SOME POINTS FOR DISCUSSION IN LOCOMOTIVE DESIGN.

TAIL SPINDLES OR EXTENDED PISTON RODS.

*Paper by A. T. TAYLOR, Member, Ashford, read on
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A comparison of the various designs of modern British locomotives with each other shows that although in many instances uniformity in detail is found, there are certain parts of the engine which vary considerably, proving that widely divergent views are held by those responsible for the designs. I have selected a few such items which I propose to place before you this evening in the hope that they may serve as a basis for a useful discussion.

Tail Spindles or Extended Piston Rods.—Are they actually required? It appears to be the general practice to fit modern engines with the tail spindle, especially if they are superheated, or the cylinders of large diameter. There are, however, several exceptions—the G.W., L. and N.W. and G.N. Railways have many engines running without them.

Fig. 1 shows a typical example of tail spindle, bush and casing as fitted to a superheated engine. The purpose of the tail spindle is to support the weight of the piston and keep the rings floating, thus avoiding excessive wear of the cylinder. Its disadvantages are the extra reciprocating weight and addition to the clearance volume. The gland bush here shown is of gun-metal, and is lubricated on the bottom side, the oiling being effected by a small displacement lubricator on the footplate. The bore of the nipple, one-sixteenth diameter, is found sufficient for the purpose of lubrication. The bush is made a tight fit in the casing, and by providing extra bosses on the latter for the oil connection, the casing and bush can be readily turned round as the hole wears, thus providing further surface for wear. On the S.E. and C.R. it is the practice to fit end tail rods to all

superheated engines, and also saturated steam engines with cylinders over 19in. in diameter, but in the latter the casing is dispensed with and metallic packing similar to that fitted at the back is used. A point of interest, although it may only be a coincidence, is perhaps worth relating. A short time ago an engine was rebuilt with new cylinders, the tail spindles being omitted. During the trials one of the pistons seized, doing considerable damage to the cylinder barrel, and, in consequence, it was decided to use the tail spindle. Since this was done no further trouble has been experienced.

DISCUSSION.

The Chairman: Just by way of opening the discussion, Mr. Taylor has referred to one type of fitting, the tail spindle lubricated with the displacement lubricator. That is not, perhaps, the most common practice. Probably in more instances the lubrication is supplied from a mechanical lubricator—at any rate, at least two or three railways in this country employ tail rods in conjunction with mechanical force-feed; and I believe I am right in saying that it is the I.S. Rly. standard practice, where one feed on the mechanical lubricator is set apart and specially reduced in amount for the tail rod lubrication. Fig. 1 shows the S.E. and C. Rly. practice, and I can speak from some three and a half years' experience that it gives extremely good results; but the success of its application depends on periodically turning the bush supporting the piston rod, and for that reason special provision is made to turn the bush without dismantling the cover by merely taking off the tail rod casing, which is separate from the main cover, and turning it through one third of a circle. Owing to the weight of the piston rod and piston and the accumulation of the carbon on the top of the rod, the wear takes place in a downward direction, tending to make the hole of the bush oval. Provision is made for always applying the lubricant to the bottom, even when the bush has been turned, so there are three bosses round the casing with oil holes in each.

I am pleased to say that we have with us Mr. Dewhurst of the Jamaican Railways. I am sure we should like to hear any remarks he may have to make; but let me first say that we welcome Mr. Dewhurst here very much, seeing that he comes from a foreign clime, and some time ago wrote us a most interesting Paper, which was discussed with great zest by a good attendance at a Saturday afternoon meeting.

Unfortunately, Mr. Dewhurst was unable to be present on that occasion.

Mr. Dewhurst: As a preliminary, I must tell you that I appreciate very much indeed your kind reference to my Paper of some months back.

