in principle but has a flat tablet instead of a staff. Either staff or tablet must be received by, or delivered to, a train running at some speed, and arrangements are made for doing this, sometimes in similar fashion to the arrangement for picking up a mail bag. This system of train staff is in successful use on several American railroads and gives excellent satisfaction for single track working.

The positions of the signals should be arranged with a great deal of care, which is necessary in order to secure the proper harmony of safety and convenience. It is pretty nearly true that the length of block should be arranged, with reference to grades and curves and other matters, so that trains will follow each other with a uniform time interval between them. A safe space interval (which is what is required) will come pretty close to a uniform time interval, where grades and curves are considered. Signals must also be placed where they can be seen to advantage, and topographical conditions control this. The alignment of the railroad, cuts, buildings, car sidings, all effect this. The background for a signal is important as well as an open approach; signals in the outside of long curves are not easily visible. Furthermore the positions of interlocking signals must be considered, and to some extent the positions of station buildings, although the latter may be of minor importance on a line of large traffic where manual blocking is attended to in special signal cabins and not at the stations; the stopping of trains at stations of course is an element in fixing the length of block. The interlocking signals should form a harmonious feature in connection with the block system, and will have considerable influence on the location of the block signals.

A reconnoissance should be made first and a train at moderate speed will furnish opportunity to do this. Apparently the plan and profile of the line will furnish a chance for a preliminary study. After a provisional scheme has been adopted a further reconnoissance should be made in the same way. Some English railroads have gone so far as to set up models at all proposed signal locations, and the final reconnoissance (or final location) is practically a test of the apparent convenience and safety of the locations as thus viewed from a train approaching these signals. The expense involved would be fully justified in very many cases.

Referring again to the subject of train order signals, in connection with location, Plate 91 shows several arrangements for train order signals at stations. It is well to call special attention to Fig. 4, which is a very convenient arrangement. A train stopping at the station is held until the "advance" signal goes to safety, and need not wait until a preceding train has passed the next station. Neither is it necessary for a following train to wait at the station back of this. It may follow at speed to the distant signal and with caution as far as the home signal, by which time the train which has been at the station may have moved on. It will not be out of place in this connection to again call attention to the fact that an effective system of signals is demanded very often on the score of convenience and economy of operation and not always mainly for safety, although in many cases (perhaps most cases) this is the controlling consideration.

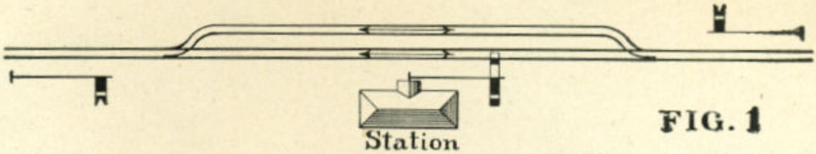


FIG. 1

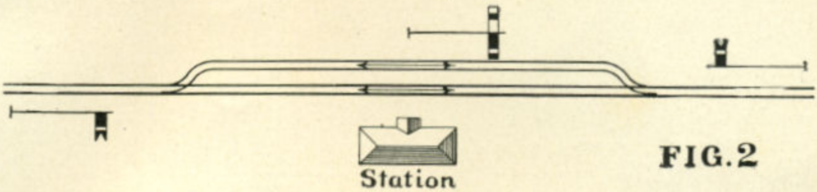


FIG. 2

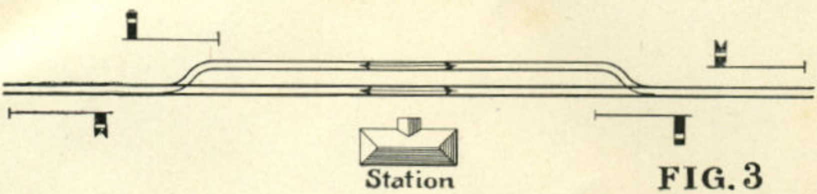


FIG. 3

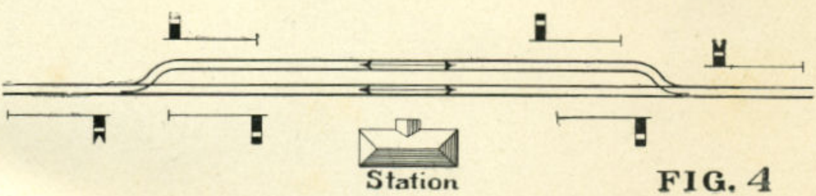


FIG. 4

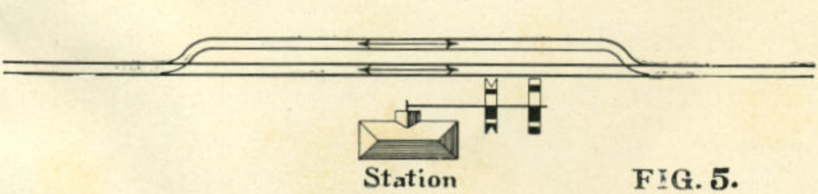


FIG. 5.

PLATE 91