SHEFFIELD STEEL.

FOR making the best steel the best iron is imperatively demanded, and for this purpose Swedish charcoal iron is generally used.

The cementing furnace is a cupola or dome-like structure, externally resembling a glass-house, and forming a characteristic feature of the gloomy landscape of Sheffield. The lower part (with the upper or conical chimney cut off) is shown in the diagram, where *f* is the ash-pit of the fire-place, the bars

A SHEFFIELD STEEL CHEST.

of which are shown endwise, just above the letter *c*; *c* are two "chests," or converting pots, shown in section. These are made of firebrick or firestone, and supporting over the fire with flues so arranged that the heated smoke shall pass up the arched space between them, and travel below them and around their outer sides, thus heating them as equally as possible. The smoky flame and heated air from the fire after traversing these flues rises into the arch, *a*, which is heated, and radiates downwards; then they slowly escape by the short chimneys on each side of the arch into the great cavity of the conical dome. The main object of all this is to steadily heat the chests with a slow-burning, semi-smothered fire, that shall yield reducing rather than oxidizing products of combustion. If there were a strong draught, the combustion would be too vivid for this, and there would be great waste of fuel by the carrying away of the heated gases too rapidly, and before they had done their work.

The chests, which are 10 to 15 ft. long, $2\frac{1}{2}$ to 3 ft. deep, and about the same width, are charged with 12 to 18 tons of bars, corresponding in length to that of the chests, and usually 3 in. wide and $\frac{1}{2}$ in. thick. The charging is conducted by first spreading on the bottom of each chest a layer of coarsely ground charcoal—that from hard wood preferred—about two inches thick, then a layer of bars with $\frac{1}{2}$ to $\frac{3}{4}$ in. space between. Over these, and into the interspaces, a layer of charcoal is sifted until about 1 inch deep above the bars. Then another layer of bars and charcoal, so on up to about 6 in. of the top. Then old cement powder (that is, the charcoal already used) and grinders' waste, or "wheels waif," is moistened, and plastered over this, and the whole covered with damp sand or clay to exclude the air. The man-hole is now stopped, but some long trial bars are left protruding from the "tasting" holes.

The furnace is maintained at a glowing red or yellow heat for eight or ten days, and the trial or tasting bars are occasionally withdrawn for inspection. The progress of the cementation is ascertained by the blisters on these, and by fracture. When the carbon has sufficiently penetrated to the centre of the bars, the furnace is allowed to cool slowly. This occupies about another week.

The bars, when removed from the furnace, have their surfaces covered more or less completely with blisters, and the steel thus formed at this stage is called "blistered steel." Chemical examination shows that the iron has combined with carbon, that the quantity of combined carbon is greatest at the surface, but some of it has penetrated to the middle of the bars. The workman determines the penetration of the carbon by the grain or fracture, for the bar-iron during the cementation process loses its fibrous structure, and acquires a very fine granular or minutely crystalline structure, which is revealed by the fracture.

That the carbon should actually penetrate these solid bars of iron in this manner is a very remarkable fact. The experiments of the late Dr. Graham, demonstrating the permeability of iron and other metals, especially when heated, to certain gases, assist in explaining the phenomena of cementation, especially as it is found that a certain quantity of hydrocarbon, or cyanogen, or other carbon compounds which become gaseous at a red heat, materially assists the cementation. The use of cyanides in steel-making—one of the profound secrets of the trade, well known to all concerned—supports this explanation.

A SHEFFIELD STEEL HAMMER.

The usual explanation is that the surface of the bar first obtains, by direct contact with the charcoal, a large dose of carbon; that this superficial film then passes on a portion of its carbon to a film within, and simultaneously regains what it gave up, from the superficial carbon, as at first. Then the second film transfers some of its carbon a stage deep, and re-absorbs a compensating amount from the outside film, and so on deeper and deeper, the carbon travelling by a sort of convection until the centre is reached.

