RAILROAD GAZETTE

FRIDAY, APRIL 7, 1893.

CONTENTS.

Contributions.

Delays in Freight Yards.

TO THE EDITOR OF THE RAILROAD GAZETTE:

I have read the article on "Delays in Freight Yards" (*Railroad Gazette* March 31), and find that it contains many interesting points as to the cause, and the cure of that enormous drain on the resources of a great railroad system. There are perhaps few interested railroad men,—yes, even the caboose committees,—but could add information on this subject, and what I have to say may help to simplify the matter.

It is well known that division terminal yards especially are grossly insufficient in capacity, and defective in design. It is a common occurrence to see the business in these yards butchered daily, so to speak, with a resulting universal obstruction to business and an enormous expense for switching or shifting. No railroad yard should be constructed without the engineer in charge taking advantage of all the information possible to be gained, from the Superintendent down to the brakemen of the shifting crew; and while it is impossible for any civil engineer to have practical knowledge of all branches of railroading, still so long as he will continue to consider himself lord of all these practical branches, our yards will remain a discredit to intelligent railroad men.

It is undoubtedly correct that all men working in a particular freight yard should be directly under the yardmaster's charge, and the very best men that any division can furnish should be selected for the position of yardmaster, down to brakemen. Observant railroad men have noticed, and perhaps wondered, why a certain shifting crew could do their work in one-half the time that is taken by other such crews. It is an easy matter to find the cause, however. The first are experts in their line of work, each one knowing his duties and doing them on the least hint given by their conductor of what is required, while the latter are that class of railroad men too prevalent on all roads who are usually in trouble or getting there. The yardmaster, if an expert in his line, can facilitate the work when many other men would be continually blocked. No railroad can afford to pay such men sparingly; they are invaluable to the company at any price.

More than one shifting engine in a yard is universally worked at a disadvantage, unless the yard provides a leader for each engine. Far better should each leader have fewer distributing tracks than two or more engines working on the same leader, and the work of one crippling that of the other.

The car inspectors, from the foreman down, should likewise be experts, and as soon as any train arrives on the receiving track, it should have a general inspection while the engines are being changed preliminary to being shifted, so that any cars requiring time to do repairs that would necessitate their leaving the train could be shifted out into the cripple track, and a final inspection completed as soon as the cars are placed on the distribution tracks. In no case, however, should the inspection delay the handling of trains, and if an expert foreman has charge of this work he will plan how to do it. The car checkers can easily do their work without interfering with the quick dispatch of trains.

The case of seven or ten trains being received at one time, as stated in the article, is so different from anything I have ever experienced, that I cannot cipher out by what kind of time-table these trains were brought over the road; if, however, it is an extraordinary case on account of wrecks, etc., delays in handling them can only be expected, even though extra force is employed.

A great deal of the trouble in our badly planned and badly managed terminals is due to the slipshod manner of handling the freight trains. A freight yard on a railroad is something like a water trough to a horse or a halfway house to a traveler of olden times—force of habit calls a halt. Now, all our first-class roads have through fast freights that have *no business going into a division terminal yard.* The bulk of through freight is received at large terminals on the system, and is to be delivered at the other end of the system. Any through freight that is put in these trains for distribution on other divisions should be so arranged that the cars will be next the engine, to be distributed at the different points as they are arrived at. If this is done it will not be necessary for these trains to enter the division terminal yards, and they can be inspected while the engines are being changed without any loss of time whatever due to their inspection. It might also be well for the division on which the receiving terminal is located to ship with these fast freights no cars to be distributed along that division, but allow them to be distributed by local trains. A careful consideration of this matter has shown that about eight or nine hours' time could be made by these fast freights passing over four or five divisions of road in this manner. It is evident that this affords enormous relief to these over-burdened division terminal yards, and a wonderful saving to the company, as well as inviting a greater amount of business, while at the same time reducing to a minimum its transportation. Of course this entails more shifting to be done in the receiving terminal, but this is just the place where it should be done, where there are no main tracks to be blocked as at these division terminal yards.

The road having insufficient terminals at each end of the system, and trying to compete for the best paying freight business, is, to say the least, doing a gross injustice to the stockholders, and pulling hard against the stream.

A. MORRISON.

TO THE EDITOR OF THE RAILROAD GAZETTE:

The delays of freight in yards is a subject that I think would be difficult to get two opinions alike on. In the first place, there is no yard in the United States big enough for the road to which it belongs. If it had 150 miles of tracks in it, you would be sure to find 150 miles of cars there. Commodious yards and many of them will break up any railroad. A yard of the capacity equal to the ordinary tonnage of the road is sufficient. An intelligent superintendent will handle his traffic to fit his yards. If he blocks his yards he increases the expenses and blocks the traffic. A yard must be in fair working condition, or an embargo is at once placed upon even a reasonably prompt movement of the traffic. An intelligent yardmaster will notify an intelligent superintendent when his yard is blocked so as to prevent the prompt dispatch of his business, and an intelligent superintendent will hold the balance of the traffic out until the yard is in condition to take it.

