of pressure is considerable, but when the brake is fully applied this difference becomes insignificant.

"The second table gives the comparative travel of piston, with an emergency application for car light and loaded. This, you will notice, is on an average about ¾ inch.

"The comparative tests showing the effect when light and loaded, were made by putting the dead levers in the corresponding holes in the guides.

"As our T. C. trucks have the center of brake shoe about 12 inches above the rail, the variation will probably be still less than in this car, where the center of brake shoe was 10 inches above the rail when the car was empty."

BRAKE EXPERIMENTS WITH S. I. C. L. CAR NO. 55,243, ROANOKE, VA., MARCH 19, 1894.

Light weight of car, 28,000 *lbs.*; *capacity*, 60,000 *lbs.*; *settled*, ½ *in. loaded with* 60,000 *lbs.*

Pressure to Train Pipe.	Reduction by Brake Valve.	Dead Lever in First Hole. Auxiliary Reservoir. Light.	First Hole. Auxiliary Reservoir. Loaded.	First Hole. Brake Cylinder. Light.	First Hole. Brake Cylinder. Loaded.	Second Hole. Auxiliary Reservoir. Light.	Second Hole. Auxiliary Reservoir. Loaded.	Second Hole. Brake Cylinder. Light.	Second Hole. Brake Cylinder. Loaded.	Third Hole. Auxiliary Reservoir. Light.	Third Hole. Auxiliary Reservoir. Loaded.	Third Hole. Brake Cylinder. Light.	Third Hole. Brake Cylinder. Loaded.	Fourth Hole. Auxiliary Reservoir. Light.	Fourth Hole. Auxiliary Reservoir. Loaded.	Fourth Hole. Brake Cylinder. Light.	Fourth Hole. Brake Cylinder. Loaded.
70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
65	5	58	60	25	10	57	60	30	15	58	63	35	14	58	63	48	25
60	10	55	55	25	25	56	56	40	30	55	56	50	30	55	56	50	45
55	15	58	50	47	46	52	50	50	46	54	50	54	50	55	55	55	50
50	20	50	50	47	47	52	50	50	47	54	50	54	50	55	55	55	50
45	25	50	50	48	47	52	50	50	48	54	50	54	50	55	55	55	50
40	30	50	50	48	47	52	50	50	48	54	50	54	50	55	55	55	50

9⅛ in. from center of brake shoes to top of rail, with car loaded; wheels 23 in. diam.

TRAVEL OF PISTON IN EMERGENCY APPLICATION.

	Light.		Loaded.
First hole	8⅛ in.	.....	8⅛ in.
Second hole	7⅞ "	.....	8 "
Third hole	6 "	.....	6⅞ "
Fourth hole	4⅝ "	.....	5¾ "

Car equipped with wooden brake beam.

Both reservoir and cylinder gage invariably showing 60 lbs. pressure (regardless of piston travel) with emergency application.

A Historical Sketch of Railroad Signals.*

(*Concluded from page 615.*)

About the year 1846 it became common practice in England to concentrate the switch and signal operating levers at a central point in yards and terminal stations. The objects in view were safety and economy. It was found, however, that this concentrated control introduced new dangers of a very serious nature. The signal man, through mistake or carelessness, often gave conflicting signals and switches, and many serious and fatal collisions resulted from this cause. It then became evident that something would have to be done to secure the harmonious operation of these concentrated nests of switch and signal levers. The agitation arising from the loss of life and limb, led to the introduction, step by step, of what is now known as the interlocking system. Col. Yolland, of the Royal Engineers, one of the Government inspectors of railways, made authoritative demands for better public safeguards. The first attempt at an interlocking machine was made by Mr. Gregory, of the Croydon Railway, about the year 1843. Improvements were soon afterwards introduced by Stevens, Chambers, Saxby and others, and I will briefly describe and illustrate some of these early machines. Fig. 1, shows a simple double track junction. There are two switches operated by levers 3 and 4 in the signal cabin. There are four home signals, viz.: 2, 2, 5 and 7, and three distant signals, viz.: 1, 6 and 8. This makes a total of 8 levers. It will be seen at a glance that if signals 2 and 5 could be simultaneously placed in the "all clear" position, there would be great risk of one of the trains thus signaled cutting the other in two. Again, if signals 5 and 7 could be cleared simultaneously for two converging trains, these trains would very likely collide. To show the degree of danger at such a junction, where no interlocking existed, and leaving the distant signals out of the question, it may be stated that there would be about sixty-four possible combinations of switches and signals, only thirteen of which would be safe.

