

and broad, its mouth wide, furnished with six barbels, of which those of the upper jaw are very long. Both jaws and the palate are armed with broad bands of small closely-set teeth, which give the bones a rasp-like appearance. The eyes are exceedingly small. The short body terminates in a long, compressed, muscular tail, and the whole fish is covered with a smooth, scaleless, slippery skin. Specimens of 4 and 5 feet in length, and of .50 to 80 lb in weight, are of common occurrence. Its food consists chiefly of other bottom-feeding fishes, and in inland countries it is considered one of the better class of food fishes. Stories about children having been found in the stomach of very large individuals are probably inventions.

III. The *Siluridæ Anomalopteræ* are a small section from tropical America, in which the dorsal and adipose fins are very short and belong to the caudal vertebral column, while the anal is very long, and the gill-membranes are entirely separate, overlapping the isthmus.

IV. The *Siluridæ Proteropteræ* are a section extremely numerous in species, and represented throughout the tropics. The dorsal fin consists of a short-rayed and an adipose portion, the former belonging to the abdominal vertebral column; the anal is always much shorter than the tail. The gill-membranes are not confluent with the skin of the isthmus; they have a free posterior margin. When a nasal barbel is present, it belongs to the posterior nostril. This section includes among many others the genus *Bagrus*, of which the "Bayad" (*B. bayad*) and "Docmac" (*B. docmac*) frequently come under the notice of travellers on the Nile; they grow to a length of 5 feet, and are eaten. Of the "Cat-Fishes" of North America (*Ameiurus*), locally called "bull-heads" or "horned-pouts," with eight barbels, some twenty species are known. Some of them are valued as food, especially one which is abundant in the ponds of New England, and capable of easy introduction into other localities (*A. nebulosus*). Others which inhabit the great lakes (*A. nigricans*) and the Mississippi (*A. ponderosus*) often exceed the weight of 100 lb. *Platystoma* and *Pimelodus* people the rivers and lakes of tropical America, and many of them are conspicuous in this fauna by the ornamentation of their body, by long spatulate snouts, and by their great size. The genus *Arius* is composed of the greatest number of species (about seventy), and has the widest distribution of all Siluroids, being represented in almost all tropical countries which are drained by large rivers. Some of the species enter salt water. They possess six barbels, and their head is extensively osseous on its upper surface; their dorsal and pectoral spines are generally developed into powerful weapons. *Bagarius*, one of the largest Siluroids of the rivers of India and Java, exceeding a length of 6 feet, differs from *Arius* in having eight barbels, and the head covered with skin.

V. In the *Siluridæ Stenobranchiæ* the dorsal fin consists of an adipose portion and a short-rayed fin which belongs to the abdominal vertebral column, and, like the adipose fin, may be sometimes absent. The gill-membranes are confluent with the skin of the isthmus. The Siluroids belonging to this section are either South-American or African. Among the former we notice specially the genus *Doras*, which is distinguished by having a series of bony scutes along the middle of the side. The narrowness of their gill-openings appears to have developed in them a habit which has excited the attention of all naturalists who have visited the countries bordering upon the Atlantic rivers of tropical America, viz., the habit of travelling during seasons of drought from a piece of water about to dry up to ponds of greater capacity. These journeys are occasionally of such a length that the fish have to travel all night; they are so numerous that the Indians fill

many baskets of them. Hancock supposes that the fish carry a small supply of water with them in their gill-cavity, which they can easily retain by closing their branchial apertures. The same naturalist adds that they make regular nests, in which they cover up their eggs with care and defend them,—male and female uniting in this parental duty until the eggs are hatched. *Synodontis* is

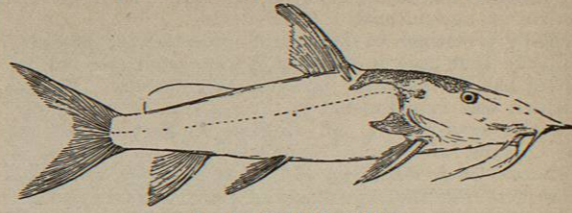


FIG. 2.—*Synodontis ziphius*.

