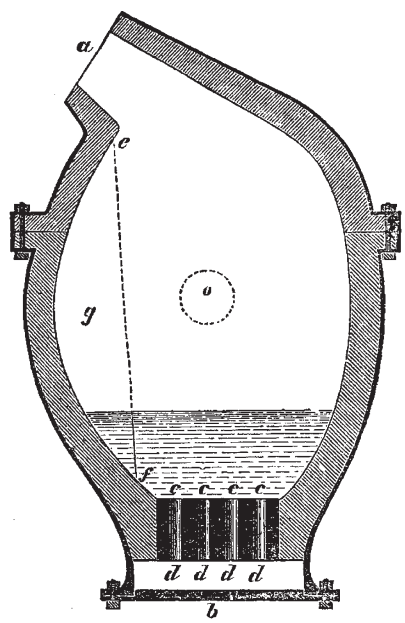
PAPERS ON IRON AND STEEL

No. II.—The Bessemer Process.

IN this paper I propose to describe the general phenomena of the Bessemer process, and then to examine the chemical actions producing these phenomena and the changes they effect in the material operated upon.

In the first place the pig-iron is melted in a suitable furnace, usually in that form of furnace known as the "cupola." The melted iron is run from this by means of moveable troughs into the "converter," which is a pear-shaped spouted vessel, lined with fire-clay, "ganister," or other refractory substance.

This pear-shaped vessel, a vertical section of which in the upright position and without mechanical details is represented in the annexed figure, is truncated at the lower end, and thus a flat circular bottom is formed. This bottom, which is readily detached and renewable, is fitted with longitudinally perforated fire-clay cylinders shown in section at *cd*, *cd*, *cd*, *cd*, each perforation or clay tube being about one-half or three-quarters of an inch in diameter,



and all communicating with the space *d d*, into which opens the blast tube from a powerful blowing engine. The number of these blast holes varies from fifty or sixty to a hundred or more, according to the size of the converter.

The converter is mounted on trunnions so arranged that it may turn on a transverse axis crossing about the middle of the vessel, as shown by the dotted circle *o*. The turning is effected by hydraulic machinery, controlled by levers readily worked by a man who stands on a platform in full view of the converter. In order to receive the charge of melted iron, the converter (the lining of which has been previously raised to a bright red heat) is turned over so that the dotted line *e f* becomes horizontal, and corresponds to the surface of a full charge. The belly *g* of the converter is so curved that it shall in this position retain the whole charge without any of it reaching the blast holes at *f*, or the mouth at *e*, and yet allow the whole charge to be readily "teemed" by turning the converter a little further down.

When the full charge is thus received in the belly of the converter, the blast is turned on, *after which* the converter is turned to the upright position, as shown in the figure, and the melted metal then stands directly over the perforated bottom. As will thus be seen, all the fluid metal above the openings is now resting upon a bed of air, and is only prevented from falling through by the blast being maintained at a pressure exceeding the falling force of the column of liquid above it. It would fall through these orifices into the blast-way and do serious mischief should the blast be stopped or slackened for an instant, or should the converter be turned upright or overcharged before the commencement of the blast. An accident of this kind but rarely happens, though it is by no means an unknown casualty.

The "blow," as it is termed, now commences; the hundred streams of air tear through the pool of melted iron, and a huge flame roars furiously from the mouth of the converter. At irregular intervals magnificent cascades of brilliant coruscating sparks are belched forth, and the dazzling spray as it dashes against the walls of the flame-shaft rebounds with redoubled splendour, each glowing globule being shattered by the shock and bursting into rescintillating fragments. The loud-bellowing blast roars on monotonously, but the flame becomes brighter and brighter continuously, and grows in length and breadth as it increases in brilliancy, until at the end of about ten minutes it attains its maximum, when its splendour is painful to the eye, and yet so fascinating that few who see it for the first time can turn their dazzled eyes away. The spark eruptions still burst upwards from time to time, and still dash against the brickwork and the ground, and still reverberate in fiery splinters, but their appearance has changed. They are now no longer red hot, or yellow hot, or white hot, but have a curious purple luminosity different from anything one has ever seen before. If it is daytime and the sun shining, the sunlight out of doors has a sickened partial-eclipse aspect when viewed directly after gazing at the flame, and at night the ordinary gas lights appear red and smoky.

