bent pipe *h*1 *h*2 conveys the air into a second longitudinal pipe *h*2 *h2*, by which the stream of air returns back to the end of the oven at which it entered, and is conducted by a second bent pipe *h*3 *h*3 into the third tubular vessel *h*3 *h*3 in which it is for the last time exposed to the heated metal, and passes off from the heating oven into the smelting fur­nace, by the hot air pipe S, whence, as formerly, it is dis­charged through the twyre into the hearth of the furnace. The fuel is placed through the door D upon the fire of the oven on the bars *r*, and by means of a number of small pigeon holes *ccc, ccc, ccc,* is spread over the whole length of the pipes with some measure of uniformity, whereas, if allowed to act directly on the retorts, it would irregularly and less effectually heat their surface. The manner of protecting the retorts from the direct action of the fire, is well shown in the transverse section : a brick arch *aaa* is thrown over the fire, and the flame is only permitted to ascend through the aforesaid openings *cc, ce.* It will be noticed that the retorts are every where clear of the building and of each other, that they are wholly enclosed by the oven Ο Ο O ; and it will also be seen in the transverse section, and in the lon­gitudinal section, that the products of combustion are car­ried off by a descending flue *ff* regulated by a damper *ee,* into the short vertical chimney C. This damper is very use­ful in retarding the draught of air, so as to leave the products of combustion a longer time in contact with the heaters.

This apparatus is more effective and more durable than the last. It raised the heat of the air as high as 400° to 500°, being 200° higher than the former plan, as indeed we should expect from the greater number and length of the vessels, and the greater surface in contact with the air. The result, compared with the last, is as follows :

By the former plan with air at 240°,

3 tons of coal were required

to melt 1 ton of iron.

By the improved plan, with air at 400° to 500°,

213/20 tons of coal were required to melt 1 ton of iron.

The reader will not fail to be struck with the fact, that a much greater gain was obtained by the original ruder plan of using the air, when compared with the old sys­tem of hot-blast, than was afterwards got from the introduc­tion of the improved apparatus over the former one. The higher temperature does not appear to have conferred an ad­vantage at all proportionable to the increased temperature.

Fig. 4 is a very superior and durable heating apparatus, which continues in efficient use to the present time. Its form is well adapted to prevent all the evils of expansion and contraction ; and it is our opinion that by multiplying the vessels, a more effective apparatus might be made than any now in use. Its form is very ingenious, and its functions may be easily learned by studying the figure, in which the letters describe the same parts with those of the previous figures. B is the pipe coming from the blow­ing apparatus to the heating furnace OO OO ; S is the hot air pipe, proceeding from the heating oven to the smelting furnace; h1 h1 h1 is a large retort into which the air is at first carried, and from the further end of which a malleable iron tube *i1i1*, concentric with the retort, carries it back again to that end where it first entered, and through a bent pipe II conducts it along by a second interior tube *i2i2* to the further end of the second heater *h2h2h2*, along the hot surface of which it returns in the manner shown by the ar­rows to the base of the second retort : now, this second re­tort communicates at the base with a third *h3* *h3,* and after traversing its heated surface to the end, is brought back by a tube concentric with the axis to the base of the retort. This process might be continued with great advantage, and make one of the best series of heating vessels. The fire is covered by arches *a a a,* with small apertures *ccc,* as in the former case, to prevent the vessels from being injured by the local action of the intense fires.

This apparatus raised the temperature to between 500o and 600°, and produced a further saving in coals. By the former plan 213/20 tons of coal were required to smelt one ton of iron. By this improved apparatus, 210/20 tons of coal melted a ton ofiron.

Figs. 5 and 6 are the general forms of apparatus now most extensively used. Fig. 5 is a form first given to the apparatus, we believe, by Mr. Dixon at Calder, and hence generally called the Calder pipes. Similar pipes were also early introduced at Gartsherrie, and at Wedensbury ; and are very generally approved of from their extensive heat­ing surface, although they are liable to the inconvenience of cracking, from unequal expansion. The form, as erect­ed at Butterly, consists of two parallel horizontal pipes L L called technically “ the lying pipes,” one forming a communication immediately with the cold-blast pipe B, and the other with the hot-blast pipe S. Into sockets formed in the lying pipe, are inserted a series of smaller pipes springing up at right angles with the one lying pipe, and after forming an arch, returning down to the second lying pipe, being inserted In like manner into sockets in it. The air, therefore, on entering the first lying pipe, is forced through these transverse heating pipes, or “ A pipes” as they are call­ed from their figure, and thus exposed to the heat of a very extensive surface, is delivered into the hot-air pipe. Some­times, as at Gartsherrie and many other works, there are se­veral times as many pipes as in this example, and the air is made to cross and recross the fire several times.

The figures of the transverse pipes are as various as the taste of the parties who use them. Sometimes they rise up and form a large semicircular arch over the fire, which is placed in the centre ; sometimes a double tier of such arches is employed. Sometimes they cross the fire in the form of a pointed arch variously acuminate. Then again by some, the pipes are carried up four, six, eight, or ten feet, like columns, united at the top by a semicircular arch.

The cross section of the heating pipe is as various as the form into which the pipe itself is made to bend. A circular pipe was used at first, then a flattened elliptical one for the purpose of exposing more surface in proportion to volume ; next a pipe, flat at one part, and semicircular on the other, was introduced ; next a pipe of a cardioid or heart-like sec­tion was employed. At Butterly Mr. Terrop used a circu­lar pipe cast with a solid core, to keep the air near the hot surface, as shown in the figure ; and finally, he employed the rectangular section as shown in our figure 6th. All of these appear to answer their purpose of heating the air sufficiently well, and all of them cause trouble and expense by cracking now and then.

The result of all these forms is to produce a hot-blast of more than 600° temperature, and at Butterly, figs. 5 and 6 yield as follows : 21/3 tons of coal melt one ton of iron. It is found, however, at Butterly, that pigs, for the forge, require about three cwt. less of coal than this average quantity, and that No. 1 iron requires about three cwt. more than this, as we should expect.

The Scotch use less coal than the Butterly Company, principally on this account, that the former use calcined ore, of which thirty-two cwt. with seven cwt. of lime, makes a ton of iron, while at Butterly, the quantity used for a ton of iron is 23/4 tons, with a ton of lime, being 33/4 tons of materials in one case, and less than two tons in the other.

The explanation of the principles from which hot-blast derives its efficacy as the means of producing elevated tem­perature, is very easy and plain to any one acquainted with the elementary principles of chemistry and mechanics. All that we think it necessary to add on this subject, we shall state in the words of Mr. Babbage and Dr. Ure.

“ The increased effect,” says Babbage, “ produced by thus heating the air is by no means an obvious result ; and an analysis of its action will lead to some curious views repecting the future appli­cation of machinery for blowing furnaces.

“ Every cubic foot of atmospheric air, driven into a furnace, con-