an African genus and common in the Nile, where the various species are known by the name of "Shal." They frequently occur among the representations of animals left by the ancient Egyptians. The upper part of their head is protected by strong osseous scutes, and both the dorsal and pectoral fins are armed with powerful spines. Their mouth is small, surrounded by six barbels, which are more or less fringed with a membrane or with branched tentacles. Finally, the Electric Cat- or Sheath-Fishes (*Malapterurus*) also belong to this section. Externally



FIG. 3.—*Malapterurus electricus*.

they are at once recognized by the absence of a rayed dorsal fin, of which only a rudiment remains as a small interneural spine concealed below the skin. The entire fish is covered with soft skin, an osseous defensive armour having become unnecessary in consequence of the development of a powerful electric apparatus, the strength of which, however, is exceeded by that of the electric eel and the large species of *Torpedo*. It has been noticed in vol. xii. p. 650. Three species have been described from rivers of tropical Africa, of which one (*M. electricus*) occurs in the Nile; it rarely reaches a length of 4 feet.

VI. The section of *Siluridæ Proteropodes* contains small forms, some of which are of interest by the degree of specialization to which they have attained in one or the other direction. Many of them are completely mailed; but all have in common a short-rayed dorsal fin, with the ventrals below or rarely in front of it. Their gill-openings are reduced to a short slit; their pectorals and ventrals have assumed a horizontal position; and their vent is before, or not much behind, the middle of the length of the body. The first group of this section comprises alpine forms of the Andes, without any armature, and with a very broad and pendent lower lip. They have been referred to several genera (*Stygogenes*, *Arges*, *Brontes*, *Astroplebus*), but are collectively called "peñadillas" by the natives, who state that they live in subterranean craters within the bowels of the volcanoes of the Andes, and are ejected with streams of mud and water during eruptions. These fishes may, however, be found in surface waters at all times, and their appearance in great quantities in the low country during volcanic eruptions can be accounted for by numbers being killed by the sulphuretted gases which escape during an eruption and

by their being swept down with the torrents of water issuing from the volcano. The lowland forms have their body encased in large scutes, either rough, scale-like, and arranged in four or five series (*Chatostomus*), or polished, forming broad rings round the slender and depressed tail (*Loricaria*, fig. 4), or polished and large, so as to form two series only along the body and short tail (*Callichthys*; fig. 5). In India this sec-

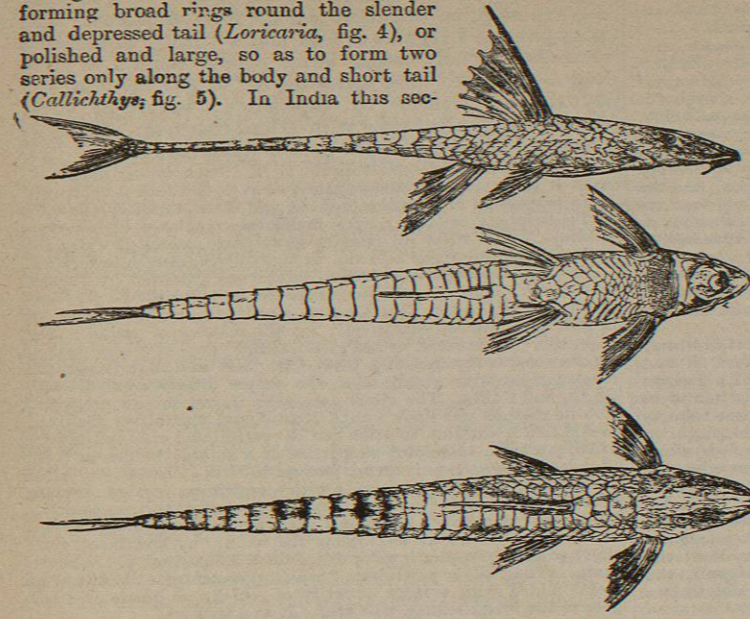


FIG. 4.—*Loricaria lanceolata*, from the upper Amazons. Natural size.