However this may be, the outside of the bar being harder and containing more carbon than the interior, and the bars being unequally charged with carbon, both as compared with each other and in different portions of their length, it becomes necessary, in order to obtain uniformity of composition, to mix these varying portions together. The most obvious method of doing this is to cut the bars into small pieces, mix them well together, and melt them. This is done in the manufacture of the best quality of British steel, the "cast steel," or "pot steel," of Sheffield. It is, however, a costly process, in consequence of the high temperature required and the consumption of fuel and destruction of crucibles. As only small quantities are melted at one time, the

labor charges are also high upon every ton of steel thus melted.

So great is the destruction of crucibles, that in and around Sheffield garden walls and other structures are commonly built of old pots instead of bricks.

This process of melting is applied to the hardest or most highly carburized steel for two reasons. First, that such steel should combine hardness and toughness in the highest degree, and consequently must be homogeneous; and secondly, because it is more practicable with hard steel containing the most carbon, as this is the most fusible.

Although this is the best means of rendering steel homogeneous, it is not the only one available. A cheaper method is practised very extensively, in the manufacture of softer second-class steel. The cemented bars of blister steel are cut into short lengths, then packed together in bundles or "faggots;" these are raised to a welding heat, then hammered out with a tilt hammer striking 300 to 400 blows per minute, so rapidly that the heat of the faggot is maintained by the percussion. This bundle, thus welded into one piece, is rolled into bars, sheared, re-faggoted, and re-tilted. Steel thus treated is called "shear steel," "single shear," "double shear," etc., according to the repetition of the process.—Prof. W. M. Williams.

CATALAN STEEL BLOOMERY AND BLOWING APPARATUS.

CATALAN STEEL BLOOMERY.

By Prof. M. W. WILLIAMS.

STEEL made directly from the iron ore was the primitive method. In the ancient bloomeries, where pure oxides and charcoal fires were used, most of the iron contained enough carbon to come under the modern definition of mild steel, and some of it sufficient to form hard steel. It was merely a matter of more or less blowing, and varying proportions of ore and fuel, whether iron, semi-steel, mild or hard steel was produced. The same is still the case with the primitive iron workers of India, Burmah, Borneo, Africa, China, Madagascar, etc.

The Catalan, or Corsican, furnace, which is still used in the south of Europe, especially in the neighborhood of the Pyrenees, demands some further description. It is shown in the diagram, where *f* is the hearth, or furnace, in which the ore is reduced. The bottom of this is made of a sandstone capable of standing a great heat, and is lined with a coating of charcoal dust. A pile of ore—usually rich hematite—is placed on the hearth, and heaped up over the curved wall opposite the tuyere; and this portion is arranged to lie parallel to this curved wall. The hearth is then filled up with charcoal and covered over with "greillade," that is, charcoal dust and small ore moistened and matted together. A gentle blast is applied at first, and when the flame bursts through the coating of greillade more is laid over it to check or damp the combustion, and prevent the heap of ore piled over the curve from falling in too soon. This is continued for about two hours, then the blast is turned on fully, and the cinder tapped out. The ore that was piled on the curved wall is then pushed down gradually as the lower portion is reduced, and this is continued until the whole is reduced and a mass of spongy iron formed. The bloom thus obtained is then drawn out, hammered, and rolled with very primitive machinery. Some skilful management is necessary in order to flux away the silica; this is done at the expense of the iron oxide of the ore.

Here, then, we have a miniature blast furnace, wherein the operation is stopped at the reducing zone, and the spongy iron is taken out before the absorption of impurities and subsequent fusion occurs. Steel, or hard steely iron, is usually and most easily produced. In order to obtain soft iron a greater inclination is given to the tuyere, and the blast is increased. A charge of 8 or 9 cwt. of ore, containing 45 per cent of iron, yields about 33 per cent of iron; and about three tons of charcoal are used for every ton of finished iron produced. If this process were used in England, with charcoal at 50s. per ton, the cost of fuel alone would be £7 10s. per ton of iron, besides very high charges for labor.

The American or Canadian bloomery is similar. It is used in Vermont, Quebec, etc., but with a hot blast and a consumption of about $\frac{1}{2}$ of charcoal to 1 of finished iron.

