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AND

Dictionary of Foundry Terms

USED IN THE PRACTICE OF MOULDING.

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BY

SIMPSON BOLLAND,

Practical Moulder and Manager of Foundries;
Author of "The Iron Founder," "The Iron Founder Supplement," etc.

FIRST EDITION.

FIRST THOUSAND.

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PREFACE.

The ordinary dictionaries and encyclopædias of general literature, and even those of the arts and sciences, contain but few notices of *foundry* terms; and where these do occur, the explanations are in many instances very meagre, and often wide of the mark, showing either a limited knowledge of the subjects treated or a want of appreciation of their importance to the practical moulder, as well as to others who need information on such topics.

If this work helps to supply this deficiency the author will be well rewarded. Opportunity has been taken throughout its pages to introduce words which, until lately, had apparently no connection with the founder's art, and in the explanation of which special care has been observed to explain their meaning by such methods of illustration as will bring them into direct association with the whole science of founding particularly.

It is with this view that names of minerals, metals, and chemicals have been inserted, the author believing that, remote as some of them may appear, they all have a bearing, direct or indirect, upon the general business of founding at this day, and should receive at least as much attention as has been accorded them.

The treatment of brass founding, etc., is a reflex of the author's life-experience largely; and whenever it has been thought proper to consult the chemist, metallurgist, or mechanical engineer, the best authorities on these subjects have been chosen.

SIMPSON BOLLAND.

NEW YORK, May, 1894.

THE ENCYCLOPEDIA OF FOUNDING.

A.

Acetate.—A salt formed by the union of *acetic acid* with a salifiable base; as, the acetate of copper, the acetate of silver, etc.

Acetic Acid.—If vinous fermentation is not checked in due time, it passes at once to the stage of *acetous fermentation,* and the liquid becomes sour; oxygen is absorbed, and the alcohol converted into vinegar, or *acetic acid.* See PITCH.

Adhesion.—This is a force which unites dissimilar bodies, and is exerted between substances of all kinds. The sticking of blackening to mould-surfaces, loam to bricks, glue to wood, etc., are well-known examples of adhesive force. See AGGLUTINATION.

Agate.—This stone is an aggregate of siliceous substances, the character and color of which is maintained in the mass. Agate is composed of chalcedony, quartz, amethyst, carnelian, jasper, common opal, etc., with all their varying colors. Its hardness and beauty have brought it into great demand both for useful and ornamental purposes. See STONE; PRECIOUS STONES.

Agglutination.—The act of uniting, by means of some viscous substance, as glue, molasses, etc., which causes an adhesion or sticking together of parts or particles which of themselves have no adhesiveness. Silica-sand with molasses; the various free-sands for cores with glue, flour, rosin, etc., are familiar examples of agglutinants, and their usefulness in foundry practice. See CORE-SAND; FLOUR; GLUE.

Air.—The thin, gaseous medium which surrounds the earth. Air, like all other forms of matter, has weight, as may be proved by exhausting the air from a light flask and, after counterpoising at the balance, allowing the air to enter, when it will at once descend. One hundred cubic inchs of air weighs about 30½ grains, or 828 times lighter than water. Particles of air, like other elastic fluids, mutually repel each other, and would therefore spread out into space, and become exceedingly rare if it were not for the attraction of the earth. Consequently about 50 miles is as far as it extends from the surface, and it thus obtains weight. This weight, or pressure of the air at sea-level is 15 pounds on every square inch, which is called an *atmosphere;* 60 pounds would be four atmospheres, etc.

Several gases enter into the mixture of atmospheric air; oxygen and nitrogen constituting its bulk, however, with a small proportion of carbonic acid and watery vapor, etc. Its average composition by volume is oxygen 20.81, and nitrogen 79.19 in 10,000 parts; or, by weight, oxygen 23.01, and nitrogen 76.99.

The atmosphere is a mechanical mixture, not a chemical compound; it constituents being mixed or diffused throughout each other. A candle will burn in an artificial mixture of nitrogen 4, oxygen 1, and animals will breathe in it, as in the atmosphere. See THERMOMETER.

As a technical term in the foundry, air means any or all of the gases that generate during the processes of casting, which, if not suitably disposed of by *venting*, become a source of annoyance and danger to the moulder. For more definite information and instruction regarding the latter, see VENTING.

Air-pump.—A pneumatic machine for exhausting air from a tight vessel, and thereby produce what is called a vacuum. See VACUUM.

Air-furnace.—A furnace with a natural draft. See WIND-FURNACE.

Albata.—An English name for German silver. See GERMAN SILVER.

Albumen.—This word means the white of an egg. It is found as an organic compound in both animal and vegetable substances. Albumen forms the starting-point of all animal tissue, and may be considered the raw material of fibrin, the substance which forms the basis or *fibre* of muscular tissue. Its composition is: carbon 52.8, oxygen 23.8, hydrogen 7.5, nitrogen 15.7. The most important property of albumen is that of its coagulating or forming a white solid substance by the application of a gentle heat. Hence its use for many purposes in the arts and manufactures. See AGGLUTINATION.

Alcohol.—The purely spirituous parts of liquors which have undergone vinous fermentation. Alcohol mixes with water in any proportion, giving out heat by the mixture; a mutual penetration of the parts takes place, so that the bulk of the two fluids when mixed is less than when separate. All the alkalies when pure, several of the neutral earths and metallic salts, sulphur in vapor, phosphorous, the essential oils, resins, gum-resins, wax, spermaceti, biliary calculi, etc., are, in different proportions, soluble in alcohol. The substances which are insoluble in alcohol are the alkaline carbonates; all the sulphates; some of the nitrates and muriates, metals; metallic oxides, and metallic acids; all the pure earths; the fixed oils, unless when united to alkalies, or converted into drying oils by metallic oxides; muscular fibre; the coagulum of blood; and albumen. Alcohol is highly combustible, producing intense heat without smoke, and for this reason is well adapted to burn in lamps for chemical and other uses. See FUEL.

Alkali.—Alkalies in their pure state possess the following general properties; to the taste they are caustic and acrid; they dissolve animal matter, and form a saponaceous compound with oils or fat; they combine with acids in definite proportions, but the respective properties of each are destroyed, and a neutral salt is the result. It is on this account that most metals are precipitated from their acid solutions by the introduction of an alkali. The most important alkalies are potash, ammonia, and soda—ammonia being soluble, while potash and soda are termed fixed alkalies. See PRECIPITATION.

Allowance.—A foundry phrase, of general application. For example: some portion of a mould or core is scraped or filed away to prevent actual contact of two friable surfaces when closing a mould is called *allowance,* or *clearance.* A small proportion of zinc, over and above the recognized formula, to compensate for what is lost by volatilization during the process of mixing, is *allowance.* In fact, anything performed with the view of minimizing the possibilities of destroying the result of his labor, is recognized by the moulder as making *allowance* for such contingencies.

