being used with success. A vertical truncated perforated cone of thick sheet-iron serves for the reception of the ore. This cone is enclosed in a similar cone of iron, which terminates in a detachable deep iron basin below, and is provided with a tightly fitting lid. All tho joints in this outer shell are steam-tight. The inner cone having been charged and the lid secured, steam of sufficient pressure to ensure a temperature of from 125° to 135° C. is blown into the apparatus, which soon causes the sulphur to melt and collect in the basin below. After from 30 to 50 minutes, reckoning from the time when the above temperature is reached, the operation is completed. The steam is then turned off and the sulphur made to run from the basin into a receptacle beside the apparatus, to be cast into sticks or cakes. The iron basin is then detached, and by turning aside an iron damper which held the ore in its place the exhausted ore is made to drop into a pit. Each charge of ore amounts to about from 251/2 to 261/2 cwts., containing about 385 lb of sulphur. Of this some 360 lb are recovered as saleable sulphur, at the ex­pense of about 286 lb of oak-wood as fuel.

R. E. Bollmann in 1867 proposed to extract the sulphur by means of bisulphide of carbon. The process, after having been tried at Bagnoli near Naples and given up as hopeless, was intro­duced in 1873 in Swoszowice near Cracow under the guidance of Winkler and has proved a success. The apparatus is constructed so that the bisulphide used in the process of extraction is recovered by distillation ; the loss of bisulphide amounts only to one-half per cent., sometimes to less, and the sulphur produced is very pure. But by far the greater part of the purer qualities of commercial sulphur is produced from Sicilian calcarone sulphur by distillation, which removes the 3 per cent. or so of earthy impurities contained in it. The following apparatus (invented originally by Michel of Marseilles and improved subsequently by others) enables the manu­facturer to produce either of two forms of “ refined ” sulphur which commerce demands. It consists of a stone-built chamber of about 2825 cubic feet capacity, whieh communicates directly with two slightly slanting tubular retorts of iron, each of which holds about 660 lb of sulphur. The retorts are charged with molten sulphur from an upper reservoir, which is kept at the requisite temperature by means of the lost heat of the retort fires. The chamber has a safety valve at the top of its vault, which is so balanced that the least surplus pressure from within sends it up. The first puff of sulphur vapour which enters the chamber takes fire and converts the air of the chamber into a mixture of nitrogen and sulphurous acid. The next following instalments of vapour, getting diffused throughout a large mass of relatively cold gas, condense into a kind of “snow,” known in commerce and valued as “flowers of sulphur” (*flores sulphuris).* By conducting the distillation slowly, so that the temperature within the chamber remains at a sufficiently low degree, it is possible to obtain the whole of the product in the form of “flowers.” If compact (“ roll ”) sulphur is wanted the distilla­tion is made to go on at the quickest admissible rate. The tempera­ture of the interior of the chamber soon rises to more than the fusing-point of sulphur (114oC. ), and the distillate accumulates at the bottom as a liquid, which is tapped off from time to time to be cast into the customary form of rods of about 11/2 inches diameter.

In some places sulphur is extracted from iron pyrites by one of two methods. The pyrites is subjected to dry distillation from out of iron or fire-clay tubular retorts at a bright red heat. One- third of the sulphur is volatilized—3FeS2 = Fe3S4+ S2—and obtained as a distillate. The second method is analogous to the calcarone method of liquation : the ore is placed in a lime-kiln like furnace over a mass of kindled fuel to start a partial combustion of the mineral, and the process is so regulated that, by the heat generated, the unburnt part is decomposed with elimination of sulphur, which collects in the molten state on an inverted roof-shaped sole below the furnace and is thence conducted into a cistern. Such pyrites sulphur is usually contaminated with arsenic, and consequently is of less value than Sicilian sulphur, which is characteristically free from this impurity.

The substance known as “milk of sulphur” *{lac sulphuris)* is very finely divided sulphur produced by the following, or some analogous, chemical process. One part of quicklime is slaked by means of 6 parts of water, and the paste produced diluted with 24 parts of water ; 2·3 parts of flowers of sulphur are added ; and the whole is boiled for about an hour or longer, when the sulphur dissolves,—

3CaO + 12S = 2CaS5 + CaS2O3∙

The mixed solution of pentasulphide and thiosulphate of calcium thus produced is clarified, diluted more largely in a tub, and then mixed with enough of pure dilute hydrochloric acid to produce a feebly alkaline mixture ; this shows that only the bulk of the pentasulphide is decomposed,—CaS5 + 2HCl = CaCl2 + H2S + (4S of precipitated sulphur). The addition of more acid would produce an additional supply of sulphur (by the action of the H2S2O3 on the dissolved H2S) ; but this thiosulphate sulphur is yellow and compact, while the CaS5 part has the desired qualities, forming an extremely fine, almost white, powder. The precipitate is washed, collected, and dried at a very moderate heat. It is used as a

medicine. If sulphuric acid is used instead of hydrochloric acid the preparation is apt to be contaminated with hydrated sulphate of lime. In the United Kingdom, indeed, precipitated sulphate of lime used to be added intentionally to produce what the public had got accustomed to ; but this practice has been rightly stopped by the authorities.