After five or ten minutes' continuance of this maximum splendour, the flame is seen to contract somewhat, and presently the ponderous vessel turns a very deliberate summersault, the flame disappears, but the uninitiated spectator is startled by a new display; for as the converter rolls smoothly over, it disgorges a continuous stream of sparks which its rotation spreads out in a fan-shaped volley, extending from end to end of the building, and reaching the roof, descends in a broad sheet of fiery hail. This is the transformation scene which concludes the first part of the performance; for now the dazzle of the flame and the roar of the blast ceases, and a general lull intervenes.

The trough from the cupola is now swung round to the mouth of the converter, a red glow is seen to creep along it, and starry sparks dance above as it advances. This is the spiegeleisen coming from its cupola by the same path as conducted the main charge. The spectator should now change his position, and if possible find a standing place from which he may look into the mouth of the converter. At first he will distinguish nothing but a yellow glare, but by steadily fixing his gaze, he will presently, and rather suddenly, distinguish the surface and limits of the pool of melted metal. He will see that as the spiegeleisen pours into it, a furious ebullition takes place. At the same time a great mass of pale blue flame issues from the mouth of the converter, but with a quiet, leisurely waving that contrasts curiously with the previous roaring jet of white flame. This flame has but very little intrinsic luminosity, yet at night it lights up all the surrounding objects with a singular brilliancy, a sort of exaggerated theatrical moonlight effect, which is the most remarkable to a spectator outside, who on a misty night sees the long streams of ghostly light pouring through every opening of the building in pallid beams, that under favourable conditions may be traced for above a quarter of a mile. I have seen them projected in bright

discs upon the face of low clouds, and visible through the whole of their intermediate course.

When the flow of spiegeleisen has ceased, the trough is moved aside and a large counterpoised arm bearing the "ladle" is swung round upon an hydraulic piston, which forms at the same time its axis and lifter. The ladle, a large lined iron pot, is adjusted under the mouth of the converter, which is now tilted a little more, till the melted metal is poured out in a thick brilliant white-hot stream accompanied from time to time with great slabs of cinder of a darker colour which float upon its surface as it pours, and form a thick scum covering the contents of the ladle. When all the fluid metal is poured into the ladle, the converter is tilted over till completely inverted, and the remaining viscous mass of cinder drops out in a glowing heap upon the floor.

During these proceedings a set of workmen have been preparing the moulds in which the ingots of steel are to be cast. These moulds are of cast-iron, nearly cylindrical, being larger at bottom than top, and open at both ends. They have lugs or handles at top by which they are lifted. They stand upon a tile, and are well packed round the bottom with sand to prevent the outflow of the melted steel. While the blow was proceeding these were arranged in an arc of a circle whose radius exactly corresponds with the length of the arm bearing the ladle.

The ladle is now swung round and adjusted till it stands directly over the first of this row of iron vases, and a plug is released by which a hole in the bottom of the ladle is opened. Through this the steel is poured into the ingot. When the first is filled the plug is closed, the ladle swung round to the second mould, and so on, till all the steel is thus cast into ingots, the size of which varies with the kind of work for which the steel is required. A thin steel plate is placed on the top of each casting immediately the mould is filled, and over this a bed of sand is placed, and speedily and firmly pressed down.

As soon as the ingots have solidified, and while they are still glowing, the moulds are lifted off them by means of an hydraulic crane, and afterwards the ingots are picked up by tongs attached to the same machinery, and are carted away, all red hot, to the hammer-shops, where they are thumped and rolled or otherwise tortured into their required forms of rails, tyres, plates, &c.

The above are the leading phenomena of the Bessemer process; the chemical actions producing them, and the changes wrought in the pig-iron and spiegeleisen, will be treated in another part of this paper.

