Discussion.

Sir Benjamin Baker. Sir BENJAMIN BAKER, K.C.M.G., President, said both Papers were of a thoroughly practical and up-to-date character. It was very desirable that members, when referring to the Proceedings for information, should not find it of an obsolete kind. All would agree that Mr. Head's communication was a type of what a Paper for practical men should be, supplying just the kind of details required on the particular subject under discussion. Mr. Wellman's Paper gave a description of some of the most important rolling-mills in the United States, and it deserved the special thanks of the members, since it was the fourth Paper received from the other side of the Atlantic during the present session. He had great pleasure in proposing a vote of thanks to the Authors.

Mr. Head. Mr. JEREMIAH HEAD remarked that the gas- and air-valves formed one of the most important details in open-hearth furnaces.

Fig. 1.

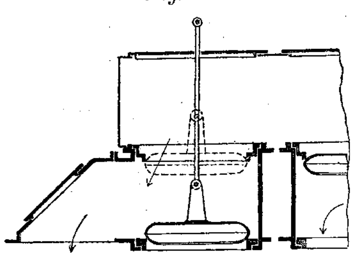
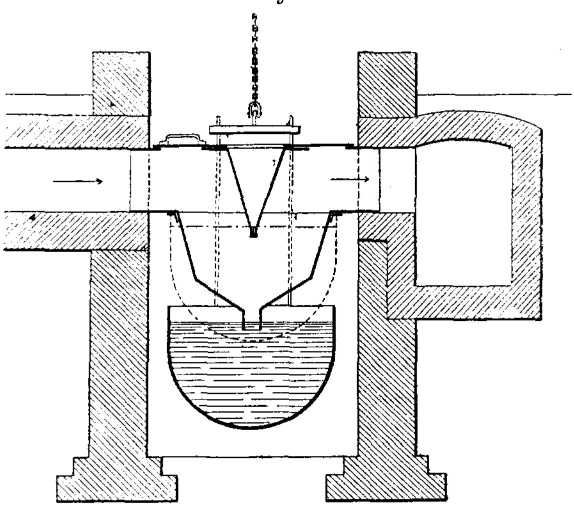


Fig. 4, Plate 7, showed the first reversing-valve adopted by Mr. Siemens. It was simply a cast-iron "butterfly" valve with the producer-gas passing to the regenerators on the upper side, and the heated products of combustion passing to the chimney on the lower side. The heat was trying to the valves, and it was exceedingly difficult to keep them tight. Upon the original form improvements had been made on both sides of the Atlantic. The valve shown in *Fig. 1* was now largely in use in America. It consisted of a thick hollow disk, the periphery of which was formed to a double bevel. It rested on the lower seat at one end of its range, and when lifted it rested against the upper seat. It was not cooled artificially, but simply relied for stiffness upon its particular shape. The valve in *Fig. 2* had been recently introduced by Mr. Wailes, of Newcastle-on-Tyne, formerly of the Patent Shaft and Axle-tree Company, who called it the "siphon valve." There was a cup below full of water, and a funnel above it. In the position shown in the *Fig.*, and when filled with water, it prevented any gas escaping from the funnelshaped orifice, but allowed it to pass along the flue. When it was lifted up until the water rose above the V-shaped mid-feather, it produced a water-seal and prevented the flow of gas altogether. It was therefore able to stop the gas or allow it to pass, according to its position. As the pressure of the gas was only equivalent to ½ inch of water, it was easily controlled in that way. The valve had been in experimental use in three works in Great Britain, and also on the Continent. In *Fig. 3* another valve devised by Mr. Wailes was shown. There were two valves on the same rod, but having independent motion, the top one being attached to a sleeve, and the bottom one to the rod. Their peripheries dipped in troughs which were kept constantly full Mr. Head.

Fig. 2.