tion is but sparsely represented, chiefly in mountain-streams, by small loach-like Siluroids, in which various kinds of peculiar apparatus are developed to enable them to hold on to stones, this preventing their being swept away by the current; in *Pseudecheneis* the adhesive apparatus consists of transverse plaits of the skin on the thorax between the pectoral fins; in *Exostoma* the mouth is modified into a suction organ, probably with the same function.

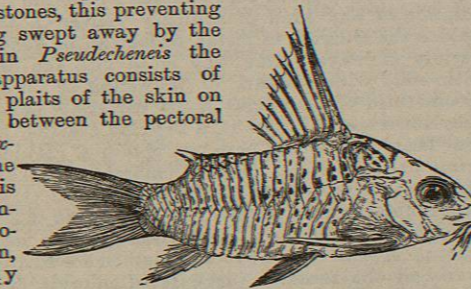


FIG. 5.—*Callichthys armatus*, from the upper Amazons. Natural size.

Finally, the South-American genus *Aspredo*, which is remarkable for the peculiar mode of protecting its eggs, as mentioned in vol. xii. p. 660, belongs also to this section.

VII. The small section of *Siluridæ Opisthopteræ* comprises South-American forms, the majority of which inhabit waters at high altitudes up to 14,000 feet above the level of the sea. All have a short-rayed dorsal fin, placed above or behind the middle of the length of the body, above or behind the ventrals, which may be absent. Also the anal is short. The nostrils are remote from each other, and the gill-membranes are not confluent with the skin of the isthmus. These little fishes, of which *Trichomycterus* and *Nematogenys* are the principal genera, replace in the Andes the loaches of the northern hemisphere; they resemble them in appearance and habits, and even in coloration, offering a striking illustration of the fact that similar forms of animals are produced under similar external physical conditions.

VIII. Finally, the *Siluridæ Branchicolæ* comprise the smallest and least developed members of the family; they are referred to two genera only from South America, *Stegophilus* and *Vandellia*, the smallest of which does not exceed the length of 2 inches. Their body is soft, narrow, cylindrical, and elongate; the dorsal and anal fins short; the vent far behind the middle of the length of the body; gill-membranes confluent with the skin of the isthmus. Each maxillary is provided with a small barbel; and the gill-covers are armed with short stiff spines. Their small size notwithstanding, these Siluroids are well known to the Brazilians, who accuse them of entering and ascending the urethra of persons while bathing, causing inflammation and sometimes death. They certainly live parasitically in the gill-cavity of large Siluroids, probably entering those cavities for places of safety, but without drawing any nourishment from their hosts. (A. C. G.)

SILVANUS, an ancient Italian god of the woods (*silva*), closely allied to Faunus. Virgil speaks of him as a god of fields and cattle, and says that the Pelasgians dedicated a grove to him near Cære. Horace calls him the god of boundaries. Pigs were sacrificed to him, and at harvest festivals he received offerings of milk. He appears sometimes, especially in inscriptions, as a domestic god, and is occasionally associated with the Lares and Penates. Virgil describes him as crowned with fennel and lilies or carrying an uprooted cypress in his hand. On a relief he appears with a crown of pine branches in his hair, a pine branch in his left hand, a skin filled with fruits hanging about his neck, a pruning-knife in his right hand, and a dog by his side. On votive tablets he is oftener represented as the god of planting and gardening than as the rough woodland deity.