The greater the capacity of the yard the longer the agony will be prolonged, and just as long as there is space left to chuck anything into, just that long will they continue crowding it. We once had upon this road an important division point, with four long tracks in it; it kept the road "hustling" to keep the freight moving, as they had not room to hold anything. The large yard has been enlarged now to a capacity of 4,000 cars. The "hustling" process has stopped, expenses are greater, freight is delayed and the larger yard is just as crowded as the smaller one was.

In your article you say what the yardmaster should have. Just as long as you furnish him big yards he will want just what he says he wants.

GENERAL MANAGER.

The Development of Fixed Signals on Railroads.*

BY ARTHUR H. JOHNSON.

Very soon after the introduction of the steam locomotive and the railroad it became apparent to the people practically interested that some scheme would have to be devised to prevent collisions between trains. I gather from my father, who has been connected with railroad signaling from its earliest days, that the first attempts were confined to a manual code of signals between the trainmen of one train and those of another, or between trainmen and men stationed on the ground. Of course it was soon found that this intercommunication only covered a small part of the field of danger, because it became necessary to indicate to the enginemen the position of switches and the right to proceed past fouling points. It is this branch of signaling—in other words the *fixed signals* of railroads—which I propose to treat at the present time.

There were a great number of different designs introduced at first, as each railroad engineer was anxious to have his own idea adopted. Figs. 1, 2 and 4 show a few of these early signals. It was found that the multiplicity of design caused great confusion, and this was carried to such lengths that the safety signal for one line would be almost identical with the danger signal of another; but it was not until the defect had led up to many serious accidents that railroad managers took up the question with a view to adopting a standard signal meaning the same on all roads.

The result of their investigation was the general adoption of the semaphore signal; that is to say, shapes and forms were abandoned as far as signaling "stop" or "proceed" was concerned, and a position signal by day and color signal by night were adopted. Many men were, however, hard to convince, and some old forms of signals linger on to this day.

The semaphore is one of the oldest forms of mechanical signals, but Mr. C. H. Gregory has the credit of its introduction for railroads in 1840. The construction was much the same as in our practice at the present time, except that the arm worked in a slot formed in the post, and the colored glasses were carried by a separate frame mounted on a separate pivot as shown by fig. 5. Audible signals in the form of detonators or torpedoes and gongs were introduced about the same time as the semaphore. For some time after the introduction of the semaphore, separate signals known as switch indicators were used entirely for signifying which way the switch stood. One of these switch indicators is illustrated by fig. 3, but this brings us to the commencement of interlocking.

Early in the forties the levers for operating systems of switches and signals began to be concentrated at a central point, with a view to safety and economy, but with this change came a new danger from the liability of the attendant to become confused and throw the wrong lever. After a series of accidents caused by this defect, one of the inspecting officers of the Board of Trade, Colonel Yolland, I believe, refused to open a certain junction until precautions had been taken to prevent conflicting signals. It may be mentioned here that the first attempt at interlocking was confined to the signals; the signals were not interlocked with the switches. The complete interlocking machine was a distinct advance on this.

As far as I can discover, the following gentlemen were foremost in the introduction of interlocking, viz., Messrs. Gregory, Saxby, Chambers and the firm of Stevens & Sons. Fig. 10 shows the first attempt at interlocking the signal and switch operating mechanism. The signals were operated by stirrups and these could only be moved to pull a signal to safety when the switch bar stood in the right position. Complete interlocking was not obtained by this apparatus. There will not be time to describe the great number of machines which have been tried for effecting interlocking of levers, but it will suffice to say that most of them have been discarded and there are now only about a dozen designs in general use. The test for a machine of this kind is the comparative simplicity, compactness and strength of its parts in a large machine. It is an easy matter to design locking for two levers.

Modern locking machines may be divided into two classes: first, those having lever locking or locking actuated direct from the lever; and second, those having latch or preliminary locking. Figs. 8 and 8a illustrate the best lever locking machine. It is the one originally designed by Stevens & Sons in the fifties. This machine is still extensively used, and the recent resignaling of Waterloo Terminus, London, includes a lever machine of this type.

Figs. 7 and 9 illustrate the two foremost machines of the latch locking type, viz., the Johnson and the Saxby & Farmer. In this type of machine, in case a lever is free to be moved, the intention of moving the main lever as expressed by grasping the handle and raising the latch will move the parts and effect all locking of other levers necessary to the safe movement of the lever in question.

