the calcination, which is completed in twelve hours, when the charge is withdrawn. The sulphur dioxide produced in this case escapes into the atmosphere; but the poorer "cupreous sulphur" ores of the 1st class are calcined in the automatic calciners of Herr Gerstenhoffer called patent calciners, when the sulphur dioxide formed is carried by the air currents into the sulphuric acid chamber, and thus used for the manufacture of that acid.

Second operation—

MELTING OF THE CALCINED ORE, ETC.

The charge, 42 to 46 cwts., consists of a mixture of the calcined ore and a proportion of the sulphide ores of the 2nd class, that do not need calcining, and metal furnace slag ("sharp slag"), containing about 3 per cent. copper.

It is melted in a reverberatory furnace called "ore furnace" for about six hours, whereby a regulus, or matte, called "coarse metal" or "ore metal," is produced, carrying from 30 to 35 per cent. copper: and a slag ("ore furnace slag"), composed of silicate of iron and earthy bases, and containing from one to three-tenths of one per cent. of copper.

The metal thus produced should not contain more than 35 per cent. copper, since that would mean a small proportion of sulphide of iron (Fe S), which would be likely to have oxidized copper in the slag; and not less than 30 per cent., if possible, since that would not be economical.

Third operation—

CALCINATION OF THE COARSE METAL.

The charge, four tons of the crushed metal, is calcined for from 24 to 36 hours at a low heat in a reverberatory calciner. The object of this is to oxidize the sulphur combined with iron, and the iron itself, leaving cuprous sulphide ($Cu_2 S$) untouched; this point, however, may not be reached, or may be overreached in actual practice. Some sulphate of copper ($Cu S O_4$) is unavoidably formed in this operation. If the calcination be very imperfect it can be corrected in the 4th operation.

Fourth operation—

MELTING OF THE CALCINED COARSE METAL

In the metal (reverberatory) furnace, mixed with certain proportions of rich ores of the 2nd, 3rd and 4th classes, rich copper slag from the 5th and 6th operations (roaster and refinery slag), copper scale and siliceous matter, called "cobbling," i.e., old pulverized bricks from furnaces (foul).

Result—A rich metal (matte) whose copper per centage varies according to circumstances from, say, 55 to 80 per cent. These products are classified into red, blue, white and pimple metal; red, from 55 to 65, blue, from 65 to 72, white, from 72 to 78, and pimple, from 78 to 80 per cent. copper. Of course there may be every grade of quality between these estimates.

The percentages can be judged, however, by a practised eye to within 1 or 2 per cent. The slag from this process contains about 3 per cent. copper as silicate of copper. It is also rich in oxide of iron and is charged into the "ore furnace," as mentioned above, when the oxide of iron acts as a flux and the silicate of copper is reduced to sulphide of copper.

Fifth operation—

ROASTING.

The pigs of fine metal, red, blue, white or pimple, as the case may be, are piled up loosely in the roaster furnace and heated with a gradually increasing heat, the current of air rushing through at the same time. The metal, as it melts and drips, called "sweating down," passes through the current of air and is oxidized; sulphur to sulphur dioxide ($S O_2$); copper to cuprous oxide ($Cu_2 O$); the oxidation occurs only on the surface of the drips, so when the whole charge is melted we have really a mixture of cuprous sulphide and cuprous oxide, when the reaction occurs–$Cu_2 S + 2 Cu_2 O = 6 Cu + S O_2$, the gas, $S O_2$, escaping through the melted charge, causing ebullition, thus bringing further quantities of $Cu_2 S$ in contact with the air, and meanwhile metallic copper collects at the bottom. Metallic copper, however, is able to dissolve limited quantities of $Cu_2 S$ and, therefore, when the whole charge becomes metallic the same reaction continues, but slower. If tapped at this point the reaction occurring in the pig before setting produces pimples on the surface, and is known as "pimple copper." If, however, it is allowed to work a little longer in the furnace less $Cu_2 S$ will be contained when tapped. Now the reaction, occurring so slowly, will not produce pimples, but raise the chilled crust into blisters; such copper is known as "blister copper."

Sixth operation—

REFINING.

About 10 tons of either pimple or blister copper is charged into the refinery furnace and sweated down; this oxidizes the large exposed surface. When melted down oxidation is continued by flapping, i.e., beating the copper with a rabble-like tool, so as to expose fresh surfaces of the copper to the air. The object of this oxidation is to oxidize and slag off impurities, such as iron, arsenic, antimony, phosphorus, and sulphur as a gas ($S O_2$). But in separating these the copper is oxidized, as well, to cuprous oxide. The bath of metallic copper dissolving it as produced; by and by the point may be reached when metallic copper will dissolve no more cuprous oxide; further oxidation of copper would slag copper itself. This pitch of the copper is called the "dry." A ladleful is taken out and allowed to set, when, if it be "dry," a depression or furrow on the surface is formed; it is brittle and has a brick-red fine granular fracture. The slag is now removed from the surface and anthracite coal is thrown upon the charge, and a green pole is plunged beneath the surface. The water of the pole produces steam, causing great disturbance, thus bringing fresh surfaces to the action of the carbon of the anthracite as well as the pole itself; this oxide of copper is reduced to metallic copper ($2 Cu_2 O + C = 4 Cu + C O_2$).

At the Hafod Refinery, however, instead of anthracite, short pieces of green wood, about 3-foot lengths, are invariably thrown upon the charge of molten copper to prevent further oxidation.

In reality the impurities are not perfectly removed. The copper, on being perfectly reduced, is not "tough" and malleable in consequence; by an excess of poling this condition is brought about, the copper is then said to be "overpoled."

The fracture of such copper would appear brass-yellow in color and coarsely fibrous.

The presence of certain quantities of cuprous oxide corrects the effect of these impurities, so the poling is carried only to that point where sufficient oxide of copper is present to balance the iron, arsenic, etc. This being now called the "tough pitch."

If that pitch should be passed, it is restored by giving a little air. The refiner decides by taking a "test,"