On plate 146, fig. 195 shows a side elevation of Chambers' interlocking apparatus, erected at Willesden Junction in 1859. This consists of levers A, B, for operating the switches, and stirrups *d* for operating the signals. Wires were connected from the top of the stirrups to the signals, and the switches were connected to the levers by rods as shown. A tappet attached to the lever was carried in a box across the path of the stirrup ends, and so arranged that the stirrups could not be depressed until the proper adjustment of the switch-moving levers had taken place. Although this frame did not afford complete interlocking, it was considered a great advance on what had gone before, and it received the high approval of the Government Inspector.

Fig. 196 represents a modern signal or switch lever in side elevation. C is the fulcrum, e is the lever tail to which is attached the switch or signal connection. The lever is capable of being latched in two positions by means of the spring latch d, which is lifted out of the notches in segment D by means of latch handle F. In the earlier locking machines, all the locking was attached directly to the main lever, but owing to the greater compactness of parts and lessened strain, nearly all modern machines have the locking connected to the latch. This is known as "preliminary" or latch-locking, and the old style as "lever-locking."

Fig. 198 shows a plan view of an early lever locking machine, designed by Saxby. The levers are shown in cross-section, and it will be readily seen that when lever A is reversed, it will impart such action to the pivoted hook plates E and F as to release lever C and lock lever B.

We shall see modified forms of this type on plate 153, in which figs. 241, 242 and 243 represent a machine designed by Saxby and Farmer. The hook plates give place here to bevelled rocking shafts. At fig. 246, another modification is shown; the only difference is the screw motion for driving the locking hooks.

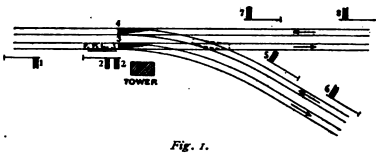
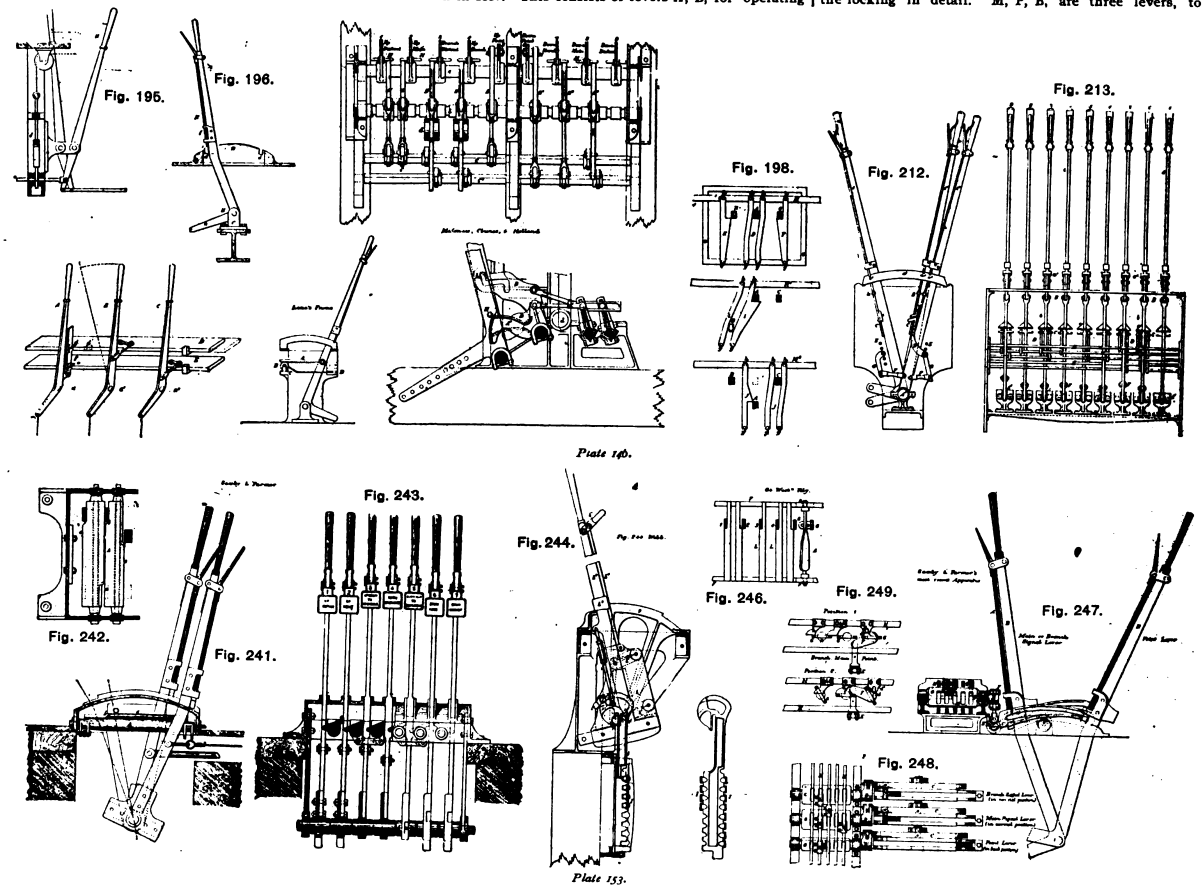


