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“Creep of Rails.”

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ONE of the many difficulties with which the railway maintenance engineer has to contend, in the efficient and economical maintenance of the roads under his charge, is dealing with, and preventing as far as possible, the creeping or movement of the rails in a longitudinal direction. In recent years, owing to the increased volume of traffic and the greater weight and speed of the trains, this difficulty has become more acute.

The type of permanent way almost universally adopted in this country consists of bull-headed rails, supported in cast-iron chairs, held in position in the latter with timber keys, the cast-iron chairs being supported on, and fastened to, rectangular transverse sleepers. It is this type of permanent way with which the Author will deal, confining his remarks to the practical points of preventing and dealing with the creep of the rails.

The chief factors tending to produce the creep or movement of the rails are :—

1. The driving-wheels of the locomotive hauling the train, when rotating, have a tendency to thrust back the rails in the opposite direction to the moving locomotive.
2. The vehicles being hauled by the engine have a tendency to pull the rails in the same direction as that in which the train is moving, due to the friction between the wheel and the rail, the flange of the former in particular when binding against the rail.
3. The weight of the moving vehicles on their wheels produces waves of deflection in the road, and has a tendency to roll out the rails in front of the vehicles.

4. The brakes, when applied on the wheels of moving vehicles, produce a skidding action, which tends to force the rails in the same direction as the vehicles.
5. The impact given to the running on end of the rails by each succeeding wheel of the moving vehicles, has a tendency to thrust the rails in a forward direction.
6. Change of temperature, expanding and contracting the rails, causes them to move in the chairs in the direction of the traffic, with the result that the expansion spaces are either contracted or opened out.

It will be seen from these observations that while there is only one factor, namely, the first-mentioned, tending to thrust the rails against the direction of the traffic, there are no less than five in combination which tend to force them with it, unless the rails are firmly held in position.

Where the trains travel in one direction only on a road, the Author has, with one exception, never experienced the rails creeping in the opposite direction to the traffic. The exception is the case in which the line has subsided from colliery-workings. The rails invariably creep with the traffic to the bottom of the slack, but against the traffic coming out of it.

On singlelines, where traffic is in both directions, the creep of the rails is irregular. It generally takes place in the direction in which the more heavily loaded trains are travelling; this is particularly noticeable in the case of mineral branches, and also in a downhill direction, where the weight and speed of the trains in each direction are approximately similar. The creep usually takes place noticeably towards stations, due to the application of the brakes pulling up the trains as they approach the stations from either direction.

The six factors enumerated produce no movement of the bulk of the sleepers where the road is well, or even moderately, boxed up with ballast, but, unless the rails are firmly secured in the chairs, they slide forward in the chairs, until the fish-plates securing the joints in the rails come in contact with the chairs on the joint sleepers at the running-on end of the rails. The result is that the chairs are moved forward on these joint sleepers, the fastenings securing the chairs to the joint sleepers are slightly sheared through and compressed into them, and the latter are pushed forward on their beds, leaving a larger space between them than is desirable; also these sleepers, in extreme cases, become tilted out of the level; in addition, the expansion spaces between the rails are unduly

opened at one end of the length of road where the creep commences to take place, and closed up at the other where it terminates.

It is seldom that the rails on opposite sides of the road creep to the same extent. This inequality of creep is more easily explained where it obtains on curves, for, if insufficient super-elevation is provided, the high rail will creep more rapidly than the low, as it will have more weight on it, and conversely, if too great a super-elevation be given, the low rail has a tendency to move in advance of the high.

The Author has observed that the uneven creep occurs quite as much on the straight as on the curves; where this takes place and is extensive, the joint sleepers are moved out of the square, if the fish-plates come in contact with the chairs on one side of the road.

After a time it becomes necessary to pull back the rails in the chairs and to adjust the expansion spaces and the joint sleepers at the running-on end of the rails. It is very essential that this adjustment should be made, as, when the expansion spaces are closed up, there is a risk in hot weather of the road being displaced and distorted laterally, owing to there being no space left to take up the expansion of the rails.