Alloys.—A combination or mixture of two or more metals. Metals combine with metals to form alloys, and each compound may be looked upon, for many purposes, as a new metal. Alloys are always more fusible than the most infusible metal of which they are composed. A metal of low fusibility, when melted in contact with one of high fusibility, causes the latter also to melt, thus acting as a flux. This principle is employed in soldering, or the joining of two metals by means of a third. See SOLDERING.

In fact, no alloy composed of two metals, as copper and zinc, or copper and tin, either files or turns with the same facility as when a third metal is added to the alloy in suitable proportions. Lead added to copper and zinc, and zinc to copper and tin, will effect this purpose.

It should always be borne in mind that, in making alloys, the more infusible metals should be melted first; and in order that the admixture should be perfect, mechanical agitation must be effected by constant stirring with an infusible rod, or repeated pouring from one ladle or crucible to another. The surface of the metal should also be carefully protected while in a fluid state from the oxidizing influence of the atmosphere. Ordinarily, resin, pitch, or wax will answer this purpose for all alloys having a low fusing-point; but for such as have a high fusing-point, borax, pounded glass, charcoal, or salt will answer. See FLUX.

Not many of the metals may be used by the founder without some alloy, and the following represent nearly all that are employed alone, viz., iron, copper, lead, tin, zinc, gold, silver, mercury, platinum, aluminum. Some are entirely too brittle to be used alone, but may be used for imparting hardness to other metals. Among these may be mentioned *bismuth, arsenic, antimony,* etc. But even copper may not be employed alone for castings, as such castings are invariably unsound, and are difficult to file or machine; yet a suitable proportion of zinc alloyed with it renders it not only sound in the casting, but capable of being either machined, rolled, or hammered, and which constitutes, according to the amount of zinc used, many different kinds of the most useful alloy known, viz., *brass*. See BRASS.

Some of the changes produced by alloying are of great importance in the arts and manufactures, as many of the alloys produced are more valuable on account of their newly-acquired properties than any of the simple metals which enter into the composition.

Strange as it may appear, a quarter of a grain of lead will render an ounce of gold perfectly brittle, although neither of the metals composing the alloy are brittle ones.

Some metals which will not combine together immediately may be united by the intervention of a third fusible alloy. Thus, mercury will not combine directly with iron, but if tin or zinc be first added to the iron, an *amalgam* may be formed of it with mercury (see MERCURY; AMALGAM). When mercury is united with another metal the compound is called an *amalgam*.

One remarkable feature in this connection is that alloys are, as a rule, more easily oxidized than their component metals. For example, it only requires to heat an alloy of tin and lead to redness, when it will at once unite with the oxygen, or take fire and burn. (All the alloys and metals of importance will be explained under their several names.) See FLUID ALLOY; FUSIBLE ALLOY.

Alum, or *sulphate of alumina and potash,* is a triple salt of great importance in the arts and manufactures. Sometimes it is found native, but it is chiefly manufactured artificially from alum-slate. A large quantity is prepared in this country by treating alumina or clay with sulphuric acid, and after the lapse of a few months adding potash.

The whole is then leached and the alum separated from the solution by crystallization. It is of great importance in dyeing, in the manufacture of leather, and in calico-printing. Alum is soluble in 16 parts of water at 60°, and in three-fourths of its weight of boiling water; its composition is: sulphate of alumina 36.85, sulphate of potash 18.15, water 45.00.

Aluminum.—A bluish-white metal of remarkable brightness, its specific gravity being only a quarter that of silver (2.56), or about the same as porcelain. Next to oxygen and silicon, it is perhaps the most abundant element upon the earth's surface, and is more abundant than any other metal, as it is supposed to constitute one twelfth of the solid crust of the earth. Most rocks and soils hold enormous quantities of this metal in combination with oxygen and silicon, and slate, marl, feldspar, clay, and many other common minerals contain it in large proportions.

Notwithstanding its abundance, it cannot be applied to the many uses for which it is so well suited, because as yet the methods for obtaining it are very costly, although considerable progress has been made of late in devising cheaper means to this end. The metal is malleable, ductile, and tenacious, and may be beaten into thin sheets, and drawn into fine wire, after the manner of silver. Hammering in the cold makes it hard, like soft iron; fusing softens it again. Hammering increases its specific gravity from 2.56 to 2.67. It melts at red heat, but does not oxidize at high temperatures; it is not acted upon by chemicals that would blacken silver, and because of this quality it preserves its lustre better than the latter metal, which is usually attacked by the sulphur contained in some foods, forming with the silver a dark composition. Nitric acid, even when concentrated, fails to touch it, and it is not soluble in dilute sulphuric acid. Concentrated hydrochloric acid dissolves it with evolution of hydrogen. The metal is also dissolved with solutions of caustic potash or soda, which forms aluminate of potash or soda, giving off hydrogen.

Aluminum is employed extensively in the manufacture of delicate apparatus, ornamental articles, etc., but it is as yet only valuable as an alloy with other metals, such as steel, cast-iron, copper, nickel, and some others, the quality of which is very perceptibly improved by certain additions of aluminum. The property of this metal, when combined with steel, iron, and copper, is to increase their tensile strength and resistance to oxidation.

The fluidity of cast-iron is much improved by this metal, and it is claimed that the castings are much more sound and cleaner when alloyed with a surprisingly small amount of aluminum.

Alloyed with brass or copper, it improves equally tensile strength, color, and durability, and gives a dense solid casting free from porosity. To effect the above result it is only necessary to flux with from ½ to 1 per cent of aluminum.

The true bronze—aluminum 10, copper 90—is a somewhat brittle, gold-colored alloy at the first melting, but it increases in tenacity and strength with successive meltings, until at a dull red heat it may be forged and hammered until it has become cold, without presenting any cracks at the edges.

One of the qualities possessed by aluminum bronze is that it may be made softer and more ductile by plunging into cold water while hot. The tensile strength of good bronze is about 90,000 pounds per square inch.

In making this bronze in crucibles, use a layer of charcoal over the copper, but no flux. When the copper has melted, push the aluminum down into the molten copper before lifting out the crucible, after which it may be skimmed clean and poured. No time should be lost in handling this alloy after it has been well stirred and freed from slag.

Small proportions of gold, silver, tin, or zinc increases the hardness, but does not materially affect the ductility of aluminum. Three per cent of zinc improves it; 7 per cent of tin impairs its lustre, and with lead, mercury, and antimony it will not combine. Articles made in this metal may be freed from the bluish tint, and made to appear like frosted silver by immersing in a hot solution of potash. Soldering aluminum has so far proven a difficult task; most solders will not stick to the surface of aluminum and owing to its high heat conductivity, the heat is very rapidly drawn away from any of the molten solders, causing them to freeze before flowing sufficiently. These difficulties have been largely overcome by having the aluminum to be soldered hot, the surfaces especially cleaned, and with very hot soldering bits or careful work with the blow pipe, and with special alloys for solders and special fluxes. Several such methods are successfully used. Soldering bits of nickel are better than copper ones, and especially good work has been done with those kept hot by a gasolene torch or electric appliance.

Due to the peculiar nature of aluminum and its commercial impurities, ordinary hard solder (composed of silver and tin), soft solder (composed of lead and zinc), or any of the ordinary forms of solder, do not "stick" to the metal.