Fig. 1.

At plate B at figs. 217 and 218, Rapier's machine is shown. The construction of this machine was extremely simple. Each lever carried a light quadrant A, A., suitably notched to receive transverse locking bars, B, B. Locks were riveted into these bars at suitable points. The bars were provided with handles, and it was necessary to make the proper adjustment of locking bars by hand, to release any desired combination of levers and at the same time lock all conflicting levers. This was, of course an unnecessarily tedious operation.

Fig. 219 shows the machine designed by Stevens & Sons, and I may say that this has been, and is to-day, by far the best lever-locking machine, owing principally to its simplicity and durability. The lever frame arrangement needs no explanation. The interlocking is performed by tappets E, which are pinned to the body of the lever and slide through locking boxes FF. Fig. 220 shows the locking in detail. M, P, B, are three levers, to

*From a lecture by Mr. Arthur H. Johnson, delivered before Lawrence Scientific School, Harvard University, Cambridge, May, 1894.



History of Railroad Signals.
"*Plate 146*" and "*Plate 153*," *with paper by Mr. A. H. Johnson.*

which are attached steel tappets E, E^1 and E^2. These tappets rest in the grooved lock box G, G, and have bevelled notches cut in them, i, i^1, i^2 and b^3. It will be seen that lever B cannot be pulled over, because the passage of its tappet E^2 is obstructed by the lock dog F^1 until lever P is first pulled over, so as to bring notch b^3 opposite dog F. Lever B can then be reversed, shooting dog F^1 into notch b^3 and thus locking lever P in its reversed position. The reversal of lever P has, however, shot the dog F into the notch i^1 of tappet E^1, so that lever M cannot be reversed. Thus any desired combination of locking may readily be effected by these bevelled dogs. Most of the modern latch locking machines use this tappet and dog principle.

We now come to a consideration of the "latch-locking" or "preliminary action" type of machine. In this type the intention to move a lever, as expressed by grasping the latch handle, and raising the latch, is made to lock all conflicting lever latches. Two inventors, viz., Saxby and Esterbrook, filed applications for a patent on this idea about the same time, and this led to expensive litigation between them, as to which of the applicants was entitled to the patent right. The Supreme Court finally decided that both should have the right to manufacture. On plate 146, figs. 212 and 213 show Mr. Esterbrook's machine. It will be seen that the latch rod was prolonged below the segment, so as to engage with locks thrown into or out of gear therewith by the action of conflicting levers.