SILVER¹ is widely diffused throughout the earth's crust, including the ocean, which contains a trace of the noble metal—minute, it is true, in a relative sense, but in absolute amount approaching 10,000 million tons. Of the varieties of silver ores, the following chiefly are metallurgically important:—(1) *Reguline Silver*, generally alloyed with mercury or gold, and if with the latter including sometimes a trace of platinum; (2) *Horn Silver*, native chloride, AgCl; (3) *Silver Glance*, native sulphide, Ag₂S; (4) *Silver-Copper Glance*, (Ag, Cu)₂S; (5) *Pyrrargyrite* ("Rothgültigerz"), Ag₂SbS₂; (6) *Stephanite*, Ag₂SbS₄; (7) *Polybasite*, 9(Ag₂Cu₂)S + (Sb₂As₂)S₃. Silver is also frequently met with in base-metallic ores, e.g., in lead ores and many kinds of pyrites. Unmixed silver minerals nowhere present themselves in large continuous masses. What we call "silver ores" are all more or less complex mixtures in which the non-argentiferous components are usually decidedly in the majority. Their metallurgic treatment depends chiefly on the nature of these admixtures, the state of combination of the silver being as a rule irrelevant in the choice of a process, because some at least of the noble metal is always present as sulphide, and our modes of treatment for it include all other native forms.

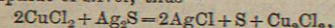
Amalgamation.—If a given ore is relatively free of base "metals" (metallurgically speaking), some process of "amalgamation" may be, and often is, resorted to.

In the *Freiberg process* the first step is to roast the (ground) ore with common salt, which converts the sulphide of silver into

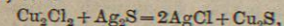
¹ Compare CHEMISTRY, vol. v. p. 528-530; also MINING, MINT, and MONEY.

chloride ($\text{Ag}_2\text{S} + 2\text{NaCl} + 4\text{O}$ from the air = $2\text{AgCl} + \text{Na}_2\text{SO}_4$). The mass, along with certain proportions of water, scrap-iron, and mercury, is placed in barrels, which are then made to rotate about their axes so that the several ingredients are forced into constantly varying contact with one another. The salt solution takes up a small proportion of chloride, which in this (dissolved) form is quickly reduced by the iron to the metallic state ($2\text{AgCl} + \text{Fe} = \text{FeCl}_2 + 2\text{Ag}$), so that there is, so to say, room made in the brine for another instalment of chloride of silver, which is reduced in its turn, and so on to the end,—the metal formed uniting with the mercury into a semi-fluid amalgam. Of this the bulk at least readily unites into larger continuous masses, which, on account of their high specific gravity, are easily separated from the dross mechanically. The amalgam is pressed in linen bags to eliminate a quantity of relatively silver-free liquid mercury (this of course is utilized as such in subsequent operations), and the remaining solid amalgam is subjected to distillation from iron retorts, whereby its mercury is recovered as a distillate while a more or less impure silver remains in the retort. This process, after having been long wrought in Freiberg with great success, is now superseded there by the Augustin method (see below), but it survives in some other places, as, for example, the Washoe or Comstock district in the Sierra Nevada (United States). It is not used in Chili, Peru, and Mexico because of the scarcity of fuel.

The Mexican process, though far less perfect than that of Freiberg, evades this difficulty. It was tried for the first time, if not actually invented, by Bartolomeo de Medina in 1557. It was adopted in Mexico in 1566 and in Peru in 1574, and is in use in both countries and in Chili to this day. The stamped ore is ground into a fine paste with water; this paste, after having been allowed to dry up a little in air, is placed on a stone floor along with a quantity of salt, and the two are trodden together by mules. On the following day there are added certain proportions of "magistral" (a kind of crude sulphate of copper made by roasting copper pyrites) and of mercury, and the mules are kept going until the silver is as far as possible converted into amalgam, which takes from fifteen to forty-five days. The rationale of the process is not quite understood. According to Boussingault, the cupric chloride (formed by the salt from the sulphate) chlorinates part of the sulphide of silver, thus—



and the cuprous chloride formed acts upon another portion of sulphide of silver, thus—



and in this way all the sulphide of silver is gradually converted into chloride. The chloride is reduced to the metallic state by the mercury ($\text{AgCl} + \text{Hg} = \text{HgCl} + \text{Ag}$) with formation of calomel, the metallic silver uniting with the surplus mercury into amalgam. The calomel is allowed to go to waste.