The interlocking machine is only part of the necessary apparatus for working a system of switches and signals. There are the necessary outdoor connections, consisting of rods for switches and switch locks, and wires for signals. There are many ingenious devices in connection with these parts, but I shall only mention a few. Fig. 6 illustrates a compound crank for automatically compensating the varying length of a switch rod caused by variations in temperature. It will be obvious that any reversing gear would accomplish the desired result, for instance, the plain swayheam, fig. 6*a*, but that has the disadvantage of altering the run of connections to one side.

Several interlocking machines have been devised by inventors for operating switches and signals by some form of power such as electricity, hydraulics or pneumatics, or a combination of them, and I have made tests with several such machines. The fact is, however, that no form of power is necessary, because switches can be worked as far from the signal tower as the safety limit of sight will permit in good practice by the present comparatively simple means. Power interlocking is certainly neither as safe nor as economical in any position as properly designed straight mechanical work. The application of power to the working of switches and signals is by no means new; pneumatic and hydraulic and electric devices were tried many years ago.

It is amusing to think that when switches were first used the two rails were not connected so as to throw simultaneously. The fireman descended from his engine and moved over first one rail and then the other. The man who first connected the two rails together was considered at the time to have made an important invention. Soon after switches began to be worked from a distance. A long bar fixed so as to have its action obstructed by the presence of wheels on the rails, and

* A paper read before the Buffalo Association of Railroad Superintendents, March 16, 1893.

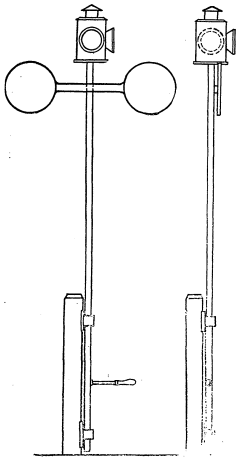


Fig. 1—Early Form of Switch Stand.

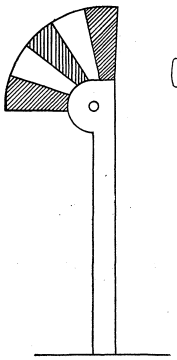


Fig. 4—Early Form of Switch Indicator.

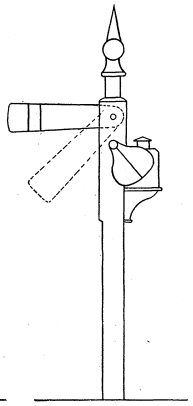


Fig. 5—Early Form of Semaphore Signal.

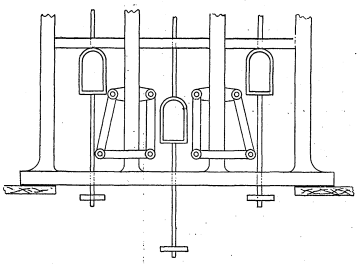


Fig. 10—Early Interlocking Machine.

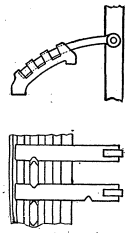


Fig. 8a—Details of Stevens Interlocking Machine

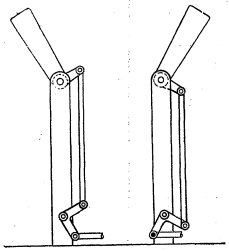
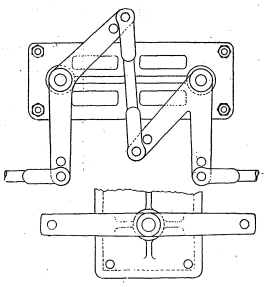


Fig. 3—Early Form of Switch Indicator.



Figs. 6 and 6a—Crank Compensator and Reversing Compensator.

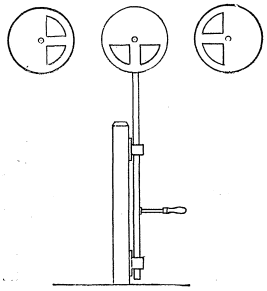


Fig. 2—Early Form of Switch Stand.

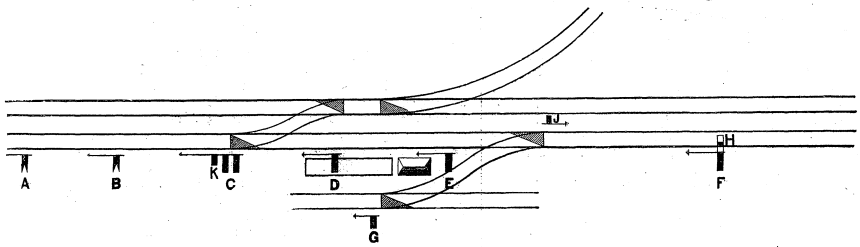


Fig. 11—Conventional Diagram of Station, Showing Different Offices of the Semaphore Signal.