The Pittsburgh Reduction Company have a process protected by letters-patent for treating aluminum so that certain forms of solder will work satisfactorily with it.

Due to the high heat conductivity of aluminum, the heat from the molten solder is conducted away from it so rapidly that it will not "flow under" as satisfactorily as could be desired. The above-mentioned company have arrangements for overcoming this difficulty and soldering satisfactorily.

The quality of ordinary bronze, or gun-metal (copper 90, tin 10), is much improved by an addition of about 2 per cent aluminum.

All anti-friction metals, especially babbitt-metal, are improved by the addition of from $\frac{1}{4}$ to $\frac{1}{2}$ of 1 per cent aluminum.

Steel is rendered more fluid for casting with by a small percentage of aluminum added to each ladleful of metal before pouring. From $\frac{3}{8}$ to 1 pound to a ton of steel is usually sufficient for this purpose; it diffuses through the mass without stirring, makes sounder castings and freer from honeycomb.

Its effect upon gray cast iron is not very pronounced, but white iron containing combined carbon 4.80, and no graphite, is changed to a gray iron containing graphitic carbon 3.45, combined carbon 0.93, by the addition of about 3.20 per cent of aluminum, thus causing an entire change from white iron to gray.

Most type-metal mixtures are appreciably improved by a further alloy of from 5 to 10 per cent aluminum, the edges of the type being made harder and metal more durable.

With nearly all brass mixtures it imparts a higher degree of homogeneity, and lessens the tendency to corrosion.

Zinc galvanizing is made more easy of accomplishment, and with improved results, by adding a slight proportion of aluminum to the zinc, a thinner and more tenacious coating being made possible by this means.

Besides the numerous aluminum alloys given elsewhere, there are many new compositions which are claiming considerable attention, in which aluminum enters as a principal ingredient, some of which are as follows:

Bourbounz-metal contains aluminum 85.74, tin 12.94, silicon 1.32.

Nickel-aluminum contains aluminum 8, nickel 20.

Metalline contains aluminum 25, copper 30, cobalt 35, iron 10.

Rosine, for jewelry, contains aluminum 30, nickel 40, tin 20, silver 10.

Cobalt-bronze contains aluminum 10, copper 40, cobalt 50. See ALUMINUM ALLOYS; ALUMINUM-BRONZE ALLOYS.

The impurities most commonly found in aluminum are silicon and iron, and it may be said of the metal made by the Pittsburgh Reduction Company that these two impurities are the only ones found. Silicon in aluminum exists in two forms, one seemingly combined with aluminum as combined carbon exists in pig-iron, and the other as an allotropic graphitoidal modification.

For many purposes the pure aluminum cannot be so advantageously used as that containing 3% or 4% of impurities, as the pure aluminum is soft and not so strong as the less pure. It is only where extreme malleability, ductility, sonorousness, and non-corrodibility are required, that the purest metal should be used.

The purity of commercial aluminum varies from 94% to 99.75%. The Pittsburg Reduction Company sells its commercial aluminum in three grades.

The No. 1 grade of aluminum has an analysis approximately as follows :

Silicon	0.50%.
Iron	0.25%.
Aluminum	99.25%.

They always have, however, in stock metal still purer than this; some running as high as 99.90% pure, which is sold at an added price for special uses.

The No. 2 grade ordinarily runs quite uniform in composition, and has an analysis approximately as follows :

Silicon.....	3%.
Iron.....	1%.
Aluminum.....	96%.

This metal, however, is not guaranteed to be over 94% pure.

Sound ingots of the No. 1 grade metal, suitable for rolling, are kept in stock of the following sizes :

12 inches	x	18 inches	x	1⅜ inch.
12 "	x	18¼ "	x	1⅛ "
11½ "	x	16¼ "	x	1 "
12½ "	x	6 "	x	¾ "
5½ "	x	2 "	x	½ "

Aluminum for remelting is kept in stock of the various grades of metal, in what are called "waffle" ingots. They are square placques, three inches on a side and of about ¾ inch thickness, and weigh about one half pound each. They are connected together with thin webs.

A sheet of aluminum twelve inches square and one inch thick weighs 14.12 pounds; a bar of aluminum one inch square and 12 inches long weighs 1.176 pounds; a bar of aluminum one inch in diameter and 12 inches long weighs 0.918 pounds.

Weight.—The weight per cubic inch of cast aluminum is .092 lb.; of rolled aluminum, .098 lb.

The weight per cu. ft. of cast aluminum is .158.989 lbs.
The weight per cu. ft. of rolled aluminum is.169.510 lbs.
The weight per cu. ft. of wrought iron is...480.000 lbs.
The weight per cubic foot of soft steel is....490.450 lbs.
The weight per cubic foot of brass is.......524.160 lbs.
The weight per cubic foot of copper is......558.125 lbs.

The weight of a given bulk of cast aluminum being 1, soft steel or iron is 3.0 times as heavy; copper is 3.6 times as heavy; nickel, 3.5 times as heavy; silver, 4 times as heavy; lead, 4.8 times as heavy; gold, 7.7 times as heavy, and platinum 8.6 times as heavy.

Strength.—The tensile, crushing and transverse tests of aluminum vary very considerably with different conditions of hardness, due to cold working; also by the amount of work that has been put upon the metal, the character of the section, etc. Cast aluminum has about an equal strength to cast iron in tension, but under compression is comparatively weak. The following is a table giving the average results of many tests of aluminum of 98.5 % purity:

		POUNDS.
Elastic limit per sq. in. in tension	(castings)	8,500
" " " "	(sheet)	12,500 to 25,000
" " " "	(wire)	16,000 to 30,000
" " " "	(bars)	14,000 to 25,000
Ultimate strength per sq. in. "	(castings)	18,000
" " " "	(sheet)	24,000 to 50,000
" " " "	(wire)	30,000 to 65,000
" " " "	(bars)	28,000 to 45,000
Per cent of reduction of area in tension	(castings)	15
" " " "	(sheet)	20 to 30
" " " "	(wire)	40 to 60
" " " "	(bars)	30 to 40

Elastic limit per square inch under compression in cylinders, with length twice the diameter....... 3,500

Ultimate strength per square inch under compression in cylinders, with length twice the diameter. 12,000

The modulus of elasticity of cast aluminum is about 11,000,000.

Aluminum in castings can readily be strained to the unit stress of 1500 lbs. per sq. inch in compression, and to 5000 lbs. per sq. inch in tension. It is rather an open metal in its texture; and for cylinders, to stand pressure, an increase in thickness over the ordinary formulæ should be given to allow for its porosity.

Under transverse tests, pure aluminum is not very rigid, although the metal will bend nearly double before breaking, while cast iron will crack before the deflection has become at all large.

The texture and strength of aluminum are greatly improved by subjecting the ingots to forging or pressing at a temperature of about 600° Fahrenheit.

Taking the tensile strength of aluminum in relation to its weight, it is as strong as steel of 80,000 pounds per square inch. Comparative results in this way are tabulated below as taken from Richards' work on "aluminum."