The Augustin process of silver extraction is only a peculiar mode of metallizing and collecting the silver of an ore after it has been by some preliminary operation converted into chloride or sulphate. Either salt is brought into solution—the chloride by means of hot brine, the sulphate by means of hot water, acidified with oil of vitriol; the solution is separated from the insolubles, and made to filter through a bed of precipitated copper. The copper reduces the silver to metal, which remains on the bed as a spongy mass, while an equivalent quantity of copper chloride (or sulphate) passes through as a solution. The silver sponge is collected, freed from adhering copper by muriatic acid in contact with air, and then sent to the furnace. From the copper liquor that metal is precipitated in its original form by means of iron.

The silver furnished by any of these methods is never pure, even in the commercial sense. A general method for its purification is to fuse it up with lead and subject the alloy to cupellation (see LEAD, vol. xiv. p. 376). Cupel-silver is apt to contain small quantities of lead (chiefly), bismuth, antimony, copper, and more or less of gold, of which metals, however, only the first three are reckoned "contaminations" by the metallurgist. They can be removed by a supplementary cupellation, without added lead, at a high temperature. Addition of lead would remove the copper likewise, but it is usually allowed to remain and the alloy sent out as cupriforous silver, to be alloyed with more copper and thus converted into some kind of commercial "silver" (see below). If gold is present to the extent of 0.1 per cent. or more, it is recovered by treatment of the metal with nitric acid or boiling vitriol. The gold in either case remains as such; the silver becomes nitrate or sulphate, and from the solution of either salt is recovered by precipitation with metallic copper. Although nitric acid is the more expensive of the two parting agents, it is often now preferred because photography has created a large demand for nitrate of silver. Compare GOLD, vol. x. p. 749.

For the "incidental" extraction of silver from essentially base-metallic ores the method in the case of all lead ores is simply to proceed as if only lead were present,

and from the argentiferous lead produced to extract the noble metal by one of the processes described under LEAD (vol. xiv. p. 376-7), while for the treatment of sulphureous copper ores one method is so to smelt the ore (with, if necessary, an addition of galena or some form of oxide of lead) as to produce a regulus of lead and a "mat" of sulphide of copper, (Cu_2S), which latter should contain as little lead as possible. The silver follows chiefly the lead, and is extracted from it by cupellation; but some silver remains in general even with a lead-free mat. Compare account of the Lautenbach process under LEAD.

A modern mode of extracting the silver from a copper mat is to roast it at a very low temperature, so as to produce a relatively large proportion of metallic sulphate, and then to destroy the bulk of the sulphate of copper by a judiciously-regulated higher temperature. The silver still remains as sulphate, which is extracted by hot dilute sulphuric acid and wrought by the Augustin method.

Very interesting is the process which was patented by Claudet for the remunerative extraction of the few hundredths of a per cent. of silver contained in that kind of cupriforous iron pyrites which is now used, almost exclusively, for the making of vitriol. The "cinders," as returned by the vitriol maker, are habitually worked up for copper by roasting them with salt and lixiviating the roasted mass with water, when the copper dissolves as chloride, Cu_2Cl_2 and CuCl_2 . The silver goes with it, but for its precipitation no method was known until Field found that silver dissolved as AgCl in a chloride solution can be precipitated exhaustively by addition of the calculated proportion of a soluble iodide, as AgI . Claudet's process is only an adaptation of Field's discovery. After having diluted the copper liquor with a certain proportion of water he adds the weight of iodine, calculated from the assay, as solution of iodide of zinc, which produces a very impure precipitate of iodide of silver. From it he re-extracts the iodine, by treatment with zinc and dilute sulphuric acid, as iodide of zinc, which is used over again. The "silver precipitate," which now contains its silver as metal mixed with a large quantity of (chiefly) sulphate of lead, goes to the metal-refiner, who treats it as a lead ore.