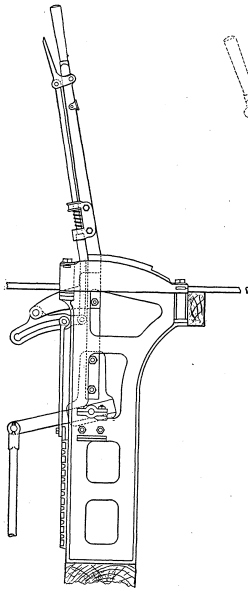


Fig. 7—Johnson Interlocking Machine.

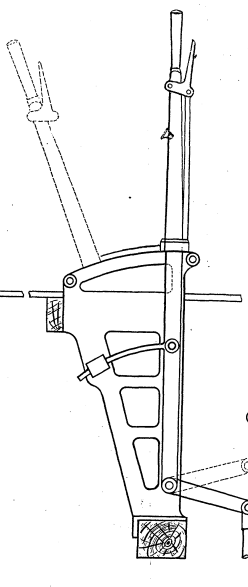


Fig. 8—Stevens, Lever-Locking Interlocking Machine.

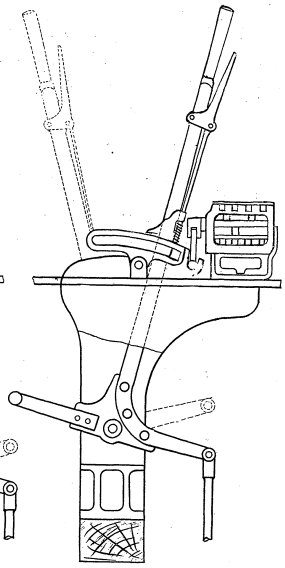


Fig. 9—Saxby & Farmer Interlocking Machine.

HISTORY AND DEVELOPMENT OF FIXED SIGNALS.

known as a detector bar, was coupled to and worked with the switch, the purpose being to prevent the reversal of the switch during the passage of a train. It was soon found that owing to lost motion the detector bar fixed in this way did not prevent a partial reversal of the switch. This led up to the invention of the facing point lock by Lives and Edwards. The invention simply consisted of working the detector bar in combination with a locking bolt adapted to lock the switch in either position by a separate and distinct lever from that operating the switch. It was not considered necessary to so lock trailing switches, and the "facing point lock" was only applied to facing switches over which passenger trains were run. Hence its name.

Although semaphore signals are all of similar pattern except that distant signals have their ends notched, and large rings are sometimes fixed to siding signals, they may be divided into ten different classes, and they are governed in this respect by their position as relating to switches, stations, etc. These ten classes are named as follows: First distant, A; second distant, B; rear home, C; home, D; starting, E; advance, F; siding, G; shifting, J; wrong track, H, and calling on K. We seldom find all these classes at any one station. The diagram, fig. 11, shows the relative position of all these signals.

In the case of fast suburban traffic it is sometimes found advisable to have two distant signals the "first distant," in the case of a level track being placed about 3,000 ft., and the "second distant," about 1,500 ft. from the home signal. The advantage of this arrangement is as follows: When a train passes the first distant *A* at danger, the block section in advance not having been cleared by the previous train, the engineman, of course, brings his train under full control. Before he reaches the second distant *B*, the chances are that the signalman has received a clear signal from the next cabin in advance, and has placed all his main line signals, including second distant *B*, at "all clear." This enables the engineman to resume full speed at once, and thus save time in cases where the home and advance signals are obscured by curves, fogs, etc. It will be very desirable to have both first and second distants when we run trains at 90 miles an hour.

The object of the rear home *C* is to furnish a route signal at the proper point. Home signal *D* protects a train standing at the platform. Starting signal *E* is used as its name indicates to start trains from the platform and to cover the fouling made by the siding. Advance signal *F*, placed a train length in advance of the siding switch, enables a shifting movement to be made under cover of the home and distant signals without entering the next block section. Siding signal *G* governs the departure of trains from the siding, and shifting signal *H* is used for moving trains westward, the normal movement on this track being eastward.

The "calling on" arm *K* is sometimes used to call on a train slowly past the home signal, as far as the signal cabin, in cases where it is not considered safe to clear the home signal.

At some busy yards tracks are regularly used for several hours a day in the wrong direction. It is usual in that case to provide wrong track signals, such as *J*, which govern these movements, and are suitably interlocked with other switches and signals.