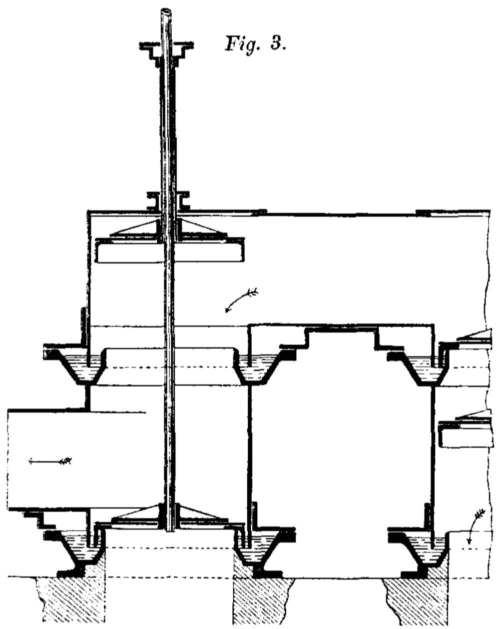


of running water. When the top valve was up and the bottom one down, the gas was passing from the producers through the regenerator to the furnace. If it was required to reverse, the lower valve would be lifted into a recess where it would be sheltered from the hot gases, and the top valve would be put down. By constant contact with water the valves could be kept fairly well in shape. *Fig. 4* was an improvement on the last mentioned valve, and was the invention of Mr. F. Mills, of the Wishaw Works in Scotland. The water was introduced from a pipe overhead down the stalk; it ran over the top of the valve and then down the vertical duct at the side. The peculiar section of the valve ensured that it was always in water. In the upper

Mr. Head. position the seal was produced by the water it carried with it, and in the lower position by that contained in the trough below. It had been used for a considerable time. He believed it had been in use in all the eight melting-furnaces of the Stockton Malleable Iron Company's Works for about two years. A photograph he had received from Mr. Mills of a valve revealed after two years' work no distortion or deterioration.

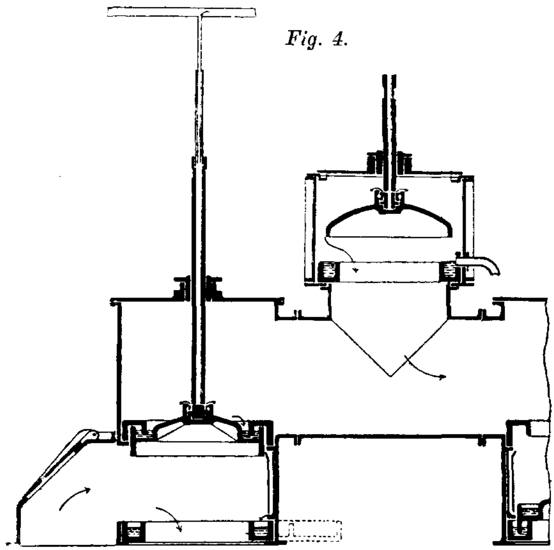
He was glad to find that the remarks of Mr. Wellman to a great extent confirmed his own. He had spoken of the almost

Fig. 3.



universal practice in the United States of making plates direct from ingots without cogging, and confirmed the statement that the plates so made, or an overwhelming portion of them, were perfectly good on the surface and also stood the tests required in a very satisfactory way. In Fig. 9, Plate 9, he had somewhat departed from Mr. Head's typical plate-mill. The engine, and the mode of driving with three pinions, and the live-roller frames, were exactly the same; but another and larger mill was added. If the engine was strong enough, and also the pinions and spindles, there was no reason why that should not be done; but it should be understood that such a second plate-mill was not an essential part of the mill as were the two stands of rolls in the English type, where the plate first passed through the roughing- and was then transferred to the finishing-rolls. The second mill, as shown by Mr. Wellman, was not merely a finishing-mill for the first one; it was an absolutely separate mill. Both mills might be at work together, and might in that case make double the number of plates that one mill alone would produce. The second mill was made with longer rolls, so that he had the option of putting the narrower plates through the one and the broader through the other. In that way he was able Mr. Head.

Fig. 4.



to some extent to sort his orders. The horizontal charging apparatus which he had seen at work in the States had been referred to by Mr. Wellman. It certainly did its work very well. His only doubt was whether the time had not come when horizontally charged furnaces should be given up, and vertical heating furnaces used for all purposes. It was so much easier to lift heavy masses vertically in and out of apertures in the floor than it was to charge or draw them horizontally. Certainly Mr. Wellman had overcome his difficulties very well, but only by employing costly, heavy and elaborate apparatus which would be entirely unnecessary if the ingots were charged and

Mr. Head. drawn vertically; and he saw no reason why that should not be done in all cases.