Chemically Pure Silver.—Even the best "fine" silver of commerce contains a few thousandth-parts of copper or other base metal. To produce perfectly pure metal the most popular method is to first prepare pure chloride (by applying the method given below under "Chloride" to a nitric solution of any kind of ordinary "silver"), and then to reduce the chloride to metal, which can be done in a great variety of ways. One way is to mix the dry chloride intimately with one-fifth of its weight of pure quicklime or one-third of its weight of dry carbonate of soda, and to fuse down the mixture in a fire-clay crucible at a bright red heat. In either case we obtain a regulus of silver lying under a fused slag of chloride— $2\text{AgCl} + (\text{CaO}$ or $\text{Na}_2\text{CO}_3) = 2\text{Ag} + (\text{CaCl}_2 + \text{O}$ or $2\text{NaCl} + \text{CO}_2 + \text{O}$) The fused metal is best granulated by pouring it from a sufficient height, and as a thin stream, into a mass of cold water. A convenient wet-way method for small quantities is to boil the recently precipitated chloride (which must have been produced and washed in the cold) with caustic soda-ley and just enough of sugar to take away the oxygen of the Ag_2O transitorily produced. The silver in this case is obtained as a yellowish-grey heavy powder, which is easily washed by decantation; but it tends to retain unreduced chloride, which can be removed only by fusion with carbonate of soda.

Stas recommends the following process as yielding a metal which comes nearer ideal purity. Slightly cupriforous silver is made into dry nitrate and the latter fused to reduce any platinum nitrate that may be present to metal. The fused mass is taken up in dilute ammonia and diluted to about fifty times the weight of the silver it contains. The filtered (blue) solution is now mixed with an excess of solution of sulphite of ammonia, $\text{SO}_2(\text{NH}_4)_2$, and allowed to stand. After twenty-four hours about one-half of the silver has separated out in crystals; from the mother-liquor the rest comes down promptly on application of a water-bath heat. The rationale of the process is that the sulphite hardly acts upon the dissolved oxide of silver, but it reduces some of the oxide of copper, 2CuO , to Cu_2O , with formation of sulphate $\text{SO}_4(\text{NH}_4)_2$. This Cu_2O deoxidizes its equivalent of Ag_2O , forming $\text{Ag} + \text{Cu}_2\text{O}$, which latter is reduced by the stock of sulphite and reconverted into Cu_2O which now acts upon a fresh equivalent of Ag_2O ; and so on to the end.

Pure silver (ingot) has a beautiful white colour and lustre; it is almost as plastic as pure gold, and, like it, very soft. It does not tarnish in natural air; but in air contaminated with ever so little sulphuretted hydrogen it gradually draws a black film of sulphide. The specific gravity of the frozen metal is 10.42 to 10.51, rising to 10.57 after compression under a die. It is the best conductor of heat and electricity. The expansion of unit length from 0° to 100° C. is 0.001936 (Fizeau). The specific heat is 0.0570 (Regnault), 0.0559 (Bunsen). It fuses at 954° C. (Violle)—i.e., far below the fusing point of copper or gold—without oxidation, unless it be in contact with a surface of silicate (porcelain glaze, &c.), when a trace of silicate of Ag_2O is produced. It volatilizes appreciably at a full red heat; in the oxyhydrogen flame it boils, with formation of a blue vapour. The fused metal readily absorbs oxygen gas (under fused nitre as much as twenty times its volume—Gay-Lussac). When the oxygenated metal freezes the absorbed gas goes off suddenly at the temperature of solidification, and, by forcing its way through the solid crust produces volcanic eruptions of metal which are sometimes very beautiful. The presence of even very little base metal in the silver prevents this "spitting"; the base metal combining with the oxygen faster than it can be reabsorbed. Pure silver retains a trace of the absorbed oxygen permanently, and Dumas in an experiment on one kilogramme of metal extracted from it 82 milligrammes of oxygen in an absolute vacuum at 400°-500° C. Water, and ordinary non-oxidizing aqueous acids generally, do not attack silver in the least, hydrochloric acid excepted,—which, in the presence of air, dissolves the metal very slowly as chloride. A solution of common salt acts similarly, the liberated sodium becoming NaOH . Aqueous hydriodic acid, even in the absence of air, dissolves silver perceptibly, with evolution of hydrogen (Deville). Aqueous nitric acid dissolves the metal readily as nitrate; hot vitriol converts it into a magma of crystalline sulphate, with evolution of sulphurous acid. Silver is absolutely proof against the action of caustic alkali leys, and almost so against that of fused caustic alkalies even in the presence of air. It ranks in this respect next to gold, and is much used to make vessels for chemical operations involving the use of fused caustic potash or soda. The ordinary "fine" metal is good enough for this purpose.