All signal stations should be equipped with three of the above mentioned classes, viz.: distant, home and advance signals, although in this country many roads have been content to dispense to a great extent with distant and advance signals. Where trains are required to run at high speeds it would appear plain that they must be expected to overrun some signals at danger, if distant

signals are not provided, unless a great reduction in speed is made in approaching each station. Advance signals should be generally used so as to enable a signal-

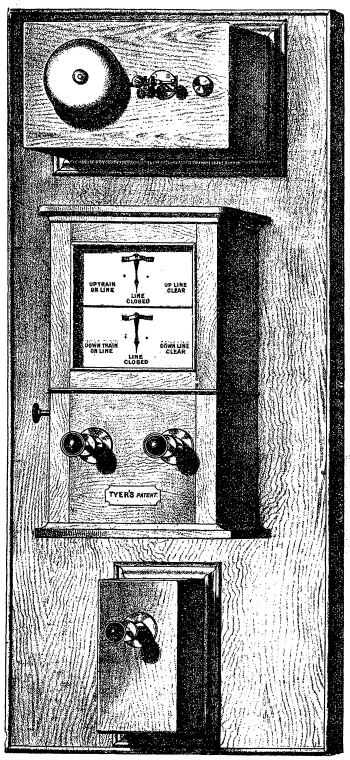


Fig. 12—English Block-Telegraph Instrument.

man to bring a train under the protection of his home signal without giving permission by signal for the train to proceed beyond his jurisdiction.

As stated before, the practice of position by day and color by night for railroad signaling was generally accepted many years ago, and is considered the best practice to-day by most experienced officers. But from the outset next to no importance has been attached in the United States to the adoption of efficient signal lamps. It is a strange fact that our present lamps, although as good as can be expected for their small cost, are little better in construction than a stable lantern. The English roads went through the same experience more than 20 years ago, and it is strange that although the American roads took up the other devices where the English roads left off, they should make such a retrograde movement as regards night signals. It was not for want of an example, for several Saxby & Farmer lamps were in use on the Pennsylvania Railroad more than 10 years. It is to the increase of the intensity of our signal lights by the betterment of our lamps to which we must look for that distinguishing feature so desirable in night signals for fast running, and not to those abortions known as illuminated blades.

There has been a departure of late years from good practice in the matter of color for signal posts. This may appear on the surface a trival matter, but it is not so. Safety in the use of fixed signals for fast running depends to a great extent on the ease with which they can be picked out by the runners of fast trains. Everyone knows that a white post with black base can be seen under nearly all ordinary conditions much better than one painted black or any color. It has for a long time been the general practice to paint signal posts white. A good many of our friends have of late years lost sight of the object for painting the posts white, and have had their posts painted black, yellow, pink, or according to their sense of beauty. Some few roads have also forsaken the red and white signal arm and now paint theirs yellow and black. There is nothing gained by this change, and the signal arms cannot be seen as distinctly as the red ones.

Speaking of fast running leads to a consideration of the block system of traffic working. As far as I can discover the block system was first introduced on the London & North-Western Railway about the year 1850. The well-known needle telegraph of Cook & Wheatstone had at that time been in use on railroads for some years, and that was the instrument first used for blocking.

Correctly speaking, there is only one block system, and that is the constantly fixed and unvarying space interval as compared with the time limit system. The line to be blocked is divided into sections of suitable length, with proper signals placed so as to govern the entrance to each block section. There are two principa- ways of working the signals. In the way most in vogue signalmen are in attendance, one at each block station. The signaling mechanism by which one signalman communicates to another the necessary information in respect to the passing of trains is very varied, and it is graduated all the way from complete enforcement of harmony in the signal movements to the investment of complete option in the signalman as regards the operation of his machine. I regret to say that common bells and even speaking telegraphs are in use at the present time in this country for block communication, although this was condemned more than 20 years ago.

Figs. 12 and 13 illustrate one type of the common form of audible and visual block instruments used in England. In the construction and operation of this instrument there are several safeguards against error, and I may here point out the obvious safety in having both audible and visual signals in this class of signaling. A signalman can always ascertain the state of a block section by glancing at his instrument.

I would strongly recommend this form of block instrument in connection with those lines where complete interlocking is for the present not obtainable. They are in general use in England and have given and are giving general satisfaction. For very congested traffic and tunnel work I would recommend the Sykes apparatus. This is an offshoot of the before mentioned class of block instruments, and it goes a step further, interlocking with the signal and switch levers in such a manner as to prevent a signal lever from being unlocked for more than one train at a time. In short, by this apparatus, a signalman is prevented from making a mistake and allowing two trains to occupy a block section at one and the same time.

The Sykes apparatus has been adopted by the New

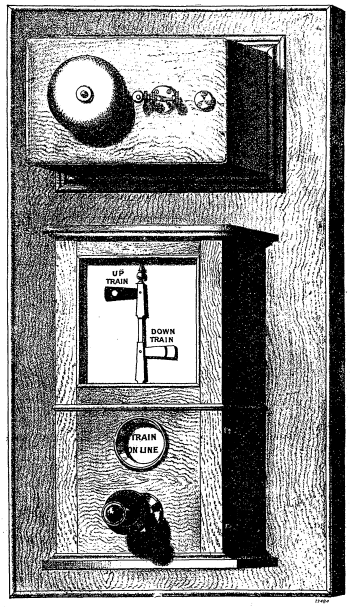


Fig. 13—English Block Telegraph Instrument—Tyer's Patent.