With regard to the particular subject at the moment, that of the tail rods, I will not say anything about the details but in a more or less general way I certainly think the tail rod is a good thing. Theoretically, it is correct, and one might say that no piston should be without a tail rod; that is, any piston which is moving more or less in a horizontal direction. Of course, for a large diameter piston it is practically essential, and particularly nowadays with superheat applications it appears to be becoming more common. Then there is the question of the pressed steel piston head. That, I think, is a great step in advance towards lightening the unbalanced end of the piston rod. I have known many very bad cases of barrels worn oval from heavy and unsupported piston heads. I have noticed this frequently in American practice where there is often an absence of any provision for supporting the piston heads, that is to say, the head itself is able to touch the bottom of the cylinder barrel, and if there is sufficient slackness in the cross-head, it just scours to and fro. There is no doubt that, in the absence of a tail rod, the proper thing is the provision of some pad bearing on the piston rings themselves, backed by a spring to carry the piston head, and this is common English practice. I am a very great believer in renewable cylinder liners, which are now being used to a considerable extent.

I do not think there is anything else I can very well say on the subject except to repeat that, theoretically, every piston should have a tail rod.

Mr. Clyde Britten (L. and S.W. Rly., Eastleigh): Mr. Chairman,—I agree with Mr. Dewhurst that, theoretically speaking, there is not the slightest doubt that the supported piston rod with the tail end is absolutely correct, but the reason why it has not caught on more is that it has been badly designed. The most important thing is to have the bush lubricated at the bottom and not at the top as it is in some cases, and also to be able to turn it round; but I am not quite certain whether the extra complication of the tail rod is necessary. To give you the practice on our own line, the first lot of engines superheated, having 21 in. cylinders, were supplied with tail rods which, candidly speaking, I do not think were a success. Some inside cylinder engines

were then rebuilt with superheaters, and these had 20 in. cast iron pistons without tail rods, and no wear was found in the cylinders at all. The last new engines have mild steel pistons, 22 in. in diameter, without tail rods, and they have been running 19 months, but no wear has taken place in the cylinders as yet. It seems to be a debatable question as to whether it is really necessary to have a tail rod, although, theoretically speaking, I quite agree it appears to be the correct thing.

The Chairman: Well, if there are no other remarks from the gentlemen present, perhaps I may be allowed to extend what I said in the beginning. As Mr. Dewhurst very truly remarked, theoretically the tail rod would seem to be necessary; first of all, because the piston is sliding backwards and forwards in the cylinder very much like a squeegee on the window pane, and at the end of its long rod, supported only at the cross-head, the natural tendency, as it extends into the cylinder, is for it to fall. Piston rings cannot function properly unless they are floating. If the piston rings are allowed to carry the weight of the piston head, they use the piston rings to squeegee the cylinder down and wear, and when they have worn sufficiently, the piston head comes down on to the cylinder barrel and oval cylinders are the result. Furthermore, in many designs of cylinders the piston heads overrun the steam ports, so that the incoming steam forces the piston head to the opposite side of the cylinder from the steam port, and there again cause excessive wear at the end of the cylinder most remote from the cross-head. I have known this to happen to a very great extent indeed, necessitating the cylinders being scrapped owing to the ovality at one end.

The Midland Railway practice for all its old saturated engines is the particular application noted by Mr. Dewhurst, that of providing on the underside of the piston a brass pad forced outwards by a spring. This formed a very good carrier for the weight of the piston, and, on cylinders up to 18½ in. diameter, it was a most successful contrivance. Up to that diameter there was never any reason to apply tail rods, except for the one fact that, in many of these old cylinders, the piston head overran the steam ports.

In British locomotive practice the ruling feature is simplicity of design and all unnecessary complications are cut out; and this accounts perhaps for many railways not using the tail rod; that is to say, we take the practice as a whole, our experience as a whole, and find that the maintenance of the tail rod costs money and offsets the advantage which