Mr. Webb. Mr. F. W. WEBB wished to refer to the length of rolls now being made. About thirteen years ago he had been anxious to try a locomotive boiler barrel in one plate; but at that time there was no mill in England or elsewhere that could roll it. He had accordingly built a set of rolls driven by two locomotive engines, having two 17-inch cylinders, and 24-inch stroke, coupled 35 to 1 with gearing, and he had succeeded in rolling a plate 11 feet wide. This he had used for the boiler, and he had recently had the pleasure of getting inside it and finding the barrel in perfect order; there was apparently very little pitting, and it seemed likely to work well for another seven or eight years. With regard to the method described in the Papers, he thought there was a tendency to make the ingots too thin, so as to avoid the process of hammering. He had already expressed his opinion as to the effect of using comparatively thin ingots for rolling plates. It was well known that ingots cast in a cast-iron mould had certain surface imperfections, and if the ingot was thin those imperfections formed a very large portion of the finished plate when it was rolled. His experience since he had made his first locomotive boiler of steel twenty-five years ago, had shown him that hammering was well worth its cost. It enabled an ingot to be taken much thicker than if it were rolled down direct, and consequently the surface imperfections of the finished plate were comparatively a very small portion of the whole. That, he thought, was one of the reasons of the success achieved with the locomotive boilers at Crewe. He had made more than four thousand, most of them by the Bessemer process, carrying pressures between 120 lbs. and 175 lbs. per square inch; and he had hitherto not had a single failure or a ruptured plate, though, of course, boilers had been "scrapped" from ordinary wear and tear. When he first began to make steel locomotive boilers he had been told, as Watt told Trevithick about high-pressure steam, that he ought to be put in gaol or in a lunatic asylum; but he was glad to say the prejudice had been overcome, and he thought very few engineers would now return to iron boilers. He would emphasize the importance of not attempting to cheapen plates too much by using too thin ingots; otherwise surface pitting would occur. With regard to rolling rails, the practice at Crewe was similar to that adopted in America. The ingots were cogged down, and were used on the London and North Western Railway in rails 60 feet in length; and sometimes, for passing

Mr. Webb.

over bridges, to avoid splices on the top of the bridge or in the centre of the opening, they could be rolled up to 100 feet or 120 feet, in fact as long as was required. The rails were now rolled in a reversing cog-mill, the last pass in which was opposite the first pass of the roughing-rolls of the three-high finishing mill. The ingots weighed 18 cwt. or 1 ton each, and they were rolled with one man at the back of the rolls. All the work of carrying about of the ingots was done on live rollers on each side of the three-high mill and cogging-mill. In the finishing-rolls the rails were sent up an incline so as to get the weight of the rail to help to pass it on the next pass. There was no trouble in the work. In that respect it was different from the American practice, as he did not like pushing the work on too quickly. He had found that rails rolled and sent out of the mill too hot had not the same wearing qualities as those that were rolled somewhat colder. From what he had heard in America, he could not help thinking that quickly-made American rails were not lasting as long as some that he had rolled and sent over to the United States. He had lately heard a good character of them, and he had been asked to give the analysis of the steel. He had replied that he thought the reason why the rails lasted so well was that they had not been rolled so hurriedly.

Mr. Wolfe Barry.

Mr. J. Wolfe Barry, C.B., Vice-President, asked Mr. Webb if the great weight of the rails on the London and North Western Railway had been found inconvenient for the men employed in the permanent-way department, or whether any special cranes were used for lifting the rails and placing them in position. He supposed each rail weighed about $\frac{3}{4}$ ton.

Mr. Webb.

Mr. Webb said they weighed 90 lbs. per yard. The permanent-way engineer used appliances for moving the rails, he believed. It required about six men to place them in the road. There was no practical difficulty in the way. The first rails of 60 feet long were put down, at his request, in the tunnel on the Festiniog Railway many years ago, and they had recently been taken up after a long life. No difficulty had been found with the joints. The 60-foot rail was now adopted for the main line, thus saving half the joints.

Sir William White.

