Mr. LOCKE, M.P., President, feared he should not adequately express to the Author the gratification, which he was sure was felt at the production of this Paper. To a society of practical men the narration of the difficulties encountered by an Inventor, in bringing into practical use a valuable invention was most useful; Mr. Bessemer had waited for two years for the full realization of his ideas. It would be remembered, when this process of iron manufacture was first mentioned, what an effect it had upon that branch of industry; and it was felt that, if the statements were correct, a complete revolution in that manufacture was about to be introduced. Such, however, were the objections raised,—whether rightly or wrongly he need not now inquire, although it was fair to assume some of them, at least, were well founded—that Mr. Bessemer set himself to work, to endeavour to overcome them; and he had now brought before the Institution beautiful specimens of manufacture, and which, it was said, were produced at such a price that, if the calculations proved to be correct, it was evident, a great revolution in the making of iron must follow. Mr. Bessemer was, therefore, entitled to the best thanks of the Institution, which Mr. Locke felt certain, he might add, were voted by acclamation.

Mr. BRAMWELL said, he had listened attentively to the reading of the Paper, in order to learn some distinct facts in reference to this invention; but none were given. He quite concurred in the opinion of the ability displayed in the Paper, and the interesting character of the specimens exhibited, which could not fail to command attention and respect; and he therefore felt, that any expression of dissatisfaction would be but coldly received. He recollected, the interest which was excited by a Paper upon this subject, read before the British Association, and also by the experiments that were afterwards made at the works of the Great Northern Railway. That was nearly three years ago; after which the excitement soon subsided.

As far as he was able to gather, it appeared that this description of steel could not be made, except from a particular quality of pig-iron; and that Mr. Bessemer had chiefly resorted to the most expensive kinds of Swedish iron, in order to produce these results. Then again, in the Paper, the results as regarded iron and steel were so mixed up together, that it was difficult to separate them. It also appeared that of the British ores the hæmatite was the best for this purpose; but he believed that kind could not be obtained in any great quantities. No details were given as to how the iron was made; all that was said being, that the metal was put into the vessels, which had been described, and run into ingot moulds, then remelted, poured into water, and then melted again. As regarded the making of wrought iron, it was stated,

that after the metal had come from the ingot moulds, it was capable of being tilted, or rolled. He understood it was considered practicable to take pig iron, put it into the vessel described, increase the heat by blowing in air, and thus produce ingots capable of being extended by the hammer, or rolled. That was supposed to have been the result of the experiments which were made at the St. Pancras Iron-works. Mr. Bramwell had a portion of an ingot given to him, which he endeavoured, by all the means in his power, to draw out; but he could not succeed. As a last resource, he drilled a hole in a piece of cast iron, and plugged the piece of metal in so that it could not get away; but the hammering produced nothing but a kind of sand from the hole. He should like to know, whether the specimens exhibited were accidental results, or could always be produced with certainty? He knew how sanguine inventors were; but when a Paper of this kind was brought forward, without full opportunity for discussion, it was desirable that facts should be given, and that speculations should not be entered into. It was most important to know, whether it would be indispensable for the ironstone of one part of England to be carried to another part, however distant, for the purposes of this manufacture. He should have been better pleased with a dry history of facts, such as how much waste was made at each stage, and how much destruction there was of the vessels. At the Butterly Iron-works, he had been told that several inches of the brick lining were melted away by one charge. The Paper should have stated how that was surmounted, and how long the lining of the vessel lasted. As regarded the particular make, it seemed to him that, there were two ways of making steel. One was, to decarbonize the cast iron to a certain extent; and the other was, to convert it into wrought iron, and then to add carbon to it. He believed the amount of carbon in cast iron varied very much. In the same weight of iron there were differences in the amount of combined and uncombined carbon. That being so, and all other things being equal, the particular condition of the material would appear to depend upon the quantity of air passed through it. He thought one great difficulty was, to know the amount of carbon to be dealt with, both combined and uncombined, and what amount of air ought to be passed through the metal. A half per cent., more or less, of carbon, might make a difference in the quantity of metal produced, whether of steel, or of wrought iron. He thought the Institution would be glad to receive more information upon these points; and perhaps he might have done some good in suggesting that these deficiencies should be supplied.