would otherwise be gained from the use of the tail rod against the disadvantage of having the cylinder worn slightly oval. With modern methods of boring cylinders in position without removing them from the frames, one combats the disadvantage of fitting no tail rod somewhat by being able to re-bore the cylinders readily and avoid the expense and maintenance of the tail rod. No doubt, as one gentleman remarked, if better attention was paid to the upkeep of the tail rod, always making sure that the bush is turned round periodically, this trouble from hot tail rods and the excessive wear of the bushes would not take place, and it would be found that the tail rod and its bush were worth fitting. I have a very vivid recollection in my mind of a case which occurred at a certain running shed on the S.E. and C. Rly., where no trouble from ovality of cylinders was ever experienced. At other running sheds, with the same class of engine, trouble was experienced from cylinders wearing oval. Tail rods were not only scored and bushes worn badly, but the cylinders were undoubtedly injured, and, in many cases, spoiled owing to this trouble from the cylinder heads, which were of cast steel, scoring the bottom of the cylinders, and in many cases the cylinders had to be replaced. At the particular running shed referred to, however, it was noticed the cylinders were always in good condition extending over a period of three years, and not a cylinder had been re-bored. It was found that the fitter in charge of this special work at that shed was always careful to turn the tail rod casing and bush round through a part of the circle periodically, and so kept the piston head off the cylinder barrel.

I might just remark that I was surprised to see in one of the locomotive papers a few weeks back that a very heavy locomotive built for the Pennsylvania railway in America, which has, I believe, 23in. cylinders and 5½in. piston rods, has no tail rods. I do not know whether it has been tried for very long yet, but it is one of the latest of its type, and it contains the last word in heat-treated parts; the piston rod is hollow; every ounce has been got out of the reciprocating parts and the moving parts of the motion in order to reduce the weight, and they seem to have risked doing away with tail rods, even though the piston is unusually large and the piston rod of a very large diameter.

Mr. Dewhurst: I would like to make one remark; that is, the question appears to me to be rather—for what size of piston should tail rods be used? You should not use a tail rod for pistons up to 18½in. or 19in. diameter, whereas above that you would use one.

The Chairman: Would you use a piston carrier? I should certainly use a tail rod for anything above 19in. for superheated steam—19in. and over you find with tail rods. We have no tail rods on the line I am connected with for cylinders under 19in., but we have them over, and we have a certain class of engine—saturated, 19in. or 19½in. cylinders—without rods. I think we should be very loath to part with the tail rod on the S.E. and C. Rly.

Mr. Britten: I am not against tail rods for theoretical reasons, but I am speaking only from my own limited experience; and as I said in the beginning of my remarks, if the tail rod were properly designed, it might be all right. My experience was that very soon the piston was just in the same position as it would have been if there had been no tail rod there, and my contention is that with the piston rod and cross-head in one piece and the piston head as light as it can be, there is a saving in reciprocating weight, and candidly I do not think the tail rod is necessary under those conditions.

Mr. Holcroft (S.E. and C.R., Ashford): I do not see any very great arguments in favour of the tail rod; it all turns on a question of weight. Have we reached the end of weight-saving in the piston? In the absence of a tail rod the present design of piston with its big cast iron or cast steel head, when it reaches 20in. diameter or about that size, begins to show some sign of wear on the bottom of the cylinder owing to its weight. Have we found the best design of piston yet; for instance, would it not be possible to have a steel piston rod and head in one, made of very light section? With modern processes it should be possible to do away with the piston fastening altogether in this way and lighten up the piston itself by making it of dished form for strength. Then again, in this country we have never tried boring out the piston rods at all, and I do not see why the piston rod should not be made slightly larger in diameter and bored out. The carrier for the rings could be cast iron fastened to the rim of the piston and made easily renewable, and then the piston itself should last until the rod wears to its minimum diameter. The maximum size of piston possible in this country is only about 22in. diameter, so that it is only a question of those sizes between 19in. and 22in. that we have to allow for.

Mr. Taylor: I do not know that I can add very much to what I said in my opening remarks, but I think the trend of the discussion this evening can be summed up in the fact

that the extended piston rod can be looked upon as a refinement, one of those things which, if properly looked after, will give good results, but, if it is neglected—and we have had experience of such neglect—the results are worse than if it had not been fitted at all. From the experience on the S.E. and C. Rly., I think that we can say that, whether the tail rod is fitted or not, it makes very little difference in the wear of the cylinders. We have not found it effective in that respect.