Sir William H. White, K.C.B., had read both the Papers with great interest, and considered them very valuable. There was one point in Mr. Head's Paper to which he should like to refer, because he thought it a matter of national importance. It was true that the open-hearth acid process was practically the only one in general use in Great Britain for manufacturing ingots for plates, Sir William White.

but it was true in a great measure by the choice of the manufacturers. The Admiralty, for example, were large buyers of steel, and for many years its specifications had permitted the use for ship-work of open-hearth basic steel on the same terms as open-hearth acid steel. There was nothing to prevent any maker from tendering for open-hearth basic instead of open-hearth acid, subject to the mechanical tests imposed. The invitation, however, had not been responded to. Before those terms had been laid down he had conducted a long series of experiments[1] on basic steel made both by the Bessemer and by the open-hearth process. The experiments had led the Admiralty to the conclusion that neither with Bessemer acid nor with Bessemer basic steel as used in riveted structures could the same certainty and uniformity be assured as by open-hearth steel, whether made by the one process or by the other. He knew that position had been challenged. He had seen quite lately a statement in a letter from a leading American steel-maker to the effect that in America the same difficulties had not been met with. He could only say, speaking of what he had repeatedly witnessed in experiments he had personally conducted, that in riveted samples of steel made by the Bessemer process, either acid or basic, less uniformity of result had been obtained under tensile test than had been obtained with similar riveted samples of steel made by the open-hearth process. But the point he wished specially to make was this: it was no doubt a matter of national importance that the ores which were most abundant in this country should be available for steel-making. The basic process allowed those ores to be used. The Admiralty, as a large purchaser, had allowed the use of basic steel made by the open-hearth process, and the manufacturers had not availed themselves of the opportunity. He presumed the only conclusion to be arrived at was, that under existing conditions and with existing plant it had been commercially preferable to continue the acid process. But it was a matter which, so far as the Admiralty was concerned, was entirely in the hands of the manufacturers. He thought it important that Mr. Head's statement should be qualified in the way he had mentioned.

Sir Benjamin Baker.

Sir BENJAMIN BAKER, K.C.M.G., President, said he knew that others had had a much wider experience of basic steel than himself; but in his own experience he had had more trouble and anxiety over the use of basic-steel plates for about six months

[1] Transactions of the Institution of Naval Architects, vol. xxix. p. 59; and Journal of the Iron and Steel Institute, 1892, p. 32.

than he had had in twenty years' use of acid steel. In many orders for bridge-work received from abroad, he was expressly prohibited from using basic plates on account of the trouble experienced from the work, which had been thoroughly tested, arriving, after a long voyage, fractured in very strange and old-fashioned ways, such as Sir William White was familiar with when first using Bessemer steel plates for ships. He had had cases where a member of a girder, consisting perhaps of a vertical plate, two angles and a bottom plate, had fractured right through whilst being lifted by a crane out of the ship's hold. The result had been that he had had definite instructions in many cases not to use basic steel. On the other hand, he could not shut his eyes to the immense Continental experience in basic steel, and he could only infer that it was as Sir William White had said, that under present circumstances in this country the difference in cost was so little that the manufacturers had not trained their men to the necessary nicety in turning out the requisite quality of material. Up to the present time he agreed that the statement in Mr. Head's Paper was substantially correct. Sir Benjamin Baker.

Mr. F. W. Webb stated that during a practice of about thirty-three years in working the acid Bessemer process he had had no difficulty whatever in obtaining the uniform quality of steel that he required. As before mentioned he had made more than four thousand locomotive boilers beginning in 1872, and he had had no difficulty whatever. He had never had a single ruptured plate, or one that did not comply with the conditions required. The tensile strength of the steel was between 26 tons and 33 tons per square inch, according to the position in which it was placed in the boiler. He should like to ask Sir William White in what way the steel made by the Bessemer process had failed. He had always found that by putting good material into the vessel and taking care in the manipulation he could get good results, and he saw no reason whatever for changing his practice. He used both the Bessemer and the acid open-hearth processes, and had now 20-ton open-hearth acid furnaces at work for making rails and other things, but for steel plates he continued, with the greatest confidence, the acid Bessemer process. It was well known that good results could not be obtained from material containing sulphur or phosphorus; but with a careful selection of the best English hematite pig-iron and Swedish iron a uniform result could be produced. The whole of the steel plates used for H.M.S. "Captain," which unfortunately capsized in the Bay of Biscay, had been made by the acid Bessemer process. Mr. Webb

Sir William White.