	Weight of 1 Cubic Foot in Pounds.	Tensile Strength per Square Inch.	Length of a Bar able to Support its own Weight in Feet.
Cast iron	444	16,500	5,351
Ordinary bronze	525	36,000	9,893
Wrought iron	480	50,000	15,000
Hard structural steel	490	78,000	23,040
Aluminum	168	26,800	23,040

Rolled Copper has a specific gravity of 8.93. One cubic foot weighs $558\frac{125}{1000}$ lbs. One square foot of one inch thick weighs $46\frac{51}{100}$ lbs.

Rolled Aluminum has a specific gravity of 2.72. One cubic foot weighs $169\frac{510}{1000}$ lbs. One square foot of one inch thick weighs $14\frac{126}{1000}$ lbs. Rolled copper is 3.283 times heavier than similar sections of rolled aluminum.

COMPARATIVE WEIGHT OF METALS.

Metals.	Weights per Square Foot 1 Inch Thick.	Approximate Percentage.	
		Heavier than Iron.	Lighter than Iron.
Iron, rolled...........	40.000	....	....
Steel, "	40.833	2 per ct.	....
Aluminum, "	14 126	....	62.91 per ct.
Brass, "	43 68	7 per ct.	....
Copper, "	46 51	13 "	....
Gold, "	100.8	150 "	....
Lead, "	59 80	50 "	....
Nickel, "	43.2	7 "	....
Silver, "	54.75	$36\frac{7}{8}$ "	....
Tin, "	38.	....	5 per ct.
Zinc, "	37.6	....	6 "

TENSILE STRENGTH OF SOME ALUMINUM BRASS ALLOYS.

Aluminum.	Copper.	Zinc.	Tensile Strength per Square Inch. Lbs.
1.00	57.00	42.00	68,600
1.15	55.80	43.00	70,200
1.25	70.00	28.00	36,900
1.50	78.00	27.50	42,300
1.50	77.50	21.00	33,417
2.00	70.00	28.00	52,800
2.00	70.00	28.00	52,000
2.50	68.00	30.00	65 400
3.00	67.00	30.00	68,600
3.30	63.00	33.30	86,700
3.30	63.30	33.30	77,400
3.30	63.30	33.30	92,500
3.30	63.30	33.30	90,000
5.80	67.40	26.80	96,900

TABLE SHOWING WEIGHT IN POUNDS OF SHEET AND BAR ALUMINUM AND BRASS.

Rolled brass is 3.021 times heavier than rolled aluminum.
Rolled steel is 2.890 times heavier than rolled aluminum.

Thickness or Diameter in Inches.	Sheets per Square Foot.			Square Bars One Foot Long.			Round Bars One Foot Long.		
	Alum'um.	Brass.	Steel.	Alum'um.	Brass.	Steel.	Alum'um.	Brass.	Steel.
1-16	.884	2.7	2.556	.00450	.015	.013	.00346	.011	.010
1-8	1.769	5.41	5 112	.01834	.055	.053	.01453	.045	.042
3-16	2.647	8.12	7.65	.04118	.125	.119	.03253	.1	.094
1-4	3.530	10.76	10.20	.073364	.255	.212	.05780	.175	.167
5-16	4.412	13.48	12.75	.1152	.350	.333	.09032	.275	.261
3-8	5.294	16.25	15.30	.1654	.51	.478	.12970	.395	.375
7-16	6.177	19.	17.85	.2253	.69	.651	.1768	.54	.511
1-2	7.060	21.65	20.40	.2941	.905	.850	.2308	.71	.667
9-16	7.942	24.3	22.95	.3723	1.15	1.076	.2924	.9	.845
5-8	8.824	27.12	25.50	.4595	1.4	1.328	.3609	1.1	1 043
11-16	9.706	29.77	28.05	.5564	1.72	1.608	.4367	1.35	1.262
3-4	10.590	32.46	30.60	.6620	2.05	1.913	.5198	1.55	1.502
13-16	11.470	35.18	33.15	.7768	2.4	2.245	.6104	1.85	1.763
7-8	12.35	37.85	35 70	.9008	2.75	2.603	.7074	2.15	2.044
15-16	13 23	40.55	38.25	1.034	3.15	2.989	.8122	2.48	2.347
1	14.12	43.29	40.80	1.176	3.65	3.400	.924	2.85	2.670
1.1-16	15.00	45.95	43.35	1.328	4.08	3.838	1.043	3.20	3 014
1.1-8	15.88	48.69	45.90	1.488	4.55	4.303	1.169	3.57	3.379
1.3-16	16.76	51.4	48.45	1.659	5.08	4.795	1.303	3.97	3.766
1.1-4	17.64	54.18	51.00	1.838	5.65	5.312	1.444	4.41	4 173
1.5-16	18.52	56.85	53.55	2.027	6.22	7 857	1.592	4.86	4.600
1.3-8	19.41	59.55	56.10	2.224	6.81	6.428	1.747	5.35	5.059
1.7-16	20.30	62.25	58.65	2.431	7.45	7.026	1.909	5.85	5.518
1.1-2	21.18	65.	61.20	2.647	8.13	7.650	2.079	6.37	6.008
1.9-16	22.06	67.75	63.75	2.872	8.83	8.301	2.256	6.92	6.520
1.5-8	22 94	70.35	66.30	3.107	9.55	8.978	2.440	7.48	7.051
1.11-16	23.82	73.	68.85	3.350	10.27	9.682	2.631	8.05	7.604
1.3-4	24.70	75.86	71.40	3.602	11.	10.41	2.830	8.65	8.178
1 13-16	25.58	78.55	73.95	3.865	11 82	11.17	3.036	9.29	8.773
1.7-8	26.46	81.25	76.50	4.135	12.68	11.95	3.249	9.95	9.388
1.15-16	27.43	84.	79.05	4.415	13.5	12.76	3.467	10.58	10.02
2	28.22	86.76	81.60	4.706	14.35	13.60	3.696	11.25	10.68

Aluminum Alloys.—The following alloys comprise most of those which are in common use. Such alloys as have been made with other metals have not as yet been recognized as having any practical value in arts or manufactures.

	Aluminum.	Silver.	Copper.	Gold.	Tin.
Aluminum silver, for fine instruments..........	96	4			
Alloy, for watch-springs, etc....................	5		90		
Aluminum bronze, hard malleable gold color....	10		90		
" " soft " "	5		95		
" " medium " greenish gold.	7½		92½		
Solid copper castings..........................	1		99		
Aluminum copper, for engraving....	2		98		
Alloy, hard as coin-silver	5	95			
Alloy, extremely hard.........................	50	50			
Alloy, ductile, hard, greenish..................	99			1	
Alloy, brittle, crystalline	90			10	
Alloy, harder than aluminum and polishes well..	95	5			
Alloy, similar to 14-carat gold..................	10		85	5	
Gun-metal, with aluminum alloy, equal to cast-steel in strength; good for bells, etc....... ..	2		90		10

Aluminum Bronze.—The best quality of aluminum bronze is made by alloying copper with from five to ten per cent of aluminum.