It is not advisable to delay pulling back the rails when the fish-plates are hard up against the chairs and are moving the joint chairs and sleepers off their beds. When this occurs the creep becomes less rapid, and the bottom flange of the rail becomes chair-worn at the incorrect spacing, and when the rails are pulled back there is risk of the creep being more rapid, owing to the rails slipping back into the chair-worn indentations.

It is not conducive to smooth running to have the joints in the rails unevenly spaced between the joint sleepers; also, where this obtains, it causes the fish-plates to be overstrained and fracture, and, in addition, the wear on the road is greater and its life shorter.

The length of road on which it is necessary to pull back the rails at one time is generally in sections of about a mile. The rails at either end of this length of road do not require pulling back, as there has either not been sufficient creep to necessitate it, or, there are connections, such as junctions and cross-over roads, which sufficiently hold the rails in position, thus making them practically immovable.

The method of pulling back usually adopted is to commence at the end of the length from which the rails have crept, by unkeying the rails, unscrewing the fish-bolts, and, at every few lengths of rail, removing the fish-plates, levering the rails back, and adjusting

the sleepers and expansion spaces as required, then keying up the rails again, replacing the fish-plates, and screwing up the bolts. Lengths of rail are successively dealt with in this manner, until the end of the length of road, where the rails are to be pulled back, is reached, at which point it may occasionally be found necessary to insert a longer rail; but the Author has had cases where it has been found necessary in providing the required expansion spaces to use a shorter rail, either at the beginning, or part of the way through the length on which the rails are being adjusted. On lines where the traffic is not frequent, the work can be carried out on a week-day without interference with traffic, but on fast passenger lines, where the traffic is frequent, it is advisable to divert the traffic while the work is being carried out.

It is practically impossible to prevent creep entirely, and the best method of minimizing it is efficient maintenance in keeping the road in good order, particularly by having the rails thoroughly well and tightly keyed in the chairs. This is most necessary in hot and dry weather when the timber keys shrink, and they grip the rails less securely in the chairs. During and after periods of high temperature, creep is much more prevalent, due to the expansion of the rails, and, if during these periods, the fish-bolts are unevenly screwed up, the expansion spaces are closed up at those joints where the bolts are less tight. It is therefore desirable occasionally during high temperature to loosen slightly the fish-bolts, at the time of the highest temperature, so that the expansion spaces can take up the expansion of the rails evenly, the bolts being again screwed up tightly when the temperature has dropped.

Special devices have been designed with the idea of minimizing creep. These consist chiefly of:—

- (1) Steel keys of such form as to enable them to grip the rails tightly in the chairs.
- (2) Various forms of anchors fastened to the bottom flanges of the rails, in order to transfer the thrust directly from the rails which have a tendency to creep to either the chair or the sleeper.

Both these devices add very materially to the cost of the road.

There are several forms of steel keys which carry out their duties efficiently and to some extent eliminate creep. They require little maintenance but very careful adjustment and supervision, and there is difficulty in training the plate-layers to obtain the best results from their use. When the creep is not extensive, it is not neces-

sary to use these keys in every chair, but only in sufficient numbers to keep the rails in position.

The cost of these steel keys is from four to five times that of oak keys, and except where creep is very extensive, the Author is of opinion that, if every third key used were a steel one, creep would be so reduced that little pulling back of rails would be required, and a better road would be obtained. The additional cost of these steel keys would be balanced by the saving of the cost of pulling back the rails.

Rail anchors were originally brought out for use with flat-bottomed rails, and have proved very successful; they have been adapted to a small extent for chaired roads with bull-headed rails.

The anchors generally consist of two parts which are fitted to the bottom flange of the rail, and take a bearing either against the chair or sleeper, and are so designed that the greater the thrust on the chair or sleeper from the creeping rail, the tighter the rail is gripped by the anchor.

