SOUND STEEL RAILS AND INGOTS.

A COMPARISON of the properties of rails rolled in a mill from different types of ingot of substantially the same chemical composition, but cast by different processes, is a matter of interest and importance. It formed the subject of one of the papers read at the recent annual meeting of the Iron and Steel Institute in Great Britain. The paper was prepared jointly by Sir Robt. A. Hatfield, F.R.S., of London, England, and Dr. Geo. K. Burgess, of the Washington Bureau of Standards. The paper also compares in considerable detail the properties of a number of ingots made by a special feeding process, used by one of the authors, and an ingot of the usual type for rolling into rails. The investigation was made at the rail mill of the Maryland Steel Company and included a comparison between rails from somewhat imperfect ingots produced in the ordinary manner, and from ingots in which the material dealt with was free from blow-holes, piping and segregation. The ordinary piped ingot is unsound and unsuitable for rolling into rails for over half its length, whereas the ingot cast by the feeding method is sound throughout the whole of its length. Inspection indicates that a discard of 50 per cent. would be necessary for the ordinary ingot, but only about 10 per cent. in the case of the Hadfield ingot; that is, there would be practically no discard below the feeding head. A sulphur print taken of one-half face of the Hadfield ingot indicates very uniform distribution of the constituents in the metal, and practically freedom from segregation. As would be expected, the comparison ingot with its pronounced pipe shows marked segregation of carbon, phosphorus and sulphur in the piped region to a depth of 25 per cent. from the top of the ingot, and other regions of somewhat varying composition. The manganese shows but slight segregation anywhere. This examination shows the overwhelming superiority of the ingots cast by the feeding process, such ingots being physically sound and uniform throughout, also free from segregation. Drop tests on the rails from the Hadfield ingots show a high degree of uniformity of resistance to shock. The web, which is usually the part consisting of the poorest material, is practically uniform in the case of the Hadfield ingots with the remainder of the section.

Classification and Manufacture of Ingots.—Of the ingots used in this investigation there were eight made in Sheffield, also an ingot made and furnished by an American steel company, as a comparison ingot, and supposed to represent the usual type of ingot from which rails are made. Ten ingots were used. Four were cast large end up and fed by the Hadfield method in the usual manner with charcoal, the blast being continued until the molten steel had set on the top of the head, say, varying from 20 min. to 40 min. To three of these four ingots, ordinary rail steel was added 0.1 per cent. of aluminum, and 0.125 per cent. was added to the fourth, a nickel-chromium ingot. For the sake of comparison, there were also included two ingots, cast with the small end up, and fed by the feeding method; three ingots not fed, two of piping steel and one of rising or "unsound" steel.

Examination of Split Ingots.—At the Pittsburgh Laboratory of the Bureau of Standards two of the ingots were sawn in halves—one Hadfield ingot of the specially fed type cast large end up, and the comparison ingot from an American mill. That there is an exceedingly uniform distribution of the constituents in ingots made by the Hadfield method is evident. It is evident that there is freedom from appreciable segregation over 95 per cent. or more of the Hadfield ingot, which is also entirely free from piping or blow-holes, and is sound throughout. The comparison ingot, as would be usually expected with its pronounced pipe, shows marked segregation of carbon, phosphorus and sulphur in the piped region to a depth of 25 per cent. from the top, and other regions of somewhat varying composition. This comparison ingot, if rolled into rails, should have about a 50 per cent. discard, as shown from the visual examination, while the whole of the Hadfield ingot below the feeding head would be available. It has been shown by Dr. Stead, Mr. Talbot and others that an ingot of the ordinary type, such as the comparison ingot No. 10, may be somewhat improved as regards internal pipe by cogging while the centre is still fluid. Nevertheless, it is doubtful whether this treatment can be entirely relied upon, and in any case there are always evidences of segregation in the raw material. It is also stated by rail manufacturers, with what correctness we do not know, that such an ingot as the American, which is never allowed to become cold, may heal up in the interior during cogging, at least partially, whereas an ingot allowed to become cold will not, in general, weld together. Probably in no case will perfectly sound material be obtained—that is, if the original ingot is unsound. It would also appear safe to say that any surface which has been exposed to the air will not weld satisfactorily. Although an ordinary ingot may be undoubtedly improved over its condition as cast, nevertheless it would appear that considerable uncertainty always exists as to the actual final condition of such an ingot. The advantage of the special feeding process for ingots cast large end up consists in the certainty every time of producing an ingot free from pipe, blow-holes and marked segregation if sound piping steel has been used. It is, of course, evident that the securing of a completely solid ingot of uniform properties throughout its interior is in itself not sufficient to ensure the entire soundness of the resulting product, such as rails, rolled from such an ingot. For example, there are surface defects which may be present on the ingot; and the operations of re-heating, blooming and rolling may readily introduce serious imperfections. Nevertheless, in the Hadfield ingots the material is in the first case absolutely sound and free from blow-holes. Therefore the liability to such imperfections is much less. Not only are the qualities of the ingot improved, but these at once make themselves felt in the superior product obtained after rolling and forging. For example, when producing billets from ordinary ingots to be used for projectiles—that is, from ingots not cast by the sound method—it was found that there was no less than 6.2 per cent. of waster projectiles, owing to defects due to flaws and roaks, and arising from defects or unsoundness in the original ingots. In exactly the same class of article produced from ingots made from sound steel and properly fed by the method described in this paper, the total quantity of wasters reported was reduced to the figure of 1.4 per cent.; that is, wasters through seams, roaks and other causes were reduced from 6.2 to 1.4 per cent., a reduction of no less than 4.8 per cent.

General Conclusions.—In all, nine ingots were used in this investigation, all but one of which had approximately the same chemical composition. The examination of the split ingots shows the great superiority of casting large end up and feeding by the special process, such an ingot being physically sound and uniform throughout and practically free from chemical segregation. The examination of the rails shows that for ingots cast by the Hadfield process, those cast large end up will give rails of uniform