On plate 153, figs. 247, 248 and 249 show the well-known Saxby & Farmer machine. The end of the spring latch rod engages in a reversing rocker C, which in turn gives motion to the transverse reciprocating bars H, H, which carry the locking dogs, by means of universal link, E, F, and spindle G. Fig. 244 shows the London & North Western standard machine. The locking in this case is arranged vertically, the notched tappet J engaging with suitable stops screwed to the locking bars I, I. One of these machines was on exhibition at the World's Fair, as was also the Johnson interlocking machine shown in Figs. 1 A and 2 A. In the Johnson machine, action is imparted to the vertical locking tappets by means of a reversing rocker, mounted on the lever and operated by an extension of the latch rod. The chief point about this locking is its extreme simplicity, and the accessibility of the parts for examination and repair.

It will be well before leaving the subject of interlocking machines, to mention briefly the various machines for controlling switches and signals by means of steam power, acting through the medium of Hydraulics, Pneu-

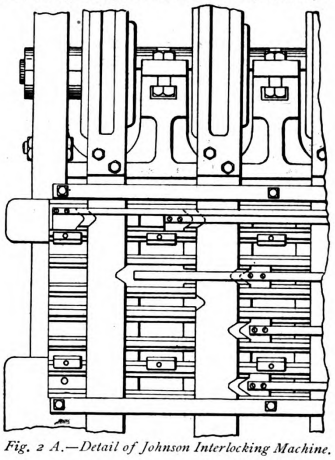


Fig. 2 A.—Detail of Johnson Interlocking Machine.

matics or Electricity or a combination of these elements.

Numerous experiments in this line have been made during the last twenty years, and the best example of this type is undoubtedly the electro-pneumatic apparatus designed by Mr. Westinghouse. The Hydraulic machine of Mr. Servattez, of Rome, Italy, is also worthy of mention. As there is nothing gained in safety and economy in this type of machine, it has found but little favor with railroad officers, owing to its comparative complication and delicacy of parts.

As every one is familiar with the general design of a point switch, it will not be necessary to describe the same. It took many years, however, to prove to some people that the point switch is preferable to any other known design. As first constructed each rail was moved separately and the fireman dismounted from his engine and forced the tongues or points over by means of a crowbar. It was considered that the man who first coupled the switch rails together by a connecting rod, had made an important invention. Switches are connected to the interlocking machines by bell cranks, the arms of which are usually about 9 inches long, and connecting rods or tubes about 1¼ inches outside diameter. These rods are carried by anti-friction rollers placed about 7 feet apart, so as to prevent buckling. Switch rods, over 90 feet long, are fitted with automatic temperature compensators to guard against the wrong adjustment of switches by expansion and contraction of the connections. This is accomplished by means of any reversing gear. For instance, a plain sway beam, placed half-way between the operating lever and the switch, will compensate for the whole length, or, as the end of the rod at the lever is fixed, that half of the rod will expand towards the compensator and will force the expansion of the other half to take place at the compensator and thus leave the switch practically fixed.

Railroad switches of whatsoever pattern, are divided into two classes, viz.: facing and trailing. They are termed Facing Switches when they are so placed that trains pass over them in the direction from left to right, fig. 159, and trailing switches when they are so placed that trains pass over them in the opposite direction. It is therefore obvious that switches used for shifting purposes are both facing and trailing, and it is also clear that a switch used in the facing direction is much more dangerous than a trailing switch, because the facing switch may stand for the branch when it should stand for the main, or it may stand half-way, thus causing a derailment of the train. In case a main line train passes in the trailing direction over a switch that is set for the branch, the switch

(*Concluded on page 689.*)