Sir WILLIAM WHITE stated that the acid Bessemer process was in that case applied to quite minor and internal parts of the structure. All the main parts were of iron. The "Captain" was not a steel-built ship. He desired it to be distinctly understood that he was not denying in the least the possibility of making good steel by the Bessemer process. The facts he had mentioned, however, had been proved, and could be referred to in the Papers he had previously quoted.[1] A Paper on the testing of acid steel made by the Bessemer and by the open-hearth processes had also been contributed by Sir Nathaniel Barnaby.[2] Facts would be there found on which the Admiralty had proceeded in preferring the use of open-hearth steel on important parts of structures of ships where the riveting of several of the parts together was a necessity. He did not in the least impugn the Bessemer process, but the experience of the Admiralty did not point to the desirability of using Bessemer steel, whether acid or basic, in riveted structures in important parts of ships. He did not question the goodness or the perfection of what had been done at Crewe.

Mr. Webb.

Mr. WEBB said all the steel plates in the "Captain" had stood a uniform test, and were made by the Bessemer process under his own supervision. He only wished to bear testimony to the fact that Bessemer steel could be made of uniform quality if good material were employed. He had used the Bessemer steel not only in ships, viz., the "Isabella" in 1878, the "Lily" and "Violet" in 1880, and the "Banshee" in 1884, the whole of the plates and frames of which were made of that material—the three latter being the fastest cross-channel steamers between Holyhead and Dublin—but in equally important structures, such as the Llandulas Viaduct, North Wales, which he had replaced in twenty-eight days after the memorable storm which washed away the seven-arch stone viaduct, on the 17th August, 1879; and he had no failures. The plates and frames of the three last steamers referred to were recently found so good that they had been re-engined with triple-expansion engines in lieu of the old low-pressure engines. The thickness of the plates in the locomotive boilers was between 1 inch and $\frac{3}{8}$ inch. The tube-plate was $\frac{3}{4}$ inch, the belly-plate $\frac{5}{8}$ inch, and the barrel-plate $\frac{1}{2}$ inch. The tube-plate would not be under tension. He might add that he had made a great many marine-boilers before they were all made of iron or steel, and

[1] *Ante*, p. 172.
[2] Journal of the Iron and Steel Institute, 1879, p. 45.

had never had any failure or trouble with them until the Board of Trade stepped in and said that they were to be made in a certain way; then they had failed. For several years some of the London and North Western Railway Company's steamers had been running with steel boilers, and before they were required to be passed by the Board of Trade a failure was unknown. Mr. Webb.

Mr. THOMAS WRIGHTSON observed Mr. Head had pointed out that the general American practice was to adopt a non-condensing non-compounding engine. Where engines were designed to reverse, in the case of some rolling-mills, there might be considerations in favour of non-condensing and non-compounding; but he thought such practice was somewhat behind the time. Attention was now being generally directed to the question of compounding mill-engines, and great economies had thus been effected in the use of fuel. The compounding and condensing engine had achieved such vast success in marine practice that it would almost appear rolling-mill engineers had been backward in not following it up. In one works in which he was interested a large economy had been the result of compounding and condensing; and he thought it would not be long before other rolling-mill engineers would direct their attention especially to that economy. Mr. Wrightson.

Mr. A. McDONNELL considered that copper was much cheaper and more reliable than steel for the fire-boxes of locomotives. He had received steel fire-boxes from America, but they had not answered well. The cost of fixing them was very heavy, and the length of time the engine was out of service while receiving a new fire-box was considerable. The life of a steel fire-box was certainly much less than that of a copper one. He did not, however, think that copper was so good or so durable as it was some twenty or twenty-five years ago. Mr. McDonnell.

Mr. J. H. R. WHINFIELD had during the past winter visited a number of rail-mills in Russia, and at one of them he had seen what was called a "mixer" or desulphurizer. He had been told it was an American device, but perhaps the Authors would say whether it was a common practice in America or not. He understood that it was adopted in order to secure uniformity of product; that the metal was run from the furnace into the "mixer," into which a large quantity was poured, and then run into the ingot-moulds to be afterwards worked down into rails. Mr. Whinfield.

