a short time, will last 15 years, especially those put in on the main line.

Col. H. S. Haines, General Manager of the "Plant" lines, writes:

I have the disposition and I wish I had the time to express my views at length on this subject; they would not be very technical either. I started out years ago with that end of the investigation, and the further I have gone the less occasion I have found for applying my information either chemically or mathematically to the determination of the qualifications of a good steel rail; or, to put it in a different way, to find out in advance the best rail for our purposes and to know when we have got it.

Of late years the impression has been growing on me that the designers and manufacturers will have to specialize in this branch of railroad engineering as has been found necessary in other branches. That is to say, that what is wanted in the way of a rail for a rock-ballasted road is not what we want in our territory where, for instance, in 1,000 miles of road in our system there is not one mile of rock or gravel ballast or any probability of obtaining it. When we first began to use steel rail, its cost being so excessive as compared with iron rails led us to use a light section, that is 50-lb. As our equipment and trainloads increased in weight, we have replaced it in a great measure with a 60-lb. section. On taking up the 50-lb. rail, we found them bowed at each end as if the base had become lengthened under the rolling of the trains, and yet very little wear on the heads. For instance, in taking up a number of rails near Savannah where our traffic was the heaviest and where they had been down 10 years we found a loss by wear of about 3 lbs. per rail of 30 ft. This may be accounted for by our exceptionally low gradients and long tangents, but it is a fact, or at least we consider it one, that the trouble with us is not the wear of the head but the bending upward of the rails at the ends, which would seem to show that rock ballast will wear off the head of a rail faster than it would wear on an unballasted road and that in designing a heavier section for our sandy roadbeds we do not need so much metal in the head of the rail, but we must seek to make the rail higher and perhaps broader. With that end in view we have recently designed a section of a 70-lb. pattern, five inches high and with a base of five inches, using the same metal in the head that we now use in our 60-lb. rail; that is to say, we are providing for increased stiffness and not for increased wear.

A western engineer says:

For physical test of rails the Pennsylvania Railroad specification seems to be in the right direction; as to the chemical test I am not prepared to say. The question of the constituent properties of rails is still in doubt. The conditions under which rails are used, laid in track and taken care of vary so much on different roads, and the experience is so different, that the matter has scarcely received sufficient attention for any one to say just what is the proper make up for rails.

Another Western engineer, who is much more than commonly well informed, writes:

I think the drop test for rails a good one, so far, that while it does not prove that a rail is a good one, it does indicate what are *worthless* ones; that is, those that are quite too brittle to be safely laid in track, and I think the same may be said of chemical analysis of rails. It may show whether a rail contains too high a proportion of an element which is well known to be injurious to the metal, without, however, showing just what proportion of elements constitute a good rail.

Our analyses of rails so far have not been very satisfactory, but from the work in that line which we now have in progress, we hope to obtain some valuable results.

I would attach more importance to physical tests than to chemical analysis, and perhaps more important than either would be a study of the mechanical treatment of the metal in the manufacture of the rail. Our company prescribes neither physical nor chemical tests in their specifications, but take their rails on the guarantee plan.

I think there has been somewhat of an improvement in the wearing qualities of rails made within the last 2 or 3 years, though not yet up to the standard of 10 or 12 years ago.

One reason for the failure of rails of recent manufacture is the excessive weight per car wheel which is brought upon them; while old rails which have become "case hardened," so to speak, under lighter rolling stock are better able to stand the crushing force of the present heavily weighted wheels.

Mr. A. A. Robinson, 2d Vice-President and Manager Atchison, Topeka & Santa Fe, says:

Up to this time, in contracting for steel rails, we have taken the guarantee of the rolling mills as to the material, only providing for a careful inspection as to the workmanship. I have looked into this subject from time to time, but as there has always been such a diversity of opinion and practice, I have not yet reached a conclusion as to which is the better plan to pursue. Of course, if we employed rigid specifications covering the amount of carbon and other costs, we are quite liable to increase the cost which we will have to pay for rails, and where the rails are used within a convenient distance of the mills, it is a question in my mind if the mill guarantee is not better than rigid specifications until we have reached greater perfection in the manufacture of steel, so that we can know, with greater certainty than at present, the component parts of any individual lot of raw material.

