which it occurs necessitating a liberal use of explosives. The vein­stuff is broken small either by hand or in rock-breakers, and stamped to fine powder in stamp mills, which are practically large mechani­cally-worked pestles and mortars, the stamp proper weighing from 500 to 1000 lb. The mineral, crushed small enough to pass a sieve with perforations 1/20 in. in diameter, leaves the stamps in suspension in water, and passes through a series of troughs in which the heavier mineral is collected; this then passes through a series of washing operations, which leaves a mixture consisting chiefly of tinstone and arsenical pyrites, which is calcined and washed again, until finally black tin containing about 60 to 65 % of metal is left. The calcina­tion is preferably effected in mechanical roasters, it being especially necessary to agitate the ore continually, otherwise it cakes. The crude tinstuff raised in Cornwall carries on an average a little over 2 % of black tin. The Bolivian tin ore is treated by first extracting the silver by amalgamation, &c., and afterwards concentrating the residues; there are, however, considerable difficulties in the way of treating the poorer of these very complex ores, and several chemical processes for extracting their metallic contents have been worked out. Of the impurities of the ore the wolframite (tungstate of iron and manganese) is the most troublesome, because on account of its high specific gravity it cannot be washed away as gangue. To remove it, Oxland fuses the ore with a certain proportion of carbonate of soda, which suffices to convert the tungsten into soluble alkaline tungstate, without producing noteworthy quantities of soluble stannate from the oxide of tin; the tungstate is easily removed by treatment with water.

2. *Smelting.—*The dressed ore is smelted with carbon by one of two main methods, viz. either in the shaft furnace or the reverbera­tory; the former is the better suited to stream tin, the latter to lode tin, but either ore can be smelted in either way, although reverbera­tory practice yields a purer metal. Shaft furnace smelting is confined to those parts of the world where charcoal can still be obtained in large quantities at moderate prices. The furnace consists of a shaft, circular (or more rarely rectangular) in plan, into which alternate layers of fuel and ore are charged, an air blast being generally injected near to the bottom of the furnace through one or more tuyeres. This was the primitive process all over the world; in the East, South America and similar regions it still holds its own. In Europe, Australasia and one large works at Singapore it has been practically replaced by the reverberatory furnace process, first introduced into Cornwall about the year 1700. In this process the purified ore is mixed with about one-fifth of its weight of a non­caking coal or anthracite smalls, the mixture being moistened to prevent it from being blown off by the draught, and is then fused on the sole of a reverberatory furnace for five or six hours. The slag and metal produced are then run off and the latter is cast into bars; these are in general contaminated with iron, arsenic, copper and other impurities.

3. *Refining.—*All tin, except a small quantity produced by the shaft furnace process from exceptionally pure stream tin ore, requires refining by liquation and “ boiling ” before it is ready for the market. In the English process the bars are heated cautiously on an inclined hearth, when relatively pure tin runs off, while a skeleton of impure metal remains. The metal run off is further purified by *poling, i.e.* by stirring it with the branch of a tree—the apple tree being preferred traditionally. This operation is no doubt intended to remove the oxygen diffused throughout the metal as oxide, part of it perhaps chemically by reduction of the oxide to metal, the rest by conveying the finely diffused oxide to the surface and causing it to unite there with the oxide scum. After this the metal is allowed to rest for a time in the pot at a temperature above its freezing point and is then ladled out into ingot forms, care being taken at each stage to ladle off the top. stratum. The original top stratum is the purest, and each succeeding lower stratum has a greater proportion of impurities; the lowest consists largely of a solid or semi-solid alloy of tin and iron.

To test the purity of the metal the tin-smelter heats the bars to a certain temperature just below the fusing point, and then strikes them with a hammer or lets them fall on a stone floor from a given height. If the tin is pure it splits into a mass of granular strings. Tin which has been thus manipulated and proved incidentally to be very pure is sold as grain tin. A lower quality goes by the name of block tin. Of the several commercial varieties Banka tin is the purest; it is indeed almost chemically pure. Next comes English grain tin.

For the preparation of chemically pure tin two methods are employed. (1) Commercially pure tin is treated with nitric acid, which converts the tin proper into the insoluble metastannic acid, while the copper, iron, &c., become nitrates; the metastannic acid is washed first with dilute nitric acid, then with water, and is lastly dried and reduced by fusion with black flux or potassium cyanide. (2) A solution of pure stannous chloride in very dilute hydrochloric acid is reduced with an electric current. According to Stolba, beautiful crystals of pure tin can be obtained as follows: A platinum basin, coated over with wax or paraffin outside, except a small circle at the very lowest point, is placed on a plate of amalgamated zinc, lying on the bottom of a beaker, and is filled with a solution of pure stannous chloride. The beaker also is cautiously filled with acidu­lated water up to a point beyond the edge of the platinum basin. The whole is then left to itself, when crystals of tin gradually separate out on the bottom of the basin.