Mr. JEREMIAH HEAD, in reply, desired to thank the members for the kind way in which his Paper had been received. The Mr. Head.

Mr. Head. remarks of Mr. Webb represented what had hitherto been the general view of English platemakers, in so far as he defended strongly the plan of cogging ingots in a separate cogging-mill before they were rolled into plates. He even went beyond that, and defended hammering. That had been much believed in a good many years ago, but now it was entirely given up by English steel makers, except in very few cases. He knew one other advocate of hammering besides Mr. Webb. As to the use of thick ingots, and the value of a great amount of reduction in section between the ingot and the finished plate, in his Paper it was stated that this view was the one generally held in England, and one of his principal objects had been to show that it was not entertained in America; and that, with the exception of one case, plates were entirely rolled from flat ingots, generally not more than 1 foot thick. Some doubt had been expressed by Mr. Webb as to the surface which was produced by such a method, and also generally as to the quality as indicated by the tests which could be sustained. He had placed on the table two specimens taken from plates made by the open-hearth basic process for cutters of the Inland Revenue Department in the United States. The tests given in the Appendix were quite as severe as any applied in Great Britain. It would be seen from the two specimens that the plates had been folded over, and then cross-folded, so as to make a four-ply corner, which was hammered down perfectly flat, the whole operation being carried out cold. The surfaces were very good and there were no flaws. Those specimens were not selected; he had inspected a large number of plates in the United States, and he could not see any greater ratio of surface defects or faults than in English plates. He found from the returns of one of the large steel works in the United States with which he was associated, that during the last five months 96 per cent. of the plates rolled out perfectly sound to the sizes for which they were intended, leaving 4 per cent. for defectives, which included plates that were cracked, pitted, scabby, burnt, buckled, spotted, cobbled and blistered; and these were not entirely wasted, but were cut down into smaller sizes. He thought the number of the rejected plates was scarcely worth considering. The acceptance by the Admiralty of plates made by either of the two open-hearth processes, but not by either of the Bessemer processes, agreed with the practice in America; but the tendency there was for the open-hearth basic to supersede the open-hearth acid, notwithstanding that three-fourths of the pig-iron made in the northern district was suitable for Bessemer purposes. At the

Carnegie Company's works, for example, four or five years ago there was only one basic-lined open-hearth furnace, but now there were sixteen. Acid-lined furnaces had been abandoned for plate-making and other things, in favour of open-hearth basic, the reason being, as he had explained, that it gave much greater latitude in the materials which could be employed. No matter what impurities went with the charge into the furnaces, the product could still be controlled and plates brought out of such a quality as those shown on the table. The fact that English plate-makers were almost all for the open-hearth acid process, was to some extent an accidental circumstance. English steel-works were mainly on the coast; there were excellent facilities for bringing the good and cheap ores of Spain to English sea-ports; and the steel-making trade for ship-building and boiler-making purposes was originally based on the supply of hematite pig-iron obtained from that foreign ore. The trade having once been established steel makers were reluctant to run the risk of trying new experiments and so had followed suit one after another in employing the acid process. It would also be remembered that in the earlier days both Lloyd's and the Admiralty naturally preferred what they had most experience of. Good plates could be made by the open-hearth acid process, and they preferred that mode of making them, being suspicious of anything that had the name of basic. That, no doubt, had a very discouraging effect on the growth of the basic steel trade of all kinds which utilized native ores. He believed that was now passing away, and he was glad to hear the statement of Sir William White that the Admiralty was quite willing to take open-hearth basic plates for its own purposes. When, however, a trade had been established as long as the open-hearth acid trade had been, and the workmen and the agents were accustomed to it, it was not easy to alter it. In fact, the workmen formed the great difficulty, and resisted its introduction. In speaking of the trouble arising from basic steel, the President probably alluded to basic Bessemer steel, which had come from the continent, especially from Germany, in large quantities. His statement was undoubtedly true that some of those products had given a good deal of trouble; but he believed that both in England and in America there had been a great improvement during the last few years, and there could be no doubt that excellent steel was made from any of the four processes. That accorded with the observation of Mr. Webb, who had made plates from the Bessemer acid process for many years without any trouble. It should be remembered that at Crewe the best prices were paid, and the best material

Mr. Head.