During the year 1875 the production of sulphur in Europe is stated to have been as follows :—

Tons.

Italy 360,000

Spain 4,000

Austria-Hungary 3 750

German empire (including 5000 tons of regenerated @@1 sulphur) 14,500 Belgium 450

Total 382,700

By far the greater part of all the sulphur produced in Sicily and elsewhere is used for the manufacture of sulphuric acid. Subjoined is an enumeration of some other applications. (1) The manufacture of gunpowder (see vol. xi. p. 320). (2) The taking of casts. (3)

The making of cements : *(a)* a mixture of molten sulphur and ferric oxide is used to cement the isolating bells to telegraph posts ; *{b)* a mixture of iron filings (100), flowers of sulphur (3 to 20), and sal-ammoniac (3 to 5) made into paste with water is used to cement iron bars (fences, &c.) into stone sockets ; (*c*) a mixture of molten sulphur with powdered quartz or glass has been recommended as an acid-proof material for sulphuric acid chambers ; *{d)* a mixture produced by the incorporation of powdered quartz and colouring matters, such as vermilion, &c., with molten sulphur is employed for ornamental articles. (4) The vulcanization of india-rubber (see vol. xii. p. 840 *sq.).* (5) Dusting vine-plants with flowers of sul­

phur is said to keep off the fungus *Oidium Tuckeri,* which has caused such devastation in the vineyards in France and elsewhere.

*Sulphur Compounds.*

Sulphuretted hydrogen, H2S (see Chemistry, vol. v. p. 499 *sq.),* is used largely as such, or as sulphide of ammonium, (NH4)2S = 2NH3 + H2S, for the detection, discrimination, and separation of metals. To give an example : the least quantity of lead dissolved in water as (say) nitrate can be detected by the addition of sulphur­etted hydrogen, which brings down the lead as a black precipitate of sulphide of lead,—Pb(NO3)2+ H2S = PbS + 2HNO3. The presence of a moderate quantity of mineral acid in the original solution does not interfere with the test. What we said of solution of salts of lead holds substantially of those of the following groups of metals. The formulæ and the colours of the sulphides are given in brackets. A. Lead (black, PbS), silver (black, Ag2S), mercury as mercurous or mercuric salt (black, HgS + Hg or HgS respectively), copper (greenish black, CuS), bismuth (brown, Bi2S3), cadmium (yellow, CdS). B. Arsenic (yellow, As2S3), antimony (orange-red, Sb2S3), tin as stannic salt (yellow, SnS2). The sulphides A are insoluble ; the sulphides B are soluble in sulphide of ammonium solution, and the latter, from this solution, can be reprecipitated by acidification with dilute sulphuric or hydrochloric acid. The brown SnS pre­cipitated from stannous salts is insoluble in the (colourless) solution of (NH4)2S, but soluble in the yellow solution of the polysulphide (NH4)2S2, as SnS2. C. The following metals are not precipitated from their salt solutions if these are acidified sufficiently by added mineral acid ; but they are precipitated from their neutral or alkaline solutions by sulphide of ammonium :—iron (black, FeS), nickel (black, NiS), cobalt (black, CoS), manganese (flesh-coloured, MnS), zinc (white, ZnS). Aluminium and chromium, given as salts of their oxides, R2O3, are precipitated by sulphide of ammonium as hydrated oxides (Al2O3.*x*H2O, colourless; Cr2O3.H2O, green or violet). The reagent acts on these as ammonia, NH3, the H2S being liberated, and behaves in a similar way to acid solutions of certain salts, *e.g.,* the phosphates, of the following group D, these salts, *e.g.,* Ca3P2O8, being precipitated as such. The ordinary salts of group D (barium, strontium, calcium, magnesium), and the salts of the alkali metals E (potassium, sodium, &c.) generally, give no precipitate with either sulphuretted hydrogen or sulphide of am­monium. It is easy to translate what we have stated into a method for the separation of groups A, B, C (D and E), from one another.

Of the three chlorides treated of in Chemistry (vol. v. p. 501) only the lowest, S2Cl2, is of industrial importance. It is prepared by passing perfectly dry chlorine gas over heated sulphur contained in a retort, the retort being connected with a condenser constructed so that the uncondensed vapours are led away into the chimney. The two elements unite readily, and chloride of sulphur, S2Cl2, distils over, contaminated, however, by more or less of surplus chlorine present as higher chlorides. To remove (or decompose) these the crude product is subjected to fractional distillation ; the thermometer rises rapidly and soon becomes constant (at about 136 under 758 mm. pressure). What afterwards distils over, at the constant boiling-point, is collected as pure S2Cl2,-ayellowish red liquid of 1·68 sp. gr. at 16°·7 C. and 1·7055 at 0° (Kopp), which emits fumes of hydrochloric acid in moist air. Its smell is charac-

@@@1 See Sodium, “ Le Blanc process for making soda ash,” p. 243 above.