*Properties.—An* ingot of tin is pure white (except for a slight tinge of blue); the colour depends, however, upon the temperature at which it is poured—if too low, the surface is dull, if too high, iridescent. It exhibits considerable lustre and is not subject to tarnishing on exposure to normal air. The metal is pretty soft and easily flattened out under the hammer, but. almost devoid of tenacity. That it is elastic, with narrow limits, is proved by its clear ring when struck with a hard body in circumstances permitting of free vibration. The specific gravity of cast tin is 7∙29, of rolled tin 7∙299, and of electrically deposited tin 7·143 to 7∙178. A tin ingot is distinctly crystalline; hence the characteristic crackling noise, or “cry” of tin, which a bar of tin gives out when being bent. This structure can be rendered visible by superficial etching with dilute acid ; and as the minuter crystals dissolve more quickly than the larger ones, the surface assumes a frosted appearance (*moirée métallique).* The metal is dimorphous: by cooling molten tin at ordinary air temperature tetragonal crystals are. obtained, while by cooling at a tempera­ture just below the melting point rhombic forms are produced When exposed for a sufficient time to very low temperatures (to —39° C. for 14 hours), tin becomes so brittle that it falls into a grey powder, termed the *grey modification,* under a pestle; it indeed sometimes crumbles into powder spontaneously. At ordinary temperatures tin proves fairly ductile under the hammer, and its ductility seems to increase as the temperature rises up to about 100° C. At some temperature near its fusing point it becomes brittle, and still more brittle from —14° C. downwards. Iron renders the metal hard and brittle; arsenic, antimony and bismuth (up to 0∙5%) reduce its tenacity; copper and lead (1 to 2%) make it harder and stronger but impair its malleability; and stannous oxide reduces its tenacity. Tin fuses at about 230° C. ; at a red heat it begins to volatilize slowly ; at 1600° to 1800° C. it boils. The hot vapour produced combines with the oxygen of the air into white oxide, SnO2. Its coefficient of linear expansion between 0° and 100° is 0·002717; its specific heat 0·0562; its thermal and electrical conductivities are 145 to 152 and 114∙5 to 140∙1 respectively compared to silveras 1000.

*Industrial Applications.—*Commercially pure tin is used for making such apparatus as evaporating basins, infusion pots, stills, &c. It is also employed for making two varieties of tin-foil—one for the silvering of mirrors (see Mirror), the other for wrapping up choco­late, toilet soap, tobacco, &c. The mirror foil must contain some copper to prevent it from being too readily amalgamated by the mercury. For making tin-foil the metal is rolled into thin sheets, pieces of which are beaten out with a wooden mallet. As pure tin does not tarnish in the air and is proof against acid liquids, such as vinegar, lime juice, &c., it is utilized for culinary and domestic vessels. But it is expensive, and tin vessels have to be made very heavy to give them sufficient stability of form ; hence it is generally employed merely as a protecting coating for utensils made essentially of copper or iron. The tinning of a copper basin is an easy operation. The basin, made scrupulously clean, is heated to beyond the fusing point of tin. Molten tin is then poured in, a little powdered sal­ammoniac added, and the tin spread over the inside with a bunch of tow. The sal-ammoniac removes the last unavoidable film of oxide, leaving a purely metallic surface, to which the tin adheres firmly. For tinning small objects of copper or brass (i.e. pins, hooks, &c.) a wet-way process is followed. One part of cream of tartar, two of alum and two of common salt are dissolved in boiling water, and the solution is boiled with granulated metallic tin (or, better, mixed with a little stannous chloride) to produce a tin solution ; and into this the articles are put at a boiling heat. In the absence of metallic tin there is no visible change; but, as soon as the metal is introduced, an electrolytic action sets in and the articles get coated over with a firmly adhering film of tin. Tinning wrought iron is effected by immersion. The most important form of the operation is making tinned from ordinary sheet iron (making what is called “ sheet tin"). This process was mentioned by Agricola ; it was practised in Bohemia in 1620, and in England a century later. The iron plates, having been carefully cleaned with sand and hydrochloric or sulphuric acid, and lastly with water, are plunged into heated tallow to drive away the water without oxidation of the metal. They are next steeped in a bath, first of molten ferruginous, then of pure tin. They are then taken out and kept suspended in hot tallow to enable the surplus tin to run off. The tin of the second bath dissolves iron gradually and becomes fit for the first bath. To tin cast-iron articles they must be decarburetted superficially by ignition within a bath of ferric oxide (powdered haematite or similar material), then cleaned with acid, and tinned by immersion, as explained above. (See Tin-Plate.) By far the greater part of the tin produced metallurgically is used for making tin alloys (see Pewter, Bronze).

*Compounds of Tin.*

Tin forms two well-marked series of salts, in one of. which it is divalent, these salts being derived from stannous oxide, SnO, in the other it is tetravalent, this series being derived from stannic oxide, SnO2.

*Stannous Oxide,* SnO, is obtained in the hydrated form Sn2O(OH)j from a solution of stannous chloride by addition of sodium car­bonate; it forms a white precipitate, which can be washed with