Mr. BESSEMER explained the peculiarities of several of the samples exhibited; and in reference to the difficulty which had been suggested in the wasting of the lining of the vessel, said

that at first he used fire brick for lining, but he found that material was rapidly acted upon by the intense heat. He then tried a variety of substances, and thus ascertained that road-drift, or ganister, was the most refractory material, yielding less than any other to the fluid matters contained in the vessel. The cost of re-lining a vessel was about twelve shillings, and the time occupied in doing it was very short. Each lining would last during the manufacture of from 70 to 90 tons of metal. It had been found, that the best way of re-lining was to place a wooden mould in the interior of the vessel, ram the drift round it, and then heat and glaze it. A charge of metal might be put into the vessel within two hours after the re-lining. As to the waste of material, he might state, that in the manufacture of steel, the waste was generally from 13 to 15 per cent., while upon the iron it was from 20 to 22 per cent. It was to be observed, however, that the waste which took place in this process was not upon the valuable material, but upon the pig-iron, the value of which was not enhanced by labour, or by the consumption of fuel. If 20 per cent. was lost at first, and nothing afterwards, it was not equal to 20 per cent. loss by the ordinary process, which extended through every stage of the manufacture, and was upon a progressively more expensive material. It was not true that expensive kinds of iron had to be resorted to. Swedish pig-iron ranging from £6. 10*s.* to £7. a ton, was, however, employed in the production of the higher-priced qualities of steel, which were more suitable for cutting edges, but were by no means superior to the steel made from English iron, where strength and elasticity simply were required. It was an error to suppose, that the steel made by this process was first run into ingots, and then re-melted; as the ingots were in every case suitable for the hammer or the rolls.

Mr. T. BROWN said, he had taken great interest in this process, when it was first brought forward, after the meeting of the British Association, at Cheltenham. He had been sanguine of its success, even in opposition to the opinion of others, who had no faith in it from the commencement; and he had spent £7,000 in endeavouring to carry it out. It appeared to be thought, that the quality of the iron ore had an important influence on the success of the operation. Now, he had succeeded in making samples, equal perhaps to those exhibited, from spathose ores from the mines of the Ebbw Vale Company in the Brendon Hills, Somersetshire, with a mixture of Pontypool iron. But the difficulty he experienced, amounting indeed to an impracticability, was in finding a completely refractory material for the furnace. He was astonished at the price which had been stated as that at which the article could be produced. He thought a very simple calculation was sufficient to disprove it; for the iron and the material,

without manipulation, made up the amount; in fact, the article in its first state, supposing Indian pig-iron to be used, cost £6. 10*s*. per ton. He did not wish to say anything which could be looked upon as discouraging, because he had originally been one of the warmest supporters of the invention; but he believed Mr. Bessemer was now falling into the same error as to cost, as he had done at Cheltenham. With regard to waste, under the most favourable circumstances, there was a loss in the manufacture of nearly 40 per cent. of metal; and on one occasion his agent informed him, that the whole of the metal was consumed, and that nothing but cinder remained.

Mr. T. M. GLADSTONE said, as one who, under the late Mr. Edward Thorneycroft, had gone through the whole process of iron manufacture, he ventured to assert—in opposition to what had been stated—that in the process as described, there was not one step in advance, nor anything, in fact, which had not been previously done by the manufacturers of Staffordshire. The refinery process was anterior to the puddling, and was practised for a long series of years; and in the converting of pig iron, the purification was as perfect as that claimed for this invention. The puddling process constituted a new feature in the manufacture, and was found to be sufficient and perfectly adapted to produce, with economy, a material equal in quality to that obtained from the refinery. Iron had been made so pure, that a magnifying-glass failed to reveal the presence of any impurities. The Bessemer process only brought the metal into the same condition in which it was left by the refinery, before being put into the puddling furnace. The quality of the metal was no doubt improved, by its affinity for oxygen, which was an expensive fuel, used for its conversion. This might easily be proved, by putting a piece of iron, at a red heat, into pure oxygen, when it would be consumed to a cinder. Although the specimens produced were of a beautiful character, yet, had time permitted, he would have been prepared to prove, that not the slightest advance had been made in the iron manufacture, in their production. It was a question of the highest importance, and one which should not be allowed to rest upon mere assertion, but be capable of being based upon most substantial facts.