An engineer who has had large experience with English rails, finds those made now much inferior to lighter rails made a dozen years ago. This has been true for several years, and many rails have been taken out of track after 18 months' service. They failed chiefly from flattening at the points. The rails are too soft.

A Canadian Engineer writes:

I have almost reached the conclusion that the inspection of rails is a useless service, as under the same specifications and the same inspector, and, I may add, under the same contract, one delivery of rails may turn out hard and brittle, while another delivery may prove to be as soft as lead. My belief is that under the present process of manufacture the makers are unable to insure a specific quality of rail.

Mr. E. P. Hannaford, Chief Engineer Grand Trunk Railway, writes:

First let us look at the position of the manufactures now and as existing some 18 years ago, when steel rails were first introduced on this continent as a system. In 1870 the engineers of railway companies accepted steel rails on the good faith of the manufacturers, with some misgivings and anxiety, it is true; but in those days railway engineers knew but little of the manufacture of steel rails, and as a rule everything was left to the good faith and integrity of the manufacturer, and in some cases a guarantee for a term of years was given. The imported English rails of early years, from 1870 to 1875, gave satisfaction; their wearing life under a heavy traffic was put down at 15 years, and time and service have proved their durability to be equal to the anticipation. Even up to the year 1880 the imported English rails were good in quality, although not so good as during the first five years.

From 1880 to the present time there has been a gradual falling off year by year in the wearing quality of imported rails, until their life cannot be depended upon with any certainty.

The same experience is applicable to rails made in the United States, the earlier made rails are better than those of more recent years.

This falling off in the quality of steel rails has led railway engineers to study the component parts of the rails with a view of helping the manufacturers in their endeavors to turn out good wearing rails.

Now, why are the rails of late years inferior in quality to those of earlier years? The answer is to be found in the demand for rails increasing the competition, and in turn decreasing the price. Thus, rails in 1880 to 1885 at the mills' mouth, in England, worth from $80 to $50 per ton, and in the United States from $115 to $80 per ton, are now down to $20 in England and $30 in the United States. It is useless for railmakers to say that the same ore is used, and the same care in manufacturing Bessemer steel rails is exercised now as in previous years, because facts prove the contrary. The failing wear of rails of recent years' make is evidence against such assertions.

The manufacturer who was in business in the early years knows all about the reasons of the falling away in quality, but he cannot restore the lost elements of wear. The enormous demand and output exacts his attention, and the competition in price precludes his reverting to what are termed the old-fashioned methods of twenty years ago; but, nevertheless, these original makers know all about it, and the why and wherefore rails are not so good in lasting powers as at their first introduction. Some of the makers have said: "True, the rails of early years wore well; they were hard, so hard that they caused accidents by breakages, which now happily are almost unknown." Not so; rails did not break more in the early years than those laid in later years; but the fact is that the rails of late years are not nearly so good as those of earlier date. And my experience goes to show that rails made by the same maker in 1870 to 1875 will outlast in wear and time two-fold rails made by the same makers ten years later.

Now inasmuch as railmakers of early years under the Bessemer process know all about the cause of the decrease in wearing ability, I approach the point of endeavoring to set them right, with a great deal of diffidence in my ability to do so. It seems to me very much like a patient prescribing for himself and the doctor looking on with placidity, well knowing that he (the doctor) is master of the position.

Having given you the task that railway engineers have before them, I will give you what I consider about the best constituent parts for a 65-lb. rail, gathered from the reports of the composition of rails that have given good and bad results, bearing in mind I do not run the laboratory:

Carbon	0.40	Manganese	1.10 to 1.20
Silicon	0.06	Phosphorus	0.07

And by increasing the weight of rails, say, to 75 or 80 lbs. per yard, the carbon may be increased to 0.50 to 0.55.

