fire. 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.

*Smelting.—*The purified ore is mixed with about one- fifth of its weight of 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. To refine them, 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 Banca 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 an insoluble hydrate of SnO2, while the copper, iron, &c., become nitrates ; the oxide is washed first with dilute nitric acid, then with water, and is lastly dried and reduced by fusion with black flux or cyanide of potassium. (2) A solution of pure stannous chloride in very dilute hydrochloric acid is reduced with a galvanic 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 of Pure Tin.—An ingot of pure tin is pure white (ex­cept for a slight tinge of blue) ; 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, within narrow limits, is proved by its clear ring when struck with a hard body under circumstances permitting of free vibration. The specific gravity of ingot tin is 7⋅293 at 13° C. (Matthiessen). A tin ingot, though seemingly amor­phous, has a crystalline structure, consisting of an aggregate of quadratic octahedra ; hence the characteristic crackling noise which a bar of tin gives out when being bent. This structure can be rendered visible by superficial etching with dilute acid. As the minuter crystals dissolve more quickly than the larger ones, the surface assumes a frosted appearance {moirée métallique), not unlike that of a frozen window-pane in winter time. Its crystalline struc­ture must account for the striking fact that the ingot, when exposed for a sufficient time to very low temperatures (to -39° C. for 14 hours), becomes so brittle that it falls into powder under a pestle or hammer ; 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 (vide supra), and still more brittle from -14° C. downwards. This behaviour of the metal may probably be explained by assuming that in any tin crystal the coefficient of thermic ex­pansion has one value in the direction of the principal axis and another in that of either of the subsidiary axes. From 0° to 100° the two coefficients are practically identical ; below -14° and from somewhere above 100° C. upwards they assume different values ; and, as the several crystals are oriented in a lawless fashion, this must tend to disintegrate the mass. Tin fuses at 232°·7 (Persoz); at a red heat it begins to volatilize slowly ; at 1600° to 1808° ό. (Carnelley and Williams) it boils. The hot vapour produced com­bines with the oxygen of the air into white oxide, SnO2,

Industrial Applications.—Commercially pure tin is used (princi­pally in Germany) for the making of pharmaceutical apparatus, such as evaporating basins for extracts, infusion pots, stills, &c. It is also employed for making two varieties of tin-foil,—one for the silvering of mirrors (see Mirror, vol. xvi. p. 500), 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 over a charcoal fire to beyond the fusing point of tin. Molten tin is then poured in, a little powdered sal-ammoniac added, and the tin spread over the inside with a bunch of tow. The sal­ammoniac 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, a galvanic 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 ”). The iron plates, having been carefully cleaned with sand and muriatic 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 hæmatite or similar material), then cleaned with acid, and tinned by immersion, as explained above. By far the greater part of the tin produced metallurgically is used for making tin alloys, the majority of which have been treated of in preceding articles ; see Lead, vol. xiv. p. 378 ; Pewter, vol. xviii. p. 725 ; Bronze, vol. iv. p. 366 ; Phosphorus, vol. xviii. p. 817.

Tin Compounds.—The most important of these may be arranged into two classes, namely, stannous compounds, SnX2, and stannic compounds, SnX4, where X stands for Cl, Br, ½O, &c. Stannous compounds are, in general at least, characteristically prone to pass into the stannic form by taking up additional X2 in the form of oxygen, chlorine, &c.

Stannous Chloride, SnCl2.—This can be obtained pure only by heating pure tin in a current of pure dry hydrochloric acid gas. It is a white solid, fusing at 250° C. and volatilizing at a red heat in nitrogen, a vacuum, or hydrochloric acid, without decomposition. The vapour density below 700° C. corresponds to Sn2Cl4, above 800°C. to nearly SnCL2 (Von Meyer and Züblin). The chloride readily com­bines with water into an easily soluble crystallizable hydrate (“tin crystals ”). This is made without difficulty by dissolving tin in strong hydrochloric acid and allowing it to crystallize. For its industrial preparation Nöllner passes sufficiently hydrated hydro-