The alloy is far superior to any of the common bronzes, being far more rigid—chips, files, and machines better; the turnings not being short and chippy, like brass or cast-iron, but long and connected after the manner of the best mild steel. It has a beautiful gold color, takes a splendid polish, does not easily tarnish, works well under the artist's tools; and, while it makes an excellent imitation gold, and as such is used extensively for a great variety of objects, useful and ornamental, yet it is unquestionably the king of alloys for guns, journal-bearings, bells, and many other purposes too numerous to enumerate here, owing to its great tenacity, malleability, and good wearing qualities, the fineness of its grain making it a highly desirable alloy for all parts of machinery that are subjected to friction.

Like copper, its qualities of softness and ductility are improved by sudden cooling, and, strange to say, like iron, it may be forged and welded—something utterly impossible with other alloys. But to obtain the best results it is absolutely necessary that the best copper and the purest aluminum be used for making the alloy. See ALUMINUM; ALUMINUM ALLOYS.

Amalgam means that class of alloys with which mercury forms one of the combining metals. With regard to the nature of the union that takes place in such combinations it has been remarked that, on adding successive small quantities of silver to mercury, a variety of fluid amalgams are apparently produced. Really, the chief, if not the only, compound resulting from this operation is a solid amalgam, which is intimately diffused throughout the fluid mass. In other words, the fluidity of an amalgam depends on there being an excess of mercury over and above the amount required to form a definite compound. Mercury immediately combines with silver and gold at common temperatures, but with iron, even when hot, it is not disposed to unite. See AMALGAMATION; MERCURY.

Amalgamation is the operation of mixing mercury with any metal to form an *amalgam*. This is done by fusing the metal first and adding the mercury to it, on which they at once mutually attract each other. The amalgam of gold with mercury is made by beating gold (1 drachm) into thin plates and setting them into a red-hot crucible; the mercury (1 ounce) is then poured in, and the whole well stirred with an iron rod until it begins to fume, when it must be poured into water to coagulate. Some processes of gilding and silvering are conducted by amalgamation (see MERCURY); but its most extensive use is in separating metals, silver especially, from their ores by dissolving the particles of metal and leaving the earthy matter. Substantially, the process consists of first crushing the quartz rock, in which the particles of gold are imbedded, by means of stamp-mills, and placing the dust, mixed with mercury, into rapidly revolving vessels. The mercury, by this process, attaches to itself all the gold particles and forms a semi-fluid mass, which is mercury in a half-congealed state, containing all the gold. This amalgam is then placed in a retort and heat applied; which operation separates the mercury by sublimation, to be again employed for further amalgamation, and leaves the collected gold in the body of the retort. See AMALGAM; SUBLIMATION; MERCURY; SILVER; GOLD.

Amber.—One of a number of fossil substances that resemble the resins. It is found along the shores of the Baltic, and occurs in beds of lignite in many localities. With friction it becomes highly electric. It is a mixture of several resinous bodies; it also contains *succinic* acid. Only one eighth part is, in its natural state, soluble in alcohol; but it dissolves readily after it has been fused, in which state it is used for a varnish, etc. It is composed of carbon 80.5, hydrogen 7.3, oxygen 6.7, ashes (lime, silica, alumina) 3.27. See RESIN.

American-Scotch Pig-iron.—A common name for some brands of American pig-iron, in which the silicon is high, and for which reason they have gradually supplanted the original Scotch irons which were formerly imported as softeners. See SCOTCH IRON; SOFTENERS.

Ammonia.—A colorless irrespirable gas, of an extremely pungent and caustic taste, lighter than air (sp. gr. 0.59). It exists in very minute quantities in the atmosphere, rain-water, fog, and dew. Ammonia is the only known compound of nitrogen and hydrogen; it is a constant product of the decomposition of organic substances which contain nitrogen. It is produced from the destructive distillation of horns and hoofs, but the liquor of the gas-works furnishes the chief source of commercial ammonia. Being a gas it is called *volatile alkali* to distinguish it from those which are fixed, or solid. Owing to the fact that it was derived from the horns of harts, it is commonly called spirits of hartshorn. See ALKALI.

Amorphism.—This term expresses the opposite of the crystalline state. Diamond is crystalline carbon; charcoal and lamp-black are amorphous carbon. Amorphous bodies are without any regular form or trace of crystalline structure, as wrought-iron; they fracture irregularly, in any direction, and are generally more soluble and less hard and dense than in the crystalline form. See CRYSTALLIZATION.

Anchor.—A name frequently given to studs and chaplets generally, but more correctly applied to any special contrivance for maintaining isolated portions of a mould which, but for such means, would be forced out of position. A core is *anchored down* when its security depends on a bolt, or wire, which binds it to the mould. See CHAPLET.

Analysis.—The subject of analysis in relation to general foundry practice has for some time occupied the attention of our foundry associations East and West, and called forth considerable comment from leading chemists and manufacturers all over. The writer's views upon the question are set forth in the following paper, composed by him, and read at a meeting of the Western Foundrymen's Association, held in Chicago, February 28, 1894:

An article of mine on "Mixing Cast Iron," which appeared in the issues of March 24 and 31, 1892, of the *American Machinist,* and now constitutes the third chapter in my book, "The Iron Founder Supplement," was the natural outcome of experiences therein related. It was with some trepidation on my part that the article was presented, as at that early period of my experience in these matters I hardly felt able to adequately exhibit a subject which, to me at least, appeared in the light of a revelation.

The article met with a determined opposition from some quarters, both here and abroad ; but I shall ever esteem the kindly criticism of Professor Torrey, who, while admitting that science must, for some time at least, get the lion's share of the benefits accruing from a system of chemical analysis in the foundry, thought the establishment of laboratories, and the installation of chemists in that department of the iron industries, would be a very good thing. He concludes a very instructive review of the subject as follows : "I have no intention of trying to instruct Mr. Bolland, or any other foundryman. I have simply called to mind a number of facts with which they are, presumably, as well acquainted as I am—better, perhaps, with one side. The only object in so doing is to put the question of chemistry in the foundry in its proper light with relation to existing facts. Perhaps the foundry at large, from a business point of view, would be benefited by the co-operation of the chemical laboratory; but I do not as yet believe it. . . . The foundry has not the great train of waste and by-products that many industries have, and the waste, such as it is, can be better controlled. The one place where it would seem that chemistry might come in would be in the mixing of irons, as Mr. Bolland suggests ; but, as previously stated, it is by no means certain that anything definite or satisfactory would be accomplished." Since then, however, a gradual change has been taking place, and an eminent metallurgical chemist, Mr. Clemens Jones, emphatically states that "the foundryman is in a position to say to the pig-iron maker, 'I want such a quality of iron,' and the furnace manager is in a position to light his fires and make it."

With such assurance from one so conspicuously qualified to pronounce an opinion on these themes, may we foundrymen not anticipate the time when, by reason of a superior education, we shall be able to exactly determine our requirements, and prove beyond question the validity of such an assertion?