Colonel EARDLEY WILMOT, R.A., said, he had, from the commencement of these inquiries, taken a great interest in them, and had mechanically tested the products originally produced. A chemical examination was also made at the Royal Arsenal, Woolwich, and the result had indicated, and it had been stated at the same time, that the Bessemer process was perfectly effectual for removing the silicon from iron, but that it did not operate upon the phosphorus, or the sulphur. Acting on this knowledge,

which was corroborated in many quarters, Mr. Bessemer had wisely dealt with such iron as yielded the desired result. As regarded the difficulties of the process, as well as the results of it, he thought that the best thing for a member of a practical society to do, was to follow his example, and to go and see it for himself. Nothing could be more simple, or more perfectly under control; and having, by a few trials, ascertained the particular kind of treatment required, with the sample of iron to be dealt with, it was operated upon with certainty. It was said, that there was nothing new in the process; but it might be fairly asked, was it, or was it not a new result, that a bar of iron 4 inches in diameter could be bent cold into a perfect contact, without any sign of flaw? As regarded the particular product, in which he was most interested, namely, a cast metal for cannon, projectiles, iron plates for shot-proof ships, and all military purposes, a circumstance had not been mentioned which he would name as being peculiarly instructive: while the metal, after having been operated on to the extent required to make it malleable iron, was in the ladle ready for pouring into the moulds, an accident occurred to the tapping hole of the ladle, and the metal was allowed to get cold in it, instead of being poured out. Here was the ordinary condition of a common casting in a gun mould, with, however, this important difference, that in this case it was very shallow, as compared with the gun mould, and there was, therefore, no condensation of the material from fluid pressure. A cylinder of 2 inches diameter was taken out of this mass, and gave a tenacity of 42,908 lbs. on the square inch, and a specific gravity of 7,626. A similar cylinder was drawn out under an ordinary smith's hammer to twice its length, and then gave a tenacity of 64,426 lbs., and a specific gravity of 7,841. This portion of metal was examined by the Chemist to the War Department, and was found to contain—

Silicon	0·00
Graphite	0·00
Combined Carbon . .	minute quantity
Sulphur	0·02
Phosphorus	trace
Manganese	trace

This appeared to him to approach more nearly to true iron than any he had seen. The ordinary iron of the market was in that sense, not iron, but a compound of iron and certain other ingredients. The ordinary re-melting would remove, or combine, the graphite only; the Bessemer process would remove the silicon, and when applied to an iron, having but little phosphorus and sulphur, would do all that was required. If an additional process

was discovered for removing these, all the iron ores of England, instead of only a very large portion of them, could be converted into pure iron.

As regarded the steel, he had been using it for turning the outside of iron guns, cutting off large shavings several inches in length, and he had found none superior to it, although much more costly. It was only necessary to witness the operation of the manufacture by the Bessemer process, to be satisfied that the expense of converting the pig-iron into any of the products, involved scarcely any cost beyond the labour, and that for a very short period of time. And as far as the price went, Mr. Bessemer had offered to supply such sizes as it was worth his while to make, at the prices stated.

Mr. E. A. COWPER begged to inquire, how it was that better iron was produced now, than when the experiments were made at St. Pancras two years ago? Did it depend on improvements in the processes of manufacture, or was it due to a more suitable ore being now used?

Mr. RILEY said, he was connected with one of the largest iron-works in Wales; he had made a great many experiments with the Bessemer process, and generally speaking, with similar results to those stated by Mr. Brown. He could do nothing with the iron made from ordinary Welsh forge pigs; and generally, the iron when rolled was exceedingly brittle and bad. With regard to the hæmatite ore, it might not be generally known, that a very large quantity of Lancashire red ore was imported into Wales; and that pig-iron could be made cheaper in Wales, with a mixture of red ore, than from the native clay iron-stone alone. The red ore was imported, principally from Whitehaven and Barrow, and the brown ore from the Forest of Dean, Cornwall, and some from Spain — the latter practically containing no phosphoric acid. The iron made by the Workington Iron Company was almost entirely free from sulphur and phosphorus, the proportion being as low as from ·07 to ·05 per cent.; but it contained a large quantity of silicon, say $2\frac{1}{2}$ to $2\frac{3}{4}$ per cent. Bessemer's process entirely got rid of this element. He had examined numerous specimens, and had not found any distinct trace of silicon. The effects of the refinery had been alluded to in the course of the discussion. He had seen white iron, containing $3\frac{1}{4}$ per cent. of silicon, blown for seven hours in the refinery, and it was not even then, what was technically called blown, as it still contained silicon. There was this difference between the finery and the Bessemer process,—that the refinery got rid, to some extent, of the phosphorus and sulphur, whilst the latter process, as far as his experience went, did not remove the phosphorus at all, and only the sulphur to a slight extent. It appeared to be a question of time, to displace