W. MATTIEU WILLIAMS

NOTES

OWING to Mr. Lockyer having been summoned to Malta to give evidence at the court-martial on the commander of the unfortunate *Psyche* (which we regret to hear has not been saved), we are unable to give a detailed report of the proceedings of the Sicilian Eclipse Expedition. We understand that Mr. Brothers, who was stationed at Syracuse, obtained five photographs of the Eclipse during totality. One of these shows the corona "as it was never seen on glass before." At Augusta very little was seen; but at Syracuse, the southernmost station of all, the clouds which concealed the earlier stages of the Eclipse, passed away from the sun about five minutes before totality, "disclosing," writes Mr. Brothers, "a scene I shall never forget." Next week we shall hope to be able to give a complete account of the results of the Expedition, and their bearings on any increase of our knowledge of Solar Physics.

PROFESSOR CARL GUSTAV BISCHOF, who died at Bonn on the 29th of November last, was equally distinguished as a chemist and a geologist. He was born in 1792, near Nüremberg, in Bavaria, and was consequently at the time of his death in his seventy-ninth year. In 1810 he entered the University of Erlangen, where the lectures of Prof. Hildebrandt induced him to devote his study to chemistry and physics. In 1816 he succeeded to his master's position, and brought to a conclusion his "Lehrbuch der Chemie." In 1822 he removed to Bonn, in which University he occupied the position of Professor of Chemistry from that time till his death. Shortly afterwards, however, he began to pay more attention to subjects connected with chemical and physical geology, publishing a large number of treatises of sterling merit, an enumeration of which is given in the *Geological Magazine* for January. In 1841 his "Physical, Chemical, and Geological Researches on the Internal Heat of the Globe," were published in London, and in 1854 an enlarged translation of his "Lehrbuch der chemischen und physikalischen Geologie," was issued by the Cavendish Society. He was a Foreign Member of the Geological Society of London, and had received from that body the gold Wollaston medal.

THE following courses on Anatomy and Physiology at Cambridge are announced for this term:—Zoology and Comparative Anatomy, three days a week, by Prof. Newton; Anatomy and Physiology, three days a week, by Prof. Humphry; Practical Anatomy, three days a week, by Prof. Humphry and Mr. Carver; Practical Histology, by Mr. Martin, under the superintendence of Prof. Humphry, once a week, with a Microscopical Demonstration once a fortnight; Physiology, three days a week, by Dr. Michael Foster, with Practical Instruction in the Physiological Laboratory daily.

PROFESSOR P. M. DUNCAN will shortly commence a course of Lectures at King's College, London, which is open to the public, and to those who are going in for examinations. It will comprise ten lectures on the Principles of Biology in its relation to the Succession of Life on the Globe, five on Astronomical Geology, and the rest on the Principles of Geology. The course will open on Saturday, Jan. 28, at 11.30 A.M., and will be continued through the Lent, Easter, and Michaelmas terms.

DR. E. SYMES THOMPSON will deliver two lectures at the Gresham College, Basinghall Street, "On the Circulation of the Blood," on Saturday the 14th and Monday the 16th of January, at seven o'clock, which will be free to the public. It is proposed next term to continue the course "On the Organs of Respiration and Circulation in Health and Disease."

IN answer to several inquiries, we may state that the penny lectures delivered at the Hulme Town Hall by Prof. Huxley and others, to which we referred last week, are published by Messrs. Heywood, of Manchester.

WE stated in our last number the lowest temperature recorded at Blackheath during the recent frost to have been 15·3° F. on the night of December 24. More recent tables published in the *Gardener's Chronicle* give the minimum as 9·8° on the 25th. From December 22nd to January 4th the temperature at Blackheath ranged between 6·9° below the mean of fifty years, on January 4th to 18·7° below the average on December 25th. The minimum above mentioned occurred at 7 A.M. on Christmas Day, being lower than any temperature since the morning of Christmas Day 1860, when it was 8°. In the midland and eastern counties, where the cold was most severe, it is feared that much injury has been done to vegetation, especially to the evergreens. In Paris the frost has been equally intense. In a paper recently read before the French Academy of Sciences, it was stated that during December the temperature only rose above the freezing point on nine days. In the fifty years from 1816 to 1866 the average temperature for the month of December has been 3·54° above zero C. or about 38° F. The average temperature of this last December has been 1·07° below zero C. or a little above 30° F.