Now as to the falling weight test. I am not a believer in such, aptly called "barbarous," usages as have been sometimes practiced.

The great object to arrive at is the toughness of steel at its maximum of hardness. A weight of 2000 lbs. from 18 ft. to 20 ft., two or more blows applied will test this; and if the material is tough, that is sufficient: but if it snaps off then there is the presence of too much phosphorus, or sulphur in the ore; *i. e.*, when the above quantities of carbon, silicon and manganese are used; and it must always be remembered that the bulk ore should be chosen with a natural minimum percentage of phosphorus and sulphur, and that if ores are used with a natural high percentage of phosphorus and sulphur, then the extraction or reduction of those injurious elements has to be done by what is known as the "basic process," and a good rail cannot be rolled upon.

I cannot divest myself of the feeling that much of the failure of latter years is the result of using ores inferior to what were used when Bessemer rails were first introduced, and in closing I desire again to say that while we maintenance engineers can give railmakers results, yet we are only secondary to them in knowing how to overcome the cause of failures. All the engineers' prescriptions and rail inspectors' elaborate reports will not, in my opinion, secure wearing service equal to rails made 15 and 20 years ago.

I believe that rail makers are desirous of making good rails, but the market price and tonnage output limits these conditions, and that if a rail maker turns out rails as good as those from his neighbor's mill it satisfies his conscience, and if they are not as good, then the railway engineer or inspector will possibly come in for a good share of the failure as participating in manipulating the ingredients making up the rails, and the more the patient interferes with the doctor the worse in my opinion it may be for him. Let us look at net results, the doctor to effect the cure or blame him for incompetency.

Mr. W. F. Mattes, Chief Engineer and Manager, West Superior Iron & Steel Co., writes:

Physical tests upon specimens cut or forged from pieces of the rail, or forged from sample castings of the heat, have little or no value. The drop test, undoubtedly, gives some indication of the toughness and safety of the rail, but throws little light upon its wearing qualities. I am inclined to think that a torsional test upon specimens several feet long, recorded by a large Thurston machine, would give much more information than a drop test. The demand for harder rails which has set in within a comparatively recent period, will very likely result in some of our leading railroads establishing a test for hardness.

If I were purchasing for a large railroad I would analyze occasionally. I would want to know that phosphorus and sulphur were within bounds, and that the manufacture was systematical; and yet, after all, we find ourselves unable to tell very much about the value of a rail from the record of its constituents. Within the proper limits for the various elements there is room for very wide differences in the actual qualities of the rail.

There are two objects in inspection. First, to see that the rails are mechanically perfect, and second to know that they are made of good steel. The first is easily accomplished by a man having such experience as has usually been acquired by the ordinary inspector. To be of much value in the direction of the second requirement, the inspector should be thoroughly familiar with every stage of the manufacture, and conversant with the various conditions that affect the ultimate condition of the steel. To such a man the ordinary physical and chemical tests are useful only as an occasional check.

I believe the average output to be more uniform in quality than formerly. With some mills I know this to be the case. While much has yet to be learned, the years have brought their lessons, and the various processes are now under better control. I think also that most of the mills are now turning out harder rails than they were, perhaps, one year ago. Of course such steel will show higher resistance under test. Whether it will be more liable to breakage in the track, remains to be seen. There is some danger in going too far in this direction with the light sections generally used.

(TO BE CONTINUED.)

The Johnson Interlocking Machine.