We who are not chemists naturally cling tenaciously to the only tangible support that, up to the present, has been vouchsafed us, viz.: the testing-machine; and I am persuaded that it will take some time to convert the large majority of founders to a belief in this (to them) new departure. My first acquaintance with this subject dates from the time when I was associated with Mr. Molin, metallurgical chemist, New York City. At that time I looked upon the faculty as a decided superfluity in a foundry; but it gives me pleasure to say that, while he noticed my self-assurance, he consistently acted, not only the scholar, but the gentleman. He also unmistakably demonstrated his ability to accomplish, by chemical analysis, what had before seemed impossible of accomplishment; and, while he may not have made a chemist out of such crude material, I am certainly a sound convert to the methods of which he is so able an exponent.

A careful perusal of Mr. Keep's able papers and other kindred works, as well as the exhaustive productions read before this and the Eastern Association by our foremost chemists, has established my belief beyond question. Mr. Henderson, in his address before the Foundrymen's Association, of Philadelphia, brings this whole subject out in bold relief when he says: "But what of permanent avail is accomplished by the application of physical tests to material the chemical composition of which is unknown? The very utmost that can be hoped from such tests is to establish the fact that a definite lot of material is either good or bad."

The above is preceded by a forcible plea for the recognition of chemistry as a factor in foundry practice on the following grounds: "That, whereas it is known that certain impurities in material produce certain characteristic effects upon the physical behavior of manufacture resulting from its employment; that certain combinations of impurities produce certain other effects, and that in the process of conversion, which is in every case a chemical one, these impurities may be eliminated, retained, or forced into combination with others according to fixed laws and conditions to which they are subjected." But he further affirms that in order to secure a proper adjustment of these proportions, so that the resultant casting shall meet all the requirements in the case, ability of the highest order must be employed, simply because the line is not so clearly defined, on either side of which an element may not enter into its composition without disaster.

The same author, comparing the value of chemical against physical tests, affirms that, "A fact once established by chemical research remains fixed for all time. When it is known that a certain percentage of an element in a material under certain conditions produces a certain physical effect, every time these conditions are reached in this material having the same percentage of the element this identical physical effect is obtained and no other."

Mr. Keep claims that "intelligent mixing of irons cannot be accomplished without the aid of chemistry, and con clusions must be reached by the united work of chemistry and physical experiment." That the time is not far distant when the chemist will be acknowledged as the supreme factor in foundry economics is significantly put by the same author, who on this phase of the subject says: "If a man with a thorough chemical education would learn to look at general tendencies and not hold so closely to four figures of decimals, and accept the results of late research, he could adapt himself to general foundry-work and be of great use. He would soon leave his laboratory and become the practical leader, and would only go back occasionally to solve some problem that needs new light. We cannot have too much respect for chemistry. Practical research could do nothing without it; but after general conclusions are reached, then to be of use the chemist must become the practical metallurgist."

On this head, Professor Torrey cogently informs us that "it takes the skilled metallurgical engineer to reason from the chemistry to the physics of iron; and the chemist must be a good one if the results are to be good for anything.

It may be readily inferred from the preceding that the chemist's work in the foundry must be practical in all its bearings, and that a mere school knowledge of the science would be of little service there.

Subjects like the porosity of castings, cast-iron and steel, would, under the supervision of a chemist, be subjected to a superior system of examination: even the ordinary crucible tests would receive his strict attention, with the positive assurance of their being made intelligently. Metal-mixing would be transferred from the ignorant mechanic, with his crude systems, to the more positive and scientific methods of chemical research—just where it should have been long ago. For the want of intelligent direction, the best systems of mechanical testing have always been more or less defective; and, as matters now stand, formulas of any kind are seldom understood and as seldom acted up to. The chemist would change all this with the greatest ease and dispatch. The business of steel-founding would have developed more rapidly if the chemist had been consulted with regard to the materials for forming the moulds as well as for the metal with which to fill them. Brass-founding is almost exclusively a branch of metallurgical chemistry; and it is safe to say that the few advances made in that art have emanated from the chemist's laboratory rather than the brass-shop.

There is nothing used in a foundry that does not require rigid inspection when purchased, such as an able chemist only can give; and it would be to the interest of every firm that not only the iron, but fuel, sand, fire-bricks, clays, and every material employed, should undergo close scrutiny. By this means all fraudulent impositions would be at once detected. Already we may observe that sands for foundry purposes are receiving some attention from the chemist.

Analysis at once discovers just what may be used for the numerous classes of castings made. We may expect to be informed that in the great majority of cases we have been unnecessarily annoyed by the presence of elements unfavorable to the production of good castings, when, perhaps, a more suitable material has been overlooked that might have been employed with impunity at a much less cost. The percentage of iron oxide, alumina, organic and volatile matters present being made known, there will be no difficulty in making such selection as will meet every requirement absolutely.

It is reasonable to presume that the advent of a chemist in the foundry will deter the artful agent from forcing material upon a firm that did not in every respect measure to the full what it was represented to be, and it is certain that the popularity of many favorite irons would go up with the smoke from the laboratory when a test in the latter sanctum had revealed its marked deficiencies.

Fracture will no longer be relied upon, as it is now a well-authenticated fact that analysis has shown that very many of the No. 1 irons are inferior to No. 2 of other brands which may be purchased for less money—saving, in many instances, from 50 cents to $1.50 per ton.

There can be no question as to how some of our foremost firms are producing castings for such low figures at this time. To my personal knowledge, analysis of the materials employed is at the bottom of it; for, by reason of the knowledge thus obtained, they have been enabled to purchase both pig-iron and scrap at ridiculously low figures, very much of which, under the old rule-of-thumb methods, would have been rejected as unfit for the purpose. In many instances this decided advantage has been further supplemented by the production of better castings.

It is certain that those who buy on analysis, knowing what they want, monopolize every opportunity for grabbing whatever offers cheap, as the chances for future disappointment are reduced to a minimum by the substitution for the old unsafe method of one that is not only cheap, but sure.

There is practically no difficulty in producing steel of any desired quality, owing to the fact that the different elements are now so well known and may, by chemical test, be regulated in such proportions as will result in the quality of steel required. To accomplish this without loss and inconvenience, all the material is tested before purchase is made, and the user knows exactly what he has bought, and can, without fear of mistake, proceed to the manufacture of his product, knowing from the beginning what the end will be. Surely castings, pig-iron and scrap, can be analyzed with as great nicety so that when fault is found with the resultant castings, the true cause of the trouble may be located, the mixture changed to the requisite proportions, and thus control the business as effectually as it is now done for steel. In framing mixtures for cast iron, it must naturally occur to the least observant that if a certain proportion of the elements contained in the iron produce certain chemical effects, which, in turn, are productive of certain physical properties which may be altered according to the proportions employed, we are forced to the conclusion that chemical analysis will reveal whatever is lacking, and will also suggest a remedy.

