and that he left this to be done by the Englishmen. In any case, Reaumur seems to have preferred the use of a mixture of chalk or of calcined bones, and not red ore, for decarbonizing the metal.

The pig iron used in the manufacture of malleable cast iron must be free from phosphorus and sulphur. The best materials are hence Swedish and Styrian pigs, made with charcoal from the purest ores. The last kind is used in the southern parts of Germany, but its price makes it impossible to employ it in England or even in northern Germany. The most usual material is hence pig iron made with coke from the hematite ores of the Cumberland districts. A small proportion of Swedish pig is sometimes, but probably very rarely, added. The pigs with the whitest fractures are preferably employed for larger castings, and those with a grayer fracture for smaller articles. As is usual in these cases, the proportions of the mixtures used are made a mystery by the different makers, but there can be little in this, as different establishments use pigs with different brands and varying mixtures. The principal thing is evidently to have as little phosphorus as possible. Some yeas ago a patent was taken out in France for mixing in the crucible from two per cent to seven per cent of red copper with the cast iron intended to be made malleable, in order to give it more fusibility, and to obtain castings with a better surface. We are not aware, however, whether this plan has been much adopted.

The pig is usually melted in crucibles, sometimes of plumbago, and holding about fifty or even sixty pounds—the usual size of steel crucibles—which, in the ordinary method of pouring out by hand, is determined by what an ordinary man can lift. The crucibles are covered up, in order to prevent the access of impurities from the coke, with a consequent waste in skimming the fluid metal. As with the crucibles, the furnaces used are generally those employed in melting pot steel, being from two to three feet square, and holding four crucibles. No blast is used, as the resulting saving in time would be counterbalanced by the increased consumption of coke In this part of the process the principal point is to attain as high a temperature as possible for pouring the metal into the mold. The melter mostly tells this by dipping a red hot iron bar into the crucible, on withdrawing which the fluid iron should spring off in sparks. The crucible is then taken up by a pair of tongs, and, after skimming the surface of its contents, it is emptied as quickly as possible.

The molds are made in green or in dry sand in the usual manner, but great care has been taken with the small and complicated details, the molding of which forms the most economical application of malleable cast iron. These are best cast together and broken off when cold. With heavier and more complicated castings it is very important carefully to determine where to place the feeders for forming, so to speak, reservoirs for holding the extra fluid metal intended to follow up the shrinkage. If this be neglected, small cracks are produced, which are completely visible under the subsequent operation of annealing. Such feeders must not be placed at any sudden changes in shape of the casting, such as at any corners—*e. g.*, at the pins cast on levers, and so on. The castings produced are remarkably brittle, and many wasters are produced in cleaning them. This operation is best done when they are thoroughly cooled down. To delay this till after the annealing process would of course be attended with the obvious difficulty of having to deal with a tough, mealleable material. It is also important to take the castings out of the molds as soon as possible, in order to avoid the production of cracks, as the shrinkage in cooling is considerable. In fact, almost double the usual allowance for shrinkage must be made in the patterns, though this sometimes varies, as might be expected, with the mixtures employed. The molding boxes are either set quite vertical or at a considerable inclination. The first position is always employed with smaller castings. The moulding should be done very neatly, in order to save as much as possible any cleaning after annealing.

The last and the most important, difficult, and expensive process is decarbonizing or annealing the castings. They are placed, together with powdered hematite or red ore, in cast iron cases or muffles, and kept at a high temperature for a long time. These boxes, cast with sides about an inch thick, either have covers or are piled in the furnace one above another, any openings or cracks being luted with clay. Only round muffles were used at one time, but square boxes are now employed. The castings are packed in these boxes with alternate layers of hematite ore, which is placed so as to form both the bottom and the top layer. In packing the boxes with hematite care must be taken that thin and thick castings do not come together. The boxes containing the larger ones must also be set in the furnace nearest to the fire, and those with the smaller articles in the hinder part. If this is not done, in the first case the smaller castings are burnt, and in the second the larger ones get only half decarbonized.

The decarbonizing furnace is simply constructed; the grate is in front, and the fire gases are induced between the boxes placed in the hinder part of the furnace. Or they may consist of square chambers with an inlet at the side from a door for charging and discharging; and with a bottom divided into longitudinal rows, between which are placed two or three narrow gratings extending the whole length of the furnace. The flues open from two places in the roof. A damper at the side serves to watch the firing, which must be done with great care and any access of air to the castings prevented. On lighting the fires the temperature is raised to a bright red at the end of twenty-four hours; this heat is then regularly kept up for three, four, or even five days, according to the size of the castings and the amount of annealing it is wished to give them. At the end of that time the fire is allowed to fall and the temperature to diminish during twenty-four hours; when the furnace can be opened and discharged. The boxes are then unpacked and their contents cleaned. The annealing operation is a very delicate one. With too high a temperature, should the hematite be not mixed with a sufficient proportion of previously used ore, or should the air make its way in, the castings are most likely burnt. An unequal or a too low temperature has for result an imperfect decarboniztaion and brittle castings. The most considerable expense in this manufacture consists in the