York Central & Hudson River for the whole line from New York to Suspension Bridge and by the New York, New Haven & Hartford from New York to Providence, and the New York, Lake Erie & Western Railroad has it from Jersey City to Turners.

The idea of working block signals automatically by the action of trains originated soon after the birth of the block system, and numerous devices were tried, including track circuit, clockwork, etc. Great efforts have been made to perfect various constructions of automatic block signals. We have learned one lesson from all these experiments, and that is the unreliability of any automatic signal that has parts which are liable to freeze. The Hall automatic signal is probably the most reliable automatic signal extant. All its moving parts are carefully protected from frost and snow. Strange to say, most inventors have made their automatic signals stand normally at safety, in utter defiance of the well known rule that all line signals shall stand normally at danger. The Hall people own a patent for the only means yet invented by which automatic signals are made to stand normally at danger. This is accomplished by auxiliary wire circuits.

It has been proved beyond doubt that block working is more economical than the present mode of working on most of our railroads. We have ascertained that the cost of working the block is more than made up by the average saving in small rear collisions which lay an engine up for a week or destroy several cars. Automatic block signaling has its own special field on American railroad. In fact no one particular form of block working is in my opinion suited to all the varying conditions under which railroads are operated.

By far the safest way to operate a single track railroad is by means of the Staff system. Under this system an engineman is not allowed to leave a passing station until he has received a staff which is plainly marked as belonging to that section. For a long time this system was not applicable to blocking following trains, but of late years Mr. Edward Tyer and Messrs. Webb & Thompson have devised and successfully introduced machines which contain a number of staves. Complete safety is obtained in this way. Only one staff at a time can be taken out of the machine at station A. This staff must either be put back or carried by train to station B and inserted in the machine at that station before another staff can be issued at either station. Thus only one staff, and, therefore, only one train can have permission to occupy any block section at one and the same time. Means are employed whereby the necessary staves are deposited and received at stations where a train is not scheduled to stop.

In applying the block system to a single track road where very long passing sidings are required for the accommodation of long freight trains the extreme ends of these sidings are often so far apart as to make the government of trains by signal from an intermediate point a very precarious matter. The only good way out of this difficulty, and I think those officers of the Erie who are present will agree with me, is to make the sidings long enough to reach from one block station to another so as to have a signal tower at both ends.

I wish to draw your attention to a general misunderstanding as regards the degree of safety attained by the mere erection of a signal apparatus on a railroad. The opinion seems to be general that a signal is a kind of fetish which will stave off accidents by its presence. Experience, however, has taught us that let a signal apparatus be of the very best design and workmanship, a very great deal depends, after all, upon the careful selection and discipline of the signalmen, or the men who keep the signals in repair. But even then we cannot expect the men to work uniformly without a proper set of rules and regulations. Our present signal rules are very crude, and they should be made to cover all possible contingencies of traffic.

In conclusion, I wish to point out that railroad signaling is not a new art, as many people suppose. On the contrary, it is a twin brother of the locomotive. It is, therefore, quite improbable that any great departure will be made for a long time from the best practice of to-day.

TYER'S STAFF MACHINE.

Each passing station is provided with two of the machines shown in the cut. For instance, station B has two such machines, one for operating the line from A to B, and the other from B to C. The staves of the two machines are not interchangeable. When station B wishes to issue a staff to a train bound from B to A he signals by bell to A, and if the previous staff issued at that station has been properly housed and locked in one of the machines, A can release the machine at B by holding down one of the electric plungers.

The unlocking of the B machine is indicated by an index. B thereupon turns the large knob from left to right. This knob is seen at the top of the case. One staff is thus brought under the opening covered by the lid and it is taken out. This operation changes the electric circuits between A and B, so as to prevent the

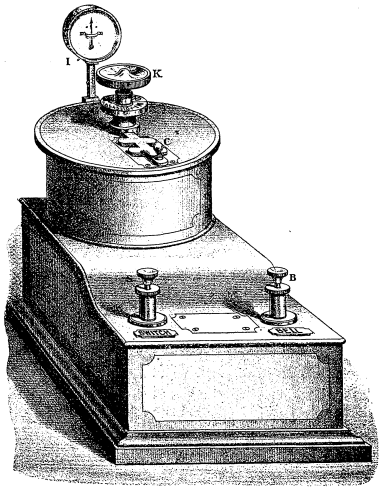


Fig. 14—Tyer's Train Staff Apparatus.

release of A by B until one of two operations has taken place, viz.: (1) The staff thus released at B is carried to A, placed in the machine there and the knob turned from right to left. That action takes the staff away from the opening, and it cannot be turned back again until released by B. This is effected by an automatic pawl. (2) B can release a staff at A by reinserting the be-

forementioned staff which was released by A and turning the knob from right to left, thus relocking that staff. The interchange of staves at speed is effected by placing the staff to be collected in a leather bag and employing similar mechanism to the well known mail pouch apparatus.