A defect in some pump-castings resulted in an analysis of the iron being made by Mr. Molin, who found that it was too high in graphitic and correspondingly low in combined carbon, which caused a soft, porous iron that would dissolve rapidly in the water from the mine. This discovery led to an immediate change in the mixture—an additional quantity of combined carbon effecting at once what under the old *régime* would not have been satisfactorily accomplished until the offending stock had been all used up and a change brought about, perhaps, by a new consignment. The latter alternative is, unfortunately, the only means of escape possible for numbers of foundries to-day almost everywhere. Desiring to learn more in reference to the above, I waited upon the superintendent of the firm, who informed me that an elaborate system of physical tests were the order of the day, and that unremitting attention was paid to this department; but he was now firmly persuaded that, unless this was accompanied by chemical analysis, they would always be subject to a like experience.

Personally, I may state that since I became satisfied in reference to the wonderful property of silicon to change white and intermediate grades of iron more or less high in combined carbon, into graphitic iron, I have experienced no difficulty whatever in arranging my mixtures, simply because a physical test informs me of its strength, and, if the shrinkage is found too high, it is evidence of hardness, which latter condition I now know may be lessened by an increase of silicon, the shrinkage always decreasing in proportion as the iron becomes more graphitic.

It is not supposed that the common run of small foundries will employ a chemist, but if it be found in the long run that the system of analysis pays, there is no question but that they too will contrive some means for obtaining these valuable aids. For instance, proprietors' sons who have hitherto been satisfied with the regular routine of office-work will now have their ordinary course of education supplemented by a course in metallurgical chemistry, and thus qualify themselves for the position of chemist as well as clerk.

A chemist lately said that the reason of foundrymen remaining in the blindfold state in which they are is simply their ignorance of the fine elements which determine the quality of their castings; and, furthermore, that this knowledge can be easily obtained by any intelligent clerk, who may then with an outfit, costing about $200, proceed to make tests for these elements as satisfactorily as any chemist.

One thing, however, is certain—our young men are gradually awakening to the advantages open for students in the technical schools; and, as chemistry is taught at most of them, we may expect in the near future to see our benevolent employers rendering substantial aid to their apprentices, in order that they may be qualified for the important duty of making an analysis.

Why is it that our technical schools stand aloof from this all-important question? Is this, like everything else pertaining to the foundry, to be tabooed also? Have moulders and founders no rights that these institutions feel bound to respect? Surely the day is now past when a foundryman is to be spurned because of the apparent griminess of his business. I think the advent of chemistry in the foundry will mark a new era in the history of foundrymen. Hitherto the faculty have shunned them on account of their surroundings, but the rays of science have penetrated the dark moulding-shop at last, and her votaries hasten to undo the errors of the past, because, discerning the numerous problems that remain as yet unsolved, they have finally cast prejudice aside, and are now walking hand in hand, the more practical moulder being guided by the scientist in paths that harmonize with physical law.

Your true man of science now acknowledges freely that the foundryman is deserving of more than ordinary credit in that so much has hitherto been accomplished by men who were shrouded in such a dark panoply of ignorance.

It is to the truly great among these men of science that the future founder must look for enfranchisement. Let furnaces and the necessary equipment for the smelting of ores, metals, alloys, etc., be at once erected in our technical schools, where our aspiring youth may be taught experimentally how to eliminate the objectionable elements from metals; also to determine by analysis of materials, including fuel, slags, ores, fluxes, etc., what their natures consist of, and thus qualify themselves for the very excellent change in their position, which to me seems inevitable in the near future.

Annealing. — The process of removing brittleness from castings, glass, and other substances by heating them to a specified temperature in suitable ovens or furnaces for a certain period, and then allowing them to slowly become cool again, prolonging the time in accordance with the nature of the article under treatment. Glass is heated to almost smelting heat to admit of a uniform arrangement of its molecules before it is in a suitable condition for grinding and polishing—from six hours to two weeks being required for this complete operation, according to thickness; heavy plate requires the longest time. The brittleness to which heavy steel-dies are subject is removed by placing them in water, heating to boiling, and then gradually cooled. Lead, tin, and zinc are annealed in the same manner. Heavy castings in bronze or cast iron may be partially annealed by slow cooling in hot cinders.

Annealing is evidently the inverse process of tempering, the latter operation acting to fix the molecular condition of steel by a rapid (*not a slow*) change of temperature. See TEMPERING; MALLEABLE CAST-IRON; CAR-WHEEL.

Animal Casts in Metal.—See INSECT CASTS IN METAL.

Anthracite.—A kind of coal which is known by many names, as stone, blind, glance, and Kilkenny coal. There are several varieties and nearly all possess the property of burning without smoke or flame. See COAL.

Anthracite Facing.—Finely ground Lehigh coal, which has been carefully selected for its freedom from impurities. It is one of the cheapest blacking-facings, and answers just as well as the dearer brands for rough work and cores when mixed with a small proportion of charcoal-facing—especially as a wet blacking. See FACING; BLACK-WASH.

Antifriction Metals are alloys compounded with the view of lessening friction in the bearings and journal-boxes of machinery. Some of the compositions given in the following table are for linings only, while others are for the bearings or steps, which require no lining.

ANTIFRICTION ALLOYS.

	Copper.	Tin.	Lead.	Antimony.	Zinc.	Grain Zinc.	Iron.
Good Lining for general use........	....	....	....	1	7¼	7½	....
Good Bearing (not a lining)	1	....	....	1½	17	..	...
" " (" " ")........	....	10	....	5	85	..	....
Lining (soften with lead if too hard)	1	8	....	2	....	..	....
Lining	1	10	....	1	...	..	....
Journal-box Lining, to be melted and run into ingots first..........	24	24	....	8	....	..	....
Lining subject to heat.............	17	0.5	0.25	..	1	.	....
Lining subject to shock	20	1	....	..	6	..	....
Lining for Loco. Axle-tree..........	86.03	13.97	....	..	....	..	....
" " " " French..	82	10	....	..	8	..	....
" " " " English..	73.96	9.49	7.09	..	9.03	..	0.43
" " " " Belgian..	89.02	2.44	....	..	7.76	..	0.78
" " " " Stephenson	79	8	....	..	5	..	...
Extra Lining (melt tin and antimony and pour to the melted copper)...	1½	25	....	3	....	..	....
Lining, for a heavy weight.........	1	2½	....	..	½	..	....
Hard Bearing	16	2	....	..	....	..	....
Very Hard Bearing................	16	2½	....	..	....	..	....
Lining for Car-axles { mix for hardening.....	4	24	....	8	....	..	....
{ then add....	....	72	....	..	....	..	....
Lining, very cheap	....	....	100	15	....	..	....
Hardening for Babbitt's Metal. .... (For linings use 1 pound of hardening to 2 pounds of tin.)	4	24	....	8	....	..	....

See Babbitt's Metal; Fenton's Antifriction Metal.

Antimony.—This is a brilliant white metal of a crystalline texture and bluish white color, and so brittle that it cannot be rolled into sheets nor drawn into wire. Its specific gravity is 6.71; melts at 810°, crystallizes in pyramids, and volatilizes at an intense heat. There are several varieties of the ore, but the sulphuric, or gray antimony, is the most abundant, and yields the metal of commerce. To reduce the ore it is first made into a powder, after which it is heated in a reverberatory furnace;

the melted sulphuret then flows from the infusible earthy matter, and is subsequently smelted and purified. Exposed to the air at ordinary temperatures antimony does not rust; this property, combined with its hardening influence on other metals, renders it eminently useful in the composition of many useful alloys to make them harder and whiter.