It is remarkable that rails should creep at some portions of a line and not at others, and more in one place than another, and many theories have been advanced as to the different effect which the alignment and level of a line, and the various types, weights and speeds of trains have in inducing creep. With a view to investigating this phenomenon, the Author kept, for a period of 5 years, on a length of line of which he had charge, a careful record of the various lengths of line on which it was found necessary to pull back the rails. The roads on this particular part of the line require relaying approximately every 20 years, so that this period of 5 years therefore covers about a quarter of the life of the road.

This section, which has an aggregate length of 350 miles, has a track mileage of about 850 miles, consisting of:—

1. Up and down fast passenger-lines and up and down slow passenger- and goods-lines, where they run side by side.
2. Up and down lines used for both passenger- and goods-traffic.
3. Single lines used for passenger-, goods- and mineral-traffic, or the two latter only.

On this 850 miles of single track during the 5 years of observation under review, it was found necessary, on an average, to adjust or pull back approximately 10 per cent. of the rails annually.

It appeared to the Author that an ideal section of this line for special investigation would be one particular stretch 50 miles in

length, rising 330 feet about midway from its commencement and falling again to its termination, where it is about 20 feet above the level of the line at the former point. The ruling gradients are approximately 1 in 160 and 1 in 180 in the down and up directions respectively, the radii of the curves range approximately between $\frac{3}{4}$ mile and 3 miles. There are four roads throughout,

viz.:—Up and down fast passenger lines, and up and down either slow passenger or goods lines.

The weight of passenger traffic is evenly distributed in either direction, but the greater weight of goods and mineral traffic is in the up direction.

Figs. 1, Plate 7, show the profile of this length of line, also the radii and positions of the curves, on the fast lines only, and underneath is shown, by scored lines, the position of the lengths of line on which it was found necessary to pull back the rails for each of the four lines, during the years 1911–1915 inclusive. On no part of these lines did creep occur in the opposite direction to the traffic.

One of the most striking things to be observed is, that in the first 7 miles at the commencement, very little pulling back was required, and that only in short lengths, the reason for

this being, that there is a very large number of connections which hold or anchor the rails in position, preventing their creeping, and all that was found necessary to be done on this portion of the line, was merely to regulate the expansion spaces. It will be noticed that between the 25th and 30th mile posts, a large amount of pulling back of the rails was found necessary. The Author is of opinion that this is due to the reverse gradients and reverse curves, which latter are of less radii in this locality than at any other part of the line, also to the high speed which is obtained between these points.

Fig. 2 is a diagram giving the percentage of rising and falling gradients and level lengths of line, and shows the two former to be about equal.

Fig. 3, which should be read in conjunction with *Fig. 2*, shows the average annual percentage of the rails pulled back during the 5 years, on the rising and falling gradients and lengths of level, on each of the four lines. It shows the lengths of rails pulled back on the fast line to be considerably greater than those on the slow passenger and goods-line, which is conclusive that the creep was produced more markedly by the speedier than the slower moving

Fig. 3.

AVERAGE ANNUAL PERCENTAGE OF RAILS PULLED BACK ON DOWN AND UP FAST LINES AND DOWN AND UP SLOW AND GOODS LINES, ON THE LEVEL, AND ON RISING AND FALLING GRADIENTS. 1911 TO 1915 INCLUSIVE.

traffic; also, that on the slow passenger and goods lines a greater length was pulled back in the up than in the down line. The number of vehicles in both directions was identical but the heavier loads in the up direction were responsible for the greater amount of creep, as shown on the diagram.

It is, however, remarkable that, when the comparison is made between the lengths of rails pulled back on the falling gradients on the down fast line and the rising gradients on the up fast line, the amount was almost identical; also, when comparing the rising

gradients on the down fast line with the falling gradients on the up fast line, the same obtains. It appears from these results which are shown on *Fig. 3*, that a rising or falling gradient had no effect on the creep of the rails on the roads under special observation.

Fig. 4 is a diagram showing the percentage of curves to the straight portion of the roads on the fast lines only, from which it

will be seen that the length of line on the curve is about 15 per cent. less than that on the straight. This diagram should be read in conjunction with *Fig. 5*, which latter gives the average annual percentage of the lengths of road, where the rails had to be pulled back on the curves and on the straight, and it will be seen that there is little difference. The inference, therefore, to be drawn is that the alignment of the roads under observation had no effect on the creep of the rails.