Mr. Tyer's ticket machine is constructed on the same lines as his staff machine, the only difference being that tickets are used instead of staves. The Webb & Thompson machine is worked on very much the same principle, the difference being in the mechanical arrangement and design.

TYER'S BLOCK INSTRUMENT.

The cuts, figs. 12 and 13, illustrate the form of block instrument commonly used in Great Britain. Each station is equipped with two such instruments. Some roads prefer the needle index and some the miniature semaphore. I will describe the operation of the semaphore instrument, fig. 13. The small arm seen on the left hand side of the post is worked from the distant station and indicates to the signalman at all times whether there is permission for a train to enter the block section which it governs. This arm is placed at "Clear" or "Blocked" by the operation of suitable plungers at the distant station, seen on the front of the instrument case.

The small arm on the right hand side of the post is simply to fill the important office of repeating the position of the block arm at the distant station. By this means the signalman can always tell if the block instrument at the distant station does not stand in accordance with the position of his operating plungers. The audible signals are given by the use of these same plungers, and the signal arms can not be changed without sounding the bell. The bell used is of a specially constructed single-tap pattern, and I have noticed that the signals obtained by this means are more distinct than those given by the common vibrating bell.

Electric Cranes in the Grant Locomotive Works.

The electric cranes in the shops of the Grant Locomotive Works are good examples of first-class modern shop machinery, and a credit to the builders, the Industrial Iron Works, Bay City, Michigan. The Industrial Works built four cranes for the Grant Works, one of 40 tons capacity for the erecting shop, one of 20 tons capacity for the boiler shop, one of 12 tons for the foundry, and one of 10 tons for the machine shop.

The illustration shown was taken from a photograph of the 10-ton crane in the erecting shop. The crane has a travel of 400 ft. in length and its range of speed is between 125 ft. a minute as a minimum, and 250 ft. maximum. The trolley traversing speed is 100 ft. a minute under load. The hoisting speed is 5 ft. a minute for loads approximating the capacity of the machine, and 18 ft. a minute for comparatively light loads. This crane runs above the pits in the erecting shop and does the heavy lifting for the erecting crews. It also runs beyond the pits, over that part of the shop in which the wheel lathes are located and does the lifting for these.

The crane in the boiler shop is like the one in the erecting shop, but its capacity is 20 tons. It travels the whole length of the shop and has the same speeds as given for the erecting-shop crane. The one in the machine shop has a travel of 350 ft., a speed of 200 ft. a minute, and the trolley has a speed of 100 ft. a minute cross travel with full load. The hoisting speed is 7 ft. a minute with full load and 21 ft. a minute with light loads.

ELECTRIC CRANE, GRANT LOCOMOTIVE WORKS—CHICAGO, ILL.

Built by THE INDUSTRIAL WORKS, *Bay City, Mich.*

Cross Ties for Railroad Bridges.*

In "Cooper's Specifications of 1890," pages 2 and 3, we find the following: "The distance between cross ties on bridges shall not exceed six inches," and "the maximum strain allowed upon the extreme fibres of the best yellow pine or white oak floor timbers will be 800 lbs. per square inch; the weight of a single engine wheel being assumed as distributed over three ties spaced" as above. The weights of engine wheels given in the same specifications are 20,000 lbs. on the Lehigh heavy engine and 25,000 lbs. on the eight-wheel engine. The writer is informed that the C. C. C. & St. L. Ry. have several new 10-wheel engines which have *actually* 39,000 lbs. on each pair of driving wheels spaced about six feet apart, or 19,500 lbs. every six feet on each wheel. The Lehigh heavy grade of Cooper has its 20,000 lbs. spaced 4 ft. 6 in., and the eight-wheel engine referred to above has its 25,000 lbs. spaced seven feet apart.

The following table is computed from the engine wheel load of 25,000 lbs. distributed over three ties, that is, 8,333 lbs. per tie. To this is added 25 per cent. for the effect of impact, making the load about 10,416 lbs. per tie.

The spacing of the track stringers is made 6 ft. 6 in., 7 ft. 0 in., 8 ft. 0 in., and 9 ft. 0 in. and the fibre strains for 8 in. × 6 in., 8 in. × 8 in., 8 in. × 10 in., 10 in. × 10 in., and 10 in. × 12 in. ties, deduced from above loads, are shown in the table:

Size of tie.		Calculated fibre strain.			
Width.	Depth.	Stringers 6 ft. 6 in.	Stringers 7 ft. 0 in.	Stringers 8 ft. 0 in.	Stringers 9 ft. 0 in.
8 in. ×	6 in.	1960	2604	—	—
8 in. ×	8 in.	1098	1500	2208	—
8 in. ×	10 in.	702	937	1407	1875
10 in. ×	10 in.	—	750	1125	1500
10 in. ×	12 in.	—	—	780	1040

For calculating the bending moment for above results a lever arm was used equal to the distance from centre of rail to centre of nearest track stringers.