SILVER ALLOYS.—Pure silver is too soft to make durable coins or vessels combining lightness with stability of form. This defect can be cured by alloying it with a little copper. All ordinary "silver" articles consist of such alloys. The proportion of silver in these (their "fineness") is habitually stated in parts of real silver per 1000 parts of alloy. In Great Britain all silver coins are made of "standard silver," the fineness of which, by legal definition, is 925. The toleration is 4 units (of pure silver in 1000 of alloy), i.e., a specimen passes as long as its fineness lies between 925 and 921 (compare MINT, vol. xvi. p. 483). As regards silver-plate the "Hall" in London refuses to stamp any poorer alloy. In Germany and in the United States all silver coins, in France and Austria the major silver coins, are of the fineness 900, with a toleration of 3 units. The minor coins of Austria are of the fineness 375 to 520; in France all silver coins under one franc contain 835 of silver, 93 of copper, and 72 of zinc in 1000 parts. The fineness prescribed by law or custom for "silver" articles is 950 or 800 (± 5) in France, 750 in North Germany, 812.5 in South Germany, and 820 in Austria. All these alloys at least are liable to "liqation," which means that, although they are perfectly homogeneous in the crucible, they freeze into layers of not absolutely the same composition. According to Leval, passing from the skin to the core of an ingot of 900 per mille silver the difference may amount to 3 units. Of all the alloys tried by that chemist only that composed according to the formula Ag_2Cu_2 , corresponding to 719 per mille of silver, remained perfectly homogeneous on freezing. He therefore recommends this alloy for coinage; unfortunately, however, any silver-copper alloy which contains less than about 750 per mille of noble metal tarnishes very perceptibly in the air. British standard silver is quite free of this defect, but it is inconveniently soft, far softer than the "900" alloy.

The extent to which the properties of silver are modified by addition of copper depends on the fineness of the alloy produced. The addition of even three parts of copper to one of silver does not quite obliterate the whiteness of the noble metal. According to Kamarsch the relative abrasion suffered by silver coins of the degrees of fineness named is as follows:—

Fineness.....	312	750	900	993
Abrasion.....	1	2.3	3.9	9.5

The same observer established the following relation between fineness p and specific gravity in coins containing from 375 to 875 of silver per 1000:—sp. gr. = $0.001647p + 8.833$.

The fusing points of all copper-silver alloys lies below that of pure copper; that of British standard silver is lower than even that of pure silver. For the alloys of silver with other metals than copper, see GOLD, PLATINUM, and NICKEL. The present writer has introduced an alloy of 91 of silver; 7 of gold, and 2 of nickel as a material far superior, on account of its higher rigidity, to fine silver for the making of alkali-proof vessels.

"Oxidized" silver is ordinary cupriforous silver superficially modified by immersion into sulphide of sodium solution (which produces a dark film of sulphide), or otherwise.