The interlocking machine which we show in this issue was designed to avoid certain defects in other modern machines, and to give a simple, strong and easily accessible locking. The locking system is one of the oldest, the Stevens, but is actuated by the catch rod. All the locking is arranged in a single tier, and in a vertical plane, making examination of the locking very easy. There are only three styles of locking-dog, and these accomplish very simply all ordinary and special locking. Any part of the locking may be removed or altered, without disturbing, locking having no relation to the alteration. The various wearing parts are of cold-rolled iron and steel. As regards the catch actuation, it is claimed by the makers that this machine has the simplest and most durable movement extant. Both the Saxby & Farmer locking and the Stevens locking have been used so long that their weaknesses and merits are well-known, or are easily ascertained, and it is unnecessary to make any comparison of the two types here. The Saxby & Farmer is, in fact, much the most widely used of all systems the world over, and is the only system which has been largely used in the United States. It has certain defects, but the great extent to which it has been used for many years is evidence enough that the balance of merit is so far in its favor. The Johnson machine, as here shown, has however, a considerable advantage in the accessibility of the locking for repairs or changes, and in the simple and strong form of the locking dogs. Although the amount of wear of the mitre lock might be supposed to be objectionable in a lever-locking machine, it can hardly be so with catch-rod locking.

It is generally acknowledged that the locking should be actuated by the preliminary action of the spring catch rod, and one of the most important reasons for this conclusion is that with direct attachment of the locking to the lever it is often difficult to determine, when a lever cannot be moved, whether the working connection or the locking is holding it. In busy places, where the operator is in a hurry, unnecessary strain is often brought to bear on the locking in such a case.

Fig. 1 is a sectional side elevation, and fig. 2 a back elevation, of a four-lever Johnson machine; 1, 2, 3 and 4 are wrought-iron levers, centered on a girder *A* attached to legs A^1 A^2. The stroke of these levers is limited by portions of the segments *B*, which form in combination with the spring catch *C* the well known means for holding the lever in either its home or its reversed position. The segments are carried by front and back girders *D* and *E*, which in turn are supported at their ends by the beams *F* F^1 and braced by being bolted to the beam *G*. The three girders are made for spans of 4 and 8 levers. The switch rods are connected to the levers at *H*. The gain stroke lever *K* being used for wire connected signals only.

It will be seen that the interlocking is all beneath the floor level, and is easy of access as that portion of the floor, which is adjacent to the windows, and rests at one end on the ledge D^1 of the girder *D*, is cleated and removable. The active and silent movements of the catch-rod are communicated to the locking tappet *N* by means of the connecting-rod *S* and small reversing rocker *R* centered at *P* to the brackets *O* O^1, which are bolted by turned bolts in reamered holes on the main lever. The locking tappets are connected to the reversing rocker by a friction roller, which fits the curved slot in the rocker, and is centered by the jaw *T*. If the tappet *N* were locked in the position shown, it will be readily seen that it would be impossible to raise the catch, by turning the catch handle *V*. In case the tappet *N* is free, the intention of moving the main lever, as expressed by grasping the handle, and raising the catch, will raise the tappet and effect all the locking of other lever catches necessary to the safe movement of the lever in question. This movement also brings the curved slot in the rocker *R* radial to the centre of the main lever, so that the result of reversing the lever is a silent action upon the locking tappet. As the catch is dropped in the reversed position of the lever, the tappet *N* is raised further, and effects the necessary releasing of those levers which should be released when that lever is reversed.

The action of one tappet is made to release or lock other tappets as the case may be, by transverse connections and dogs carried by the locking plate *U*, which also serves to guide and retain the tappets. By reference to fig. 3 this will be seen more clearly. Here is shown a front view of a locking plate for eight levers, of which Nos. 1 to 8 are the tappets, of