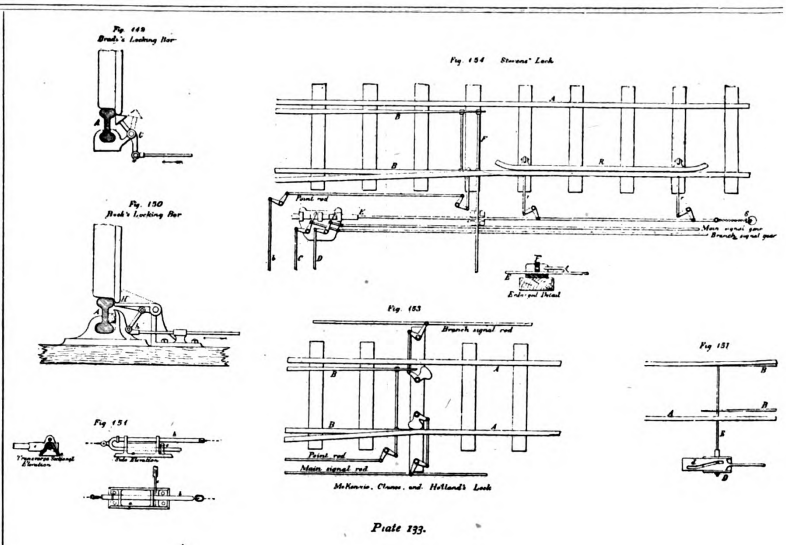


Plate 133.

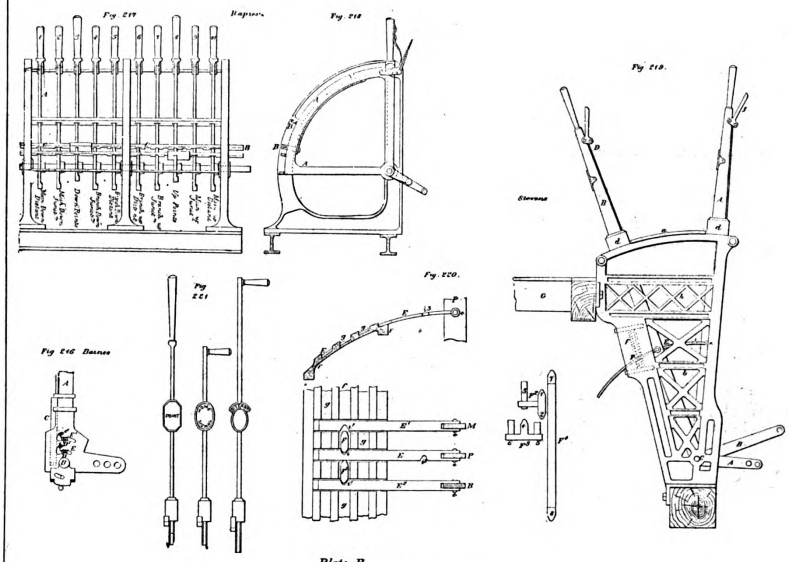


Plate B.

History of Railroad Signals.

"Plate 133" and "Plate B," with paper by Mr. A. H. Johnson.

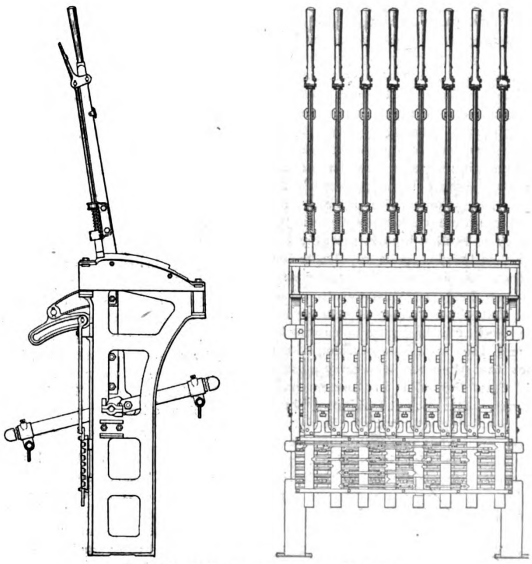


Fig. 1 A.—Johnson Interlocking Machine.