Silvering.—For the production of a silver coating on a base-metallic object we have chiefly two methods. One of these is to dissolve silver in mercury and to apply this amalgam to the (carefully cleaned) surface of the object by means of a brush. The mercury then is driven away by heat, when a coherent film of silver remains, which adheres very firmly, is quite continuous, and needs not be thick to stand polishing and other surface treatment. This very old method is to this day the best for producing a strong coating, but it is dangerous to the health of the workmen, expensive, and troublesome, and has been almost superseded by the modern process of *electroplating* (see ELECTRO-METALLURGY, vol. xviii. p. 116). Objects made of iron or steel must first be coated over with copper, and then treated as if they consisted of that metal.

For *Glass-Silvering*, see MIRROR, vol. xvi. p. 500. Inscriptions on linen, consisting of black metallic silver and consequently proof against all ordinary processes of washing, can be produced by using suitably-contrived silver solutions as inks. A mere solution of nitrate of silver (1 to 8 of water) will do, if the surface to which it is applied has been prepared by impregnation with a solution of 6 parts of soda crystals and 17 of gum arabic in 30 of water, and subsequent ironing. The ink must be applied with a quill or gold pen (compare vol. xiii. p. 81).

SILVER COMPOUNDS.—(1) *Nitrate of Silver* (AgNO_3) is made by dissolving fine silver in a moderate excess of nitric acid of 1.2 sp. gr., applying heat at the end. The solution on cooling deposits crystals—very readily if somewhat strongly acid. Even a slightly cupriforous solution deposits pure or almost pure crystals. Any admixture of copper in these can be removed by fusing the dry crystals, when the copper salt only is reduced to black oxide of copper insoluble in water and thus removable, or by boiling the solution with a little pure oxide of silver (Ag_2O), which precipitates the CuO and takes its place. Nitrate of silver forms colourless transparent sonorous plates, which, if free of organic matter, remain unchanged in the light,—which agent readily produces black metallic silver if organic matter be in contact with the salt or its solution. One hundred parts of water dissolve, of nitrate of silver—

at 0°	11°	19°5	110° C.
121.9	127.7	227	1111 parts.

The solution is neutral to litmus. The salt dissolves in 4 parts of cold alcohol. Nitrate of silver fuses at 198° C. into a thin colourless liquid, which stands even higher temperatures without decomposition. At a red heat it is reduced to metal. The fused salt, cast into the form of quill-sized sticks, is used in surgery as a cauterizing agent ("lapis infernalis," or lunar caustic). The sticks gain in firmness if alloyed with a little nitrate of potash.

(2) *Sulphate of Silver* (Ag_2SO_4) forms white crystals soluble in 200 parts of cold or 68 of boiling water, but more soluble in dilute sulphuric acid. It stands a red heat without decomposition.

(3) *Oxide of Silver* (Ag_2O) appears as a dark-brown precipitate when a solution of the nitrate is mixed with excess of caustic potash or—preferably for preparative purposes—baryta water. It is slightly soluble in water, forming a very decidedly alkaline (to litmus) solution, behaving as if it contained the (unknown) AgOH . It seems to suffer reduction in the light. In hydrogen it loses its oxygen at 100° C. (Wöhler), in air from about 250° C. upwards. Solutions of numerous organic substances and other agents reduce oxide of silver, more or less readily, to metal. Ritter produced what he took to be a peroxide of silver by decomposing a solution of the nitrate galvanically, in the form of black metallically-lustrous crystals, which gathered at the positive pole. At 110° C. these decompose almost explosively, with evolution of the 12.77 per cent. of oxygen demanded by Ag_2O_2 ; yet according to Borthelot the crystals are $4\text{Ag}_2\text{O}_2 \cdot \text{AgNO}_3 + 2\text{H}_2\text{O}$. But a hydrate of Ag_2O_2 is got by the action of peroxide of hydrogen on Ag_2O .

1 Preferably blackened for visibility by incorporation of some Chinese ink (carbon).