and 100,000. Then again the locomotives in 1885—the American passenger engine had 40,000 lbs. on the drivers, and the 10-wheel freight engines 68,000 lbs. on the drivers. To-day the average weight on drivers has increased to 122,000 lbs., or 88 per cent.

A very interesting article appears in the Railway Age issue of July 19th, attributing that the possible failure of rails in some cases can be traced to even the counter-balancing of the locomotives, and this is a point that has been frequently argued by the manufacturers. The question is often asked why it is that in the days of lighter rails breakages and wrecks were less frequent? This, I think, is not a hard problem to solve when we look at the specifications and we find that where the lighter sections were comparatively low in carbon, also in other chemical requirements, to-day conditions have changed—the 100 lb. rail seems to be the preferred standard section, and still is the section that seems to be causing worry and trouble. These 100-lb. rails are of high carbon, also in high phosphorus and high in sulphur when made by the Bessemer process, and when these three elements of brittleness remain in a rail the greatest of care should be used in manufacture and also in placing of rails on the track, in order to prevent breakages which will undoubtedly occur if the necessary precautions are not taken.

Having touched lightly on the foregoing points it might be well on account of time being limited for me to touch on the manufacturing side, which seems to be in the minds of a good many of the railway officials and engineering fraternity the main cause of failures.

Almost in every manufacturing interest to-day the capacity of their plants have been considerably increased to that of former years. In the manufacture of steel rails, dating back about seventeen years ago, the output of the average rail mill was from 40,000 to 45,000 tons per month—at the present time it is 65,000 tons per month, and even more in certain plants. This tonnage is taken care of possibly with the same equipment as that of former years. How then do we account for the increase?

Let us trace the metal from the blast furnace where in its molten state it is consigned to the converter, and after being blown into steel is poured into the ingot mold, when sufficiently cool the mold is stripped from same—the hot ingot is then placed in a heating furnace for a short duration, then further rolled into blooms and without any process of re-heating, finally rolled into rails—where formerly the practice was that in hard steel the ingots were poured from the converter and allowed to remain a certain time for cooling purposes, when they were charged for re-heating and rolled into continuous bars about 9½ inches by 9½ inches square, which was then sawed up into the required blooms for making rails. By the process of sawing it was easy to distinguish whether the bloom rolled from this ingot was solid, as any piping would distinctly appear, and could then be further sawn until the solid was reached. In the process of to-day of continuous rolling even, though with a discard from the end of the ingot of 20 or 25 per cent., further piping may still exist, but this cannot be detected, due to the fact that the ends of the bloom have been closed down by a shear which takes the place of the saw. Formerly these blooms, rolled from ingots, were allowed to cool, and before being further re-heated were gone over carefully, having all slivers or imperfections chipped out—by the process of to-day, and on account of the continuous rolling this item is overlooked, and when the finished rail is rolled it is almost impossible to detect some of these imperfections or even slivers.

Another point—regarding the reduction from the ingot to the rail section the working is much more severe, and the reduction through the various passes much larger than formerly, it being a tendency to accomplish the reduction in two passes which was originally accomplished in three. With soft steel it would be perfectly satisfactory, but with hard steel, especially high in sulphur this is different, and frequently at the mills when the ingots are being rolled large cracks in the steel are noticeable crosswise, and as we well know that in as much as hard steel cannot be satisfactorily welded, these cracks apparently disappear in the small sections such as rails, but the defect is bound to be there.

Then again in regard to steel which is poured from the converted into the mold, and in a few hours rolled into the finished rail section, more or less piping is bound to exist on account of the fact that while the ingot is sufficiently cooled when taken from the mold still the interior in parts is in a molten condition, and these ingots when rolled into blooms are rolled in a horizontal position, thus leaving a hollow cavity in the centre of the ingot caused by the metal in its molten condition being forced through to its extreme end.

A good illustration of this from actual experience of the writer when employed in connection with the testing department of one of the large steel plants where ingots of steel were poured. When sufficiently cool to be stripped of their molds, they were placed in a hot condition in a horizontal heating furnace. These ingots were rolled into a 4-inch billet and afterwards rolled into 1⅛-inch bars, developed seams throughout the entire bar. The steel in question was used for buggy axles, which when the journals were turned, developed flaws. As a remedy for our future practice, orders were given that hard steel should remain on the tracks at least twenty-four hours and be allowed to cool before being charged. This settled the difficulty satisfactorily.

On the manufacturing side, if I might term it, the mills are crowded a little too much, with the results explained, and in my opinion it is possibly the cause of a good deal of trouble in the manufacture of our present rail section.

Another point to be considered is the most excellent results that have been obtained by the open hearth process, and further aided by the Talbot process, as now in operation at the Sydney plant, where we can procure a rail that is high in carbon, and yet low in phosphorus and sulphur, with a fair percentage of manganese and silicon. I believe that criticisms have been made in favor of the open hearth process by several of the societies interested in rail manufacture—Bessemer is better suited for rails of lighter section where low carbon is required and where we can then afford to increase the phosphorus of sulphur, but if we are to increase the carbon of our rails, much is required at the present day, our sulphur and phosphorus elements must be reduced.

Another point is the design of the rail itself, which is a very important factor, and seems to have given room for much discussion. In fact so much that recommendations of revised sections have been submitted by the American Railway Association in October 30, 1907, and in fact one of our Canadian railways I believe have already revised their section somewhat on the same lines as suggested. The object of the revision of the rail section is to ensure that the percentage of metal in the base of the rail shall be equal or slightly greater than the head, and web proportionate, so as to permit of equal cooling at all points, and also to prevent as much as possible the internal stresses which undoubtedly prevail in the present heavy sections in use.

An experiment might be made on some of the existing rail sections, by taking six or eight feet of a rail which has been finished and straightened, and on a planing machine cutting the head from the web directly where the head joins the web. As soon as the cut has been made both the head and the web so cut will spring out of line, showing that great internal stresses exist. This experiment should indicate whether a revision of the rail section itself was necessary.

Then, again, the specifications themselves should control the class of product a customer should expect. Up to the present specifications have been drawn up principally to cover rails manufactured by the Bessemer process, which means that if we are to use high carbon rails, the phosphorus and sulphur elements will unfortunately be too high, thus causing brittleness. Since the introduction of open hearth, steel has been made in manufacture of steel rails, consumers realize that high carbon rails can be had with low phosphorus and low sulphur elements, which are certainly better suited to the existing requirements.

A revision of specifications is also, I believe, being made to suit the open hearth process of rail manufacture, specifying lower phosphorus and sulphur requirements, also specifying a discard clause to ensure steel free from piping. In