The blowing apparatus of the Catalan bloomery is a very interesting contrivance. It is called the "trompe." It is

available in mountainous countries where streams of water, pouring from high levels, are abundant. An upper tank *a* is erected on a ledge of rock, or other convenient place, with one end overhanging, as shown in the diagram, where this end is supported by a tree trunk. Connected with a large hole in the bottom is a wooden tube with oblique openings in its side at *b b*. This tube connects with the top of a lower tank *c*, which has an outflow opening at *d*, and which at its upper part communicates with the tuyere (made of copper) at *e*. This tank is otherwise closed and air-tight. At *a* in the upper tank is a plug that can be raised and lowered by a lever to regulate the flow of water into the descending wooden tube.

When the water is allowed to flow down this tube, its velocity is of course accelerated as it descends. This acceleration divides the column of water, and the spaces between must therefore become more or less vacuous. In consequence of this, air rushes in at *b b*, and is dragged down by the descending water, and can not return on account of the resistance offered by the fallen and broken water, which enters the lower tank by an opening suddenly contracted by the ledge shown above *d*. Thus there is a continual inflow of air as well as water to the lower tank, and a consequent pressure of air which produces a blast through the tuyere. The pressure is regulated by the quantity of water allowed to fall through from the upper tank, and may be increased until it is so great as to overcome the falling water and drive itself back again up the tube. When the inflow and outflow of water at the lower tank are equal, the blast remains steady; when the inflow is in excess its pressure increases, when less it diminishes. One defect of this arrangement, otherwise admirable, is that the air of the blast is supersaturated with water, and even carries some spray. The ascending chamber at *e* allows much of the spray to settle down before entering the tuyere.

IMPROVED GALVANIC BATTERY.

THIS arrangement of a galvanic cell by Messrs. J. C. and G. Fuller, of Fenchurch street, London, has for its object the improvement of batteries as regards their constancy and regularity of working. Hitherto, according to the inventors, it has been usual to employ a bath of mercury into which the zinc plate is so far inserted as to admit of capillary action taking place on the surface of the zinc plate; nevertheless, irregularity in the power and rapid diminution of the same take place, so that this means does not completely fulfil the object aimed at. This invention, however, improves the regularity and prolongs the lasting power of the battery by the employment of a column of mercury contained in a porous diaphragm or cell, into which the zinc plate is plunged. In the figure, which is a sectional illustration of the new cell, *A A* are the poles of the battery; *B* is the outer vessel, in which it has hitherto been customary to place the mercury and the zinc plate; *C* is the porous diaphragm or cell in which is placed the mercury or amalgam of zinc, and the zinc plate or any other conductor standing in the mercury or amalgam.

In order to further improve the constancy of the battery the inventors prefer to, more or less, cover any part of the zinc plate or other conductor which is not required for chemical action, with a coating of any suitable insulating material, and thus protect the zinc against the exciting fluid of the battery. *D* shows the insulation of the zinc (or other conductor). The uninsulated portion of this zinc plate is inserted in the mercury or amalgam, only so far as is found to be necessary for the perfect action of the battery. *E* shows the mercury or amalgam in

NEW GALVANIC BATTERY.

the porous cell, while *F* is the exciting fluid of the battery. The invention may, it is stated, be varied in its details to suit the requirements of any form of galvanic battery; but it is specially useful when applied in conjunction with bichromate of potash dissolved in sulphuric acid and water.

TO RE-VARNISH NEGATIVES.

FOR the benefit of those who wish to remove the varnish from negatives the following plan, which has been highly recommended, is offered:—Pour a saturated solution of two parts of alcohol to one part of cyanide of potassium over the plate and keep moving it about until the varnish dissolves, which it will soon do. Wash and dry the plate, then re-varnish and treat as a new negative. This method is said to be superior to the alcohol bath, ammonia and alcohol, potash and alcohol, or even alcoholic vapor; but if the negative have been intensified with chloride of mercury the cyanide of potassium must not be used.