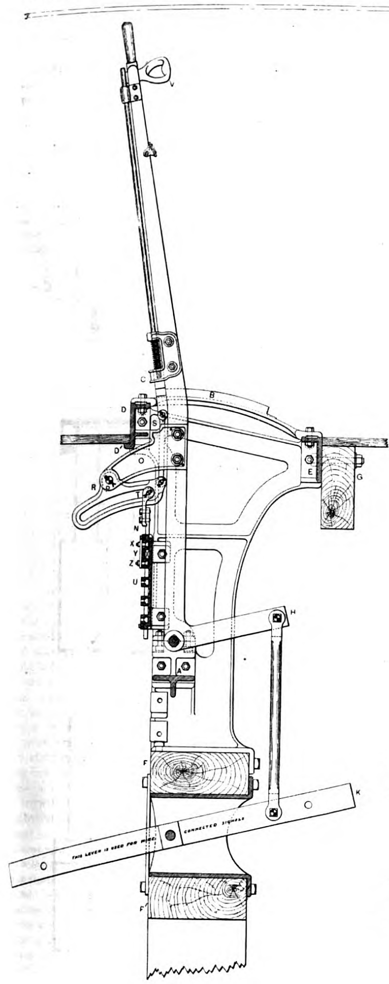

Fig. 1.

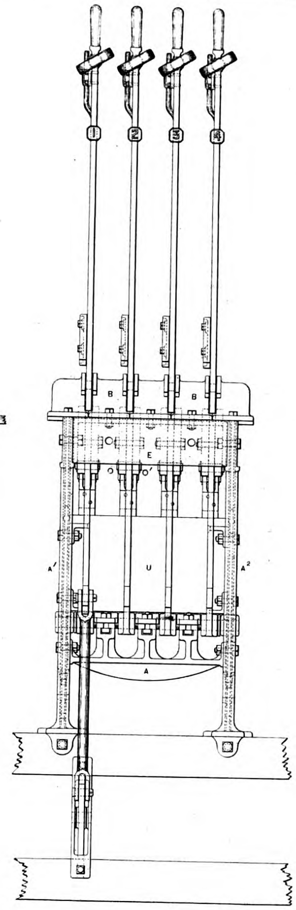

Fig. 2

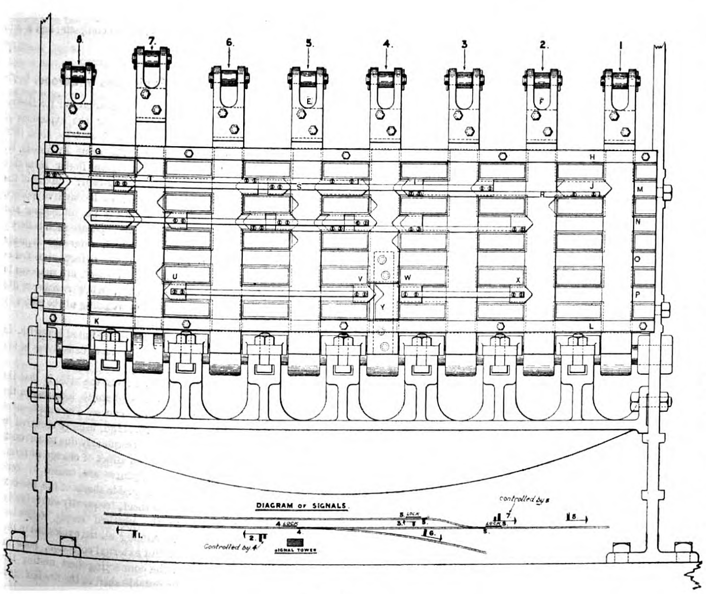

Fig. 3.

THE JOHNSON INTERLOCKING MACHINE.

cold rolled iron, free to slide vertically in planed recesses of the cast-iron locking plate, and retained by wrought-iron strips *G H* and *K L*. All the tappets are shown in their home position except No. 7, which is reversed. The malleable jaws *D, E, F*, etc., carrying the friction rollers, are set screwed to these tappets as shown. Transverse planed grooves *M, N, O, P* carry the cold rolled dogs *I J*, etc. These dogs are connected where necessary by the ⅜-in. square cold rolled bars *R, S, T*, etc., which are fastened to the front of the dogs by small steel machine screws. By a recent improvement, for which protection has been claimed, three connecting bars may be used to each line of dogs, so that the locking requires less than half the space it formerly did when only one connecting bar could be used to each space.