The present practice on many railroads is to use 8 in. × 8 in. ties with 6 ft. 6 in. spacing of track stringers. This gives a fibre strain of 1,098 lbs. per square inch, which is not excessive in consideration of the fact that we have added 25 per cent. to the actual loads. It is not stated in "Cooper's Specifications" whether the 800 lbs. fibre strain allowed by him is made that amount to include impact, or whether we are to add to the loading, as is done above. It appears to the writer that 800 lbs. fibre strain is very small unless the allowance for impact is included, as he has used 1,000 lbs. and as high as 1,200 lbs. per square inch on best white oak.

The question of the actual distribution of the engine loads over the ties is a very interesting one, but it seems not capable of accurate solution. The determination of the rigidity and the deflection of the rail connecting the ties is a problem of the greatest difficulty when we consider that the said rail is a continuous girder and the ties are its supports, none of the latter being on the same level under the moving load. It is claimed that the spacing of the stringers further apart than 6 ft. 6 in. is an advantage, as by the probable greater deflection of the tie in this case we shall distribute our wheel load more uniformly and relieve the track stringer of a portion of the effect of impact. For a spacing of 7 ft. 0 in. we should use not less than 8 in. × 10 in., for 8 ft. 0 in. not less than 10 in. × 10 in., and for 9 ft. 0 in. not less than 10 in. × 12 in. ties.

By using 10 in. × 10 in. ties, 8 in. × 8 in. guard timbers and 80 lb. steel rail we have a floor weighing 385 lbs. per lineal foot of track, or about 15 lbs. less than the usually assumed dead load of floor. The writer does not know of an instance in which a bridge tie has failed by breaking under the load, and does not think there is danger in that direction on account of the margin in the so-called factor of safety.

The spacing of 6 in. required by Cooper should not be increased, but rather should be decreased to 4 in. Many of the closely spaced floors have saved wrecks by preventing, with the help of the timber guards, the bunching of the ties. The writer would use 8 in. × 8 in. guard timbers notched one inch at each tie, and bolted to every other tie, and does not consider any additional interior guards of advantage, unless they are sufficiently far away from the rail to permit the wheels to run between the rail and the guards.

It is suggested that experiments be made to determine the actual deflection, coefficient of elasticity and from them deduce the actual fibre strain in various sizes of bridge ties, and the writer intends to do so at some future time.

DISCUSSION.

ROBERT GILLHAM, of the Engineers' Club of Kansas City: I have for many years been impressed with the view that cross-ties on bridges, viaducts and elevated railroads could be dispensed with and the structures made to serve their purpose better without them than with them. Cross-ties cannot be considered an element of strength in any structure and must be treated as a dead load, for which provision must be made in determining the strength of the structure. If ties can be dispensed with the structures can be proportionately lessened in weight, depending in some respects upon the details adopted in designing the structure, in order to meet the condition brought about by their abandonment. It is true that members could be substituted and details adopted that would result in a marked increase in metal in the structure, but good designing and good details will not result in an increase, but rather in a decrease in weight of structural parts as compared with those having cross-ties. There are structures, however, where this would not apply. Independent of the question of decrease in weight, which, after all, may not be as important to some engineers as to others, a better and more modern design is secured by the elimination of the ties.

In the case of elevated railroads every argument seems to be in favor of the omission of ties. In considering the question in designing the elevated railroad for Kansas City, Mo., it was the opinion of the Edgemoor Bridge Company and the writer, that if a design could be secured that would embrace all the requirements of strength, and meet all the conditions of erection and use, which at the same time would not require the use of the ordinary wood cross-tie, it would result in securing a higher type of modern elevated railroad construction. No one can question the serious objections offered against the New York type of elevated railroads, where cross-ties are used. These ties are the principal cause of darkening the streets through which the roads are built.

Having in mind the objectionable features of roads having cross-ties, the writer made an effort, in building the Kansas City Elevated Railway, to eliminate them, resulting in the designing and erection of a very acceptable structure without cross-ties. The details have, after five years of actual use, proven satisfactory. The train load consists of an engine of 30,000 lbs. and two coaches of 24,000 lbs. each, loaded. No objection has been offered against the structure by property owners on account of the exclusion of light. The noise due to

* From a paper by James Ritchie, member Civil Engineers' Club of Cleveland, read Dec. 13, 1892; printed in the *Journal of the Association of Engineering Societies*, February, 1893.