Fig. 6 is a diagram showing the average maximum daily sun temperature for the four summer months, June–September inclusive, for the 5 years 1911–1915, while *Fig. 7*, with which it should be compared, gives the miles of road where the rails were pulled back, for the same period of 5 years, each of these years commencing June 1st and terminating the following May 31st. From these two figures it will be seen that in the first 3 years the temperature and lengths of rails pulled back to some extent followed one another; there is, however, a rapid rise, shown in *Fig. 7*, in the length of rails pulled back in the next two succeeding years. This is accounted for by the rails not having been allowed to creep so far forward before being pulled back.

The greatest amount that the rails were pulled back at any one place was 9 inches. It was seldom that the rails on opposite sides of the road crept to the same extent; in a few places the joints got as much as 5 inches out of the square, and it was occasionally only necessary to draw back the rails on one side of the road. Practically no difference was observed in the uneven creep of the rails on curves, on each side of the road, to that which obtained on the straight section of the line.

On short lengths of line where the creep was extensive, steel keys

were used with results which justified their use. With a view to having the expansion and contraction of the rails taken up evenly at each joint, and reducing the wear on the fish-plates, an experiment was made by lubricating the fish-plates with a mixture of heavy grease and graphite, but as the desired results were not obtained, the experiment was abandoned.

One portion of the line where creep was particularly trouble-

Fig. 5.

AVERAGE ANNUAL PERCENTAGE OF ROAD WHERE RAILS HAD TO BE PULLED BACK ON THE STRAIGHT AND CURVES ON FAST LINES. 1911 TO 1915 INCLUSIVE.

some was on the down fast line, between the 42nd and 48th mile-posts. The line at this point is on a falling gradient, where very high speeds were obtained by heavy passenger trains. Trouble was experienced on this portion of the line through the rails crippling. These rails were taken out of the line in 1911, after they had been in the road 11 years, and it is suggested that the crippling was, in some measure, due to the rails having crept, causing the expansion spaces to be closed up in places, and the rails to be tight

up to one another to such an extent that they crippled. Steel keys on sections of this portion of the line were used with advantage and were found to minimize the creep.

The cost of pulling back the rails varied very considerably, due to the locality and the amount of pulling back required; it roughly approximated from £8 to £15 per mile.

The Author has formed the opinion that, where chaired roads

Fig. 6.

AVERAGE DAILY MAXIMUM SUN TEMPERATURE OF FOUR SUMMER MONTHS.
JUNE TO SEPTEMBER INCLUSIVE.

are used and well maintained, the gradients being moderate, and the curves of fairly large radii, such as obtain on the main lines of English railways, the creep of the rails is due to the high speed of trains, combined with the heavy axle-loads, and that the profile and alignment of the line have little influence on its production.

Given similar traffic, but where the gradients are steep and the curves of comparatively small radii, the creep of the rails is more extensive, particularly at those points where the brakes of the

vehicles are frequently and continuously applied. There are no possibilities of entirely eliminating creep, and it can only be reduced to a minimum by keeping the roads at a good line and level, providing and evenly maintaining correct super-elevation of the outer rail of the curves, and by giving careful attention to keeping the rails tightly keyed up in the chairs.

The Author hopes that the foregoing information and conclusions

Fig. 7.

TOTAL LENGTH OF RAILS PULLED BACK DURING EACH 12 MONTHS BETWEEN 1ST JUNE AND THE FOLLOWING 31ST MAY FOR EACH OF THE 5 YEARS COMMENCING 1ST JUNE, 1911, AND FINISHING 31ST MAY, 1916.

which he has formed will be of some help and interest to those who are engaged on the maintenance of main lines of railways in this country, where a chaired road is provided and steam traction employed.

The Paper is accompanied by four tracings, from which Plate 7 and the Figures in the text have been prepared, and by nine photographs.

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