It is usually found associated with other metals, but always contains more or less iron. The crude metal, or sulphuret, is employed for purifying gold, the sulphur from which being readily absorbed by the inferior metals, while the antimony unites with the gold. Antimony has generally been distinguished as *Regulus*, or petty king, because of the hardening influence previously mentioned; alloyed with an equal quantity of tin we have a brilliant white and somewhat hard alloy suitable for some descriptions of specula. Sodium and potassium are the metals with which antimony unites the most readily, as, even when the former are alloyed with other metals, the association is found to be of an intimate character. Antimony readily combines with gold, but destroys the ductility of the latter, producing a granular alloy of a golden tint, the depth of which is proportionate to the amount of gold present.

Antimony contracts little or none in cooling. For this reason it is doubly valuable in the production of types, music and other plates, etc., as, besides giving the requisite degree of hardness to such alloys, it enables the founder to obtain a true copy of the matrix—something almost impossible in most of the other metals employed for this purpose, owing to their high shrinking qualities.

For a large variety of alloys in which antimony enters as an ingredient, see WHITE ALLOYS; TYPE-METAL; ANTI-FRICTION ALLOYS; PEWTER; BRITANNIA METAL; QUEEN'S METAL; MUSIC METAL; SPECULUM METAL; SOLDERS.

Apothecaries' Weight.—In this arrangement the pound contains 12 ounces; each ounce 8 drachms; each drachm 3 scruples, and each scruple 20 grains.

Apprenticeship.—See TECHNICAL EDUCATION FOR THE MOULDER.

Aqua-regia.—Royal-water, so called from its power to dissolve gold, the king of metals. Its scientific name is *nitro-muriatic acid.* See GOLD.

Arabic Gum.—Gum-arabic is a gum which flows from the *acacia* tree on the banks of the Nile, Arabia, and in some other parts. It forms a clear, transparent mucilage with water, and is insoluble in alcohol or ether.

Arbor.—See CORE-ARBOR.

Argentan.—Imitation silver. See WHITE ARGENTAN.

Argol-flux.—A flux made from impure cream of tartar or acid tartrate of potash, which constitutes the incrustation on the insides of wine casks. See FLUX.

Arm.—A spindle attachment for carrying the sweep-board which forms a mould. See SPINDLE.

Arsenic.—Arsenic is sometimes found pure, but more generally combined with nickel, cobalt, sulphur, and iron. To separate arsenic from the ores, they are first crushed and the arsenic dissipated in a reverberatory furnace by roasting, when the arsenious acid is condensed into *white arsenic.* The metal is obtained from white arsenic by incorporating it with carbonaceous matter and heating in a closed crucible provided with a receiver, in which the arsenic is condensed as a brittle white metal with a slight degree of lustre; the specific gravity of which is 5.7, its melting-point being 400°. At 500° it volatilizes without fusing, the vapor having a strong tincture of garlic. The metal may be powdered in a mortar.

The chief property of arsenic is to promote the union of metals that would be otherwise difficult to mix—aluminum with iron; lead with zinc; lead with iron, etc. It promotes the fusion of many metals, and occasions some refractory ones to melt at a low temperature. Being a *union* rather than a true alloy, it is customary to call all alloys of arsenic by the name of *arsenides.*

While arsenic, like antimony, tends to crystallize other metals, they are not rendered as brittle as the latter metal makes them. Nearly all metals combine with arsenic; but, except in the case of silver and gold, such alloys may be decomposed by lengthened fusion. White tombac is copper alloyed with arsenic. The metal for lead-shot is rendered more fusible and solid by a slight proportion of this metal, and gold may be permanently alloyed to form a brittle *arseniuret of gold* by exposing the heated metal to its vapors.

From $\frac{1}{4}$ to $\frac{3}{4}$ of an ounce to the pound of any alloy will materially assist in preventing a tendency to porosity, but will result in a harder casting, somewhat lighter in color. Speculums and all similar objects are, by means of this metal, made hard, white, and lustrous.

For the manner of fluxing alloys of arsenic, also the methods employed for introducing this metal into the crucible, and alloys containing arsenic, see SPECULUMS; TOMBAC; LEAD-SHOT; COBALT.

Arsenious Acid.—White arsenic. See ARSENIC; WHITE ARSENIC.

Artificial Diamond.—See DIAMOND.

Artificial Gold.—A French substitute for gold is made as follows: Melt copper, 100; then add separately and by degrees, in powder, magnesia 6; sal-ammoniac $4\frac{1}{2}$; quick-lime $\frac{1}{8}$; tartar 9; and stir half an hour—after which add zinc, or, preferably, tin 17. Mix well, and continue the fusing for 35 minutes, with the crucible well covered before casting. This alloy does not corrode easily; when it does tarnish its former brilliancy can be restored by dipping in acid solution. See GOLD ALLOYS.

Artificial Stone.—See STONE.

Art-work.—This term is usually employed to moulding fine-art work, and comprises all castings moulded from models prepared by the sculptor or modeller. Such castings in the past have invariably been cast in bronze and kindred alloys, but very much of that which enters into both interior and exterior decoration is now produced in cast iron. The latter class of castings would prevail more extensively, if the moulders with skill sufficient to produce it were more numerous. The great dearth of such artists can only be relieved by improving the education of our youth, who by all means should be encouraged to cultivate a taste for the fine arts, as well as qualify themselves for its manipulation in the foundry, in institutes conducted for the special benefit of apprentices in all branches of the metal industries. See TECHNICAL EDUCATION FOR THE MOULDER; MODELLING; STATUE-FOUNDING.

Asbestos.—A mineral of white or gray color, appearing almost like a vegetable substance, because of its fibrous, flexible, and delicate texture. It is incombustible, and the ancients wove it into cloth in which to preserve the ashes of bodies burned on the funeral pyre. There are other varieties of this mineral, all of which pertain to the different species of hornblende, and consist chiefly of silica, magnesia, lime, and oxide of iron. Its uses for manufacture into incombustible material have now become too numerous for mention here. See REFRACTORY MATERIALS.

Ashes is what remains of animal or vegetable substance after burning with free access of air. The ashes of organic substances consist of the fixed salts contained in them—land-plants yielding salts of potash, etc., and sea-plants soda, with some iodine. Turf contains alkalies and some sand; so also does coal, with the addition of some iron occasionally. See POTASH; ALKALIES.

Asphaltum.—This substance resembles pitch, but has a higher internal polish, and is sometimes called mineral-pitch, bitumen, etc.; it breaks with a polish, melts easily, and when pure burns and leaves no ashes. Anciently, it was only procurable from Lake *Asphalites* (Dead Sea), in Judea, for which reason it is sometimes also called Jews' pitch. It formed a building cement for the Babylonians, and is now much used in flooring, roofing, paving, etc. See PETROLEUM; BITUMEN.

Assay.—The determination of the quantity of any particular