the phosphorus and sulphur, and a question of temperature as regarded the silicon and carbon. Having spoken of the intense heat of the furnaces under Bessemer's process—an intenseness which he had never witnessed before—Mr. Riley proceeded to remark upon the subject of the lining of furnaces and vessels. He found that the sand used in the balling furnaces frequently contained much clay, but upon depriving that sand of the clay, by washing, and retaining only the silicious portions, it was found that the sand lasted double the number of heats. If silica could be compressed into a solid form, it was the best material he was acquainted with for withstanding intense heat. The difficulty was in the mechanical condition of silica.

Mr. BESSEMER observed, with respect to the cost, that the average price of the metal employed to produce the specimens exhibited varied from £3. 11*s.* to £3. 15*s.* per ton. A loss of 20 per cent. upon a ton of metal would amount to 15 shillings; then there was the cost of re-melting in the cupola furnace (which was a disadvantage under which the process ought not to be placed, as the metal should be run direct from the blast furnace into the converting vessels), which might be taken at 5 shillings, making the total cost up to this point from £4. 11*s.* to £4. 15*s.* per ton. To this must be added the cost of re-lining the vessel, of the labour employed in attending the vessels, and carrying out the process, and of the blast. In the ordinary process, as many cubic feet of air were needed to refine 1 cwt. of iron as he took to make one ton of malleable iron. In this way he reckoned, that allowing for the higher price of coals in London, and the higher rate of wages paid at such establishments as the Royal Arsenal, at Woolwich, the price would reach £6. 10*s.* per ton. But he had every confidence that, it might be brought down to £6 per ton. He considered that ingots of cast-steel, or of malleable iron might be produced at the hæmatite iron-works at a net cost of £4 per ton. During the last year 970,000 tons of that ore had been raised, and he had been told the quantity could be doubled, or trebled, and that there would be no difficulty in raising a supply equal to two or three million tons a-year.

Perhaps a part of the present success arose from the workmen having acquired more experience in the process. Much had been gained by experience, the importance of which would be duly estimated by all practical men. He had already spoken of the difficulty of the rapid wearing away of the lining of the vessels, and how that had been overcome. Another source of trouble was the small charges tried at first. With a charge of 20 lbs. or 30 lbs., the metal could not be converted to steel; with a charge of 1 cwt., hard steel could be made; with 3 cwt., the quality was improved; and with 1 ton, the metal obtained was as fluid as

water, as the piece of "splash" exhibited fully testified; and the mass was homogeneous throughout. The selection of the pig-iron was the main point to be attended to. Blaenavon iron at £8 per ton was proved not to be so good for the purpose, as hæmatite pig-iron at £3. 11*s*. to £3. 15*s*. per ton. If it had been necessary to purchase the best Swedish iron, the expense would have been fatal to the general introduction of the process. But when the cheaper ore gave the better result, every confidence was felt in its ultimate success.

Hitherto there had not been much experience in the various descriptions of English iron ores, for the reason, that when his expectations were not fully realized, he investigated the cause, and found that no iron could be depended upon like the Swedish, for the manufacture of steel for cutlery. Although that might cost £7 per ton, if it could be converted into steel worth £60 per ton, it would be a profitable business. The great point, however, was to work the thing to a mercantile advantage. Having made many experiments with Swedish iron, works were built at Sheffield, and steel was now being produced daily, of the quality required by engineers and cutlers. It was not until that commercial result had been arrived at with regard to steel, that the question of the iron manufacture was entertained, and then the first attempt was made with hæmatite iron. That was found to answer so well, and was so cheap, compared with other qualities, that he had not cared to change it. There were, he believed, many other descriptions of iron, to which the process was applicable. The white carbonate of iron, the magnetic iron ores, and those of the Forest of Dean, had been made into good iron and steel by this process.

May 31, 1859.

The Session was concluded by a CONVERSAZIONE, at which the President received the Members of the Institution, and a numerous circle of distinguished visitors. The rooms were decorated with many choice works of art, and there was also exhibited a large and interesting collection of mechanical models.