The locking dogs with their connecting bars are retained in their recesses by small straps and bolts, shown at *X, Y, Z*, fig. 1. The bolts are carried by *T* slots cored in the locking plate.

The locking shown in fig. 3 applies to the safe working of a single line junction.

The following is the locking sheet:

LOCKING.

Lever.	Releases.	Locks.
1	..	2*, 4
2	1	4, 4*, 6 (7 when 4 is home), 5.
3	....	5*, 7.
4	5, 6	1, 2, between stroke 7.
5	3	2, 4*, 7 between stroke 8.
6	....	4*, 2.
7	8	5, 5*, 3.
8	....	7*.

* Reversed position.

The functions of the levers are as follows:

1. Distant signal.
2. Home signal (2 blades).
3. Siding signal.
4. Switch, lock and detector bar.
5. 2 " 2 " 2 " "
6. Home signal.
7. Home signal (2 blades).
8. Distant signal.

The action of the dogs upon the tappets is so simple that the drawing will explain itself in this respect, and will be perfectly understood when compared with the locking sheets. It will be well, however, to draw attention to the method of performing the special or conditional locking. By reference to the locking sheet it will be seen that 2 locks 7 when 4 is home, but not when 4 is reversed.

This lock is accomplished by *U, V, Y, W, X*, in the following way. *U, V*, and *W, X*, are four dogs, connected as shown. *Y* is a transverse sliding section of the tappet 4, being rabbeted into the main tappet, which has a gap at this point holding the slide *Y*. The slide has a mitre notch, which, when 4 is home, comes opposite to the dog *V*, so that 2 may be raised together with 7 when 4 is thus, as the aforesaid notch of the slide *Y* is simply made to coincide with the dog *V*, by the tappet 2 thrusting the dog *X* outward. But suppose the tappet 4 is first raised, then the solid portion of the slide *Y* will just fit between the dogs *V* and *W*, thus forming a rigid connection between the dogs *V* and *X*, making it impossible to have 7 and 2 raised simultaneously.

It will be noticed that this special locking is very simple; all its parts being in the same plane, and on the same principle as the ordinary locking. By this method of special locking any conditional lock may be performed.

Although the locking is very rigid, when a catch is free the movement of the locking offers slight resistance. The ordinary and well-known catch-handle is supplied instead of the twist-handle shown, when preferred.

The Johnson interlocking machine is manufactured and supplied by the Johnson Railroad Signal Co., of Rahway, N. J., and a small machine is open to the inspection of railroad officers at the company's factory.

The Widdifield & Bowman Brake.

On the afternoon of the 10th inst. a trial was made on the Lehigh Valley, of the Widdifield & Bowman electric brake. This brake is in its operating parts the Widdifield & Button brake, which has been known some years, but heretofore operated as a buffer brake. In that form it appeared at the Burlington trials of 1886, and was promptly found useless on 50-car trains, and withdrawn. The cars fitted with the apparatus have been in the service of the Lehigh Valley ever since, but the brake has been very little used. The brake is operated from the axle. A friction collar is fixed on the axle, and a friction pulley, which is brought against this, winds up the brake chain. The contact between the collar and the pulley was formerly secured through the inward movement of the draw-bar. In the present form, the Widdifield & Bowman, the buffer action is abandoned entirely and the frictional contact is secured by the action of the electric current.

The arrangement by which this is done is simple and ingenious. Carried on each truck are two electro-magnets, and on the locomotive is a battery. By closing a circuit on the locomotive one of the electro-magnets is energized, and the movement of its armature carries up a lever which brings a small friction wheel against the collar on the axle, and a chain is wound up on the shaft of the friction wheel. This operates a second lever, which carries the larger friction wheel against the collar on the axle, and thus the brakes are put on, as with the old buffer action. By closing another circuit in the engine cab the second magnet is energized and the movement of its armature releases the brake. The application of the brake is graduated by the strength of the current. To make the device automatic in case of break-in-two