Mr. Head. and labour were employed, under thorough supervision. He was inclined to think there was more risk of variation in the Bessemer than in the open-hearth processes. The operation was much more brief, and there was less chance of watching and doctoring the charge over a considerable length of time, and testing it; it was therefore less certain unless there were great facilities and the excellent superintendence and judgment available at Crewe. In the United States, rolling-mill engines were not compounded, because they were very simple, often of the Corliss type, where there was a considerable amount of expansion in one cylinder. It should also be remembered that they had an automatic expansion-gear, which, if needed anywhere, was needed in a rolling-mill engine, where the load factor was continually varying. That, perhaps, became a simpler thing where there was one cylinder than where there were more. In regard to condensation, the condensing water required was generally at least thirty times the weight of feed-water; and where, as in the case of the one referred to, several engines were exhausted into one common condenser in a steel-works, the amount of water was probably more like sixty times than thirty. Where the works were by a river, as in the case mentioned, and a large duct had been brought a considerable distance from it for the purpose of condensing, it became perfectly possible; but it was somewhat costly, though no doubt it paid in the end. There were many ironworks situated where that large supply of water could not be obtained, and that, he presumed, was the reason why condensation was not more frequently adopted. In the large ironworks in the Middlesbrough district, on the south side of the railway between Middlesbrough and Redcar, none of the blowing or other engines were condensing. The difficulty was that there was not enough water. As to the duration of steel as against copper for the inside fire-boxes of locomotives, he might mention that in the United States (where the length of railways was six times that in Great Britain, and the locomotives, though not quite in the same proportion, were much more numerous) the inside fire-boxes were all of steel, and they seemed to give good results. These fire-boxes were now improved, however, by the open-hearth basic process, and the steel from which they were made was very similar to that shown upon the table. Every locomotive superintendent had his specification both in regard to tensile tests and chemical tests. Whether they lasted longer or not he was not in a position to say, but he could assure Mr. McDonnell that steel was increasing in reliability and manageability. Those two circumstances in time might reverse the fashion in this country. As to the question of mixers and desulphurizers, Mr. Whinfield appeared to refer to the desulphurizers as used between the blast-furnace and the converter or open-hearth furnace, rather than between the latter and the ingot-moulds. These were large brick-lined vessels into which the molten product of a number of blast-furnaces was poured, and from which the product going to the converter or open-hearth furnace was taken. By means of charging a certain amount of manganiferous ores into the blast-furnaces, or into one of a series of blast-furnaces, and mixing them in the mixer, the manganese affected the sulphur and reduced it to about one-half. Those desulphurizing mixers were used in the northern district; at the Barrow Steel Works, at Bolckow, Vaughan & Company's Works and at the North Eastern Steel Works, and they were also used in almost all the recent works in America. They were of the greatest possible advantage. Although in Great Britain they had generally been used as preliminary to the converters, they were used in America for serving open-hearth furnaces also, with good results. It enabled white pig-iron to be used containing low silicon, which would otherwise have high sulphur. It was possible to minimize the sulphur, while retaining the advantage of low silicon, which was a matter of great importance. Mr. Head.

Correspondence.

Mr. G. W. Dickie remarked that Mr. Head, in referring to the different methods of producing mild steel, appeared to assume that an equally good quality of steel could be produced by the open-hearth basic process from impure and cheaper pig- and scrap-iron as could be produced by the open-hearth acid process, using the higher grades of pig- and scrap-iron necessary for that process; and that the basic-lined furnaces enabled manufacturers to draw supplies from a wider market, and at lower prices. "Miscellaneous scrap-iron, which is usually cheap, can be utilized."[1] He had had occasion to use large quantities of shapes, in ship-framing, requiring severe working, produced by steel-works adjacent to the ship-yard of the Union Ironworks, San Francisco. These were made until about two years ago by the open-hearth acid process; the pig- and scrap-iron being carefully selected for the purpose. Basic-linings had then been introduced, to enable large quantities of rejected scrap to be used, and while the resultant product Mr. Dickie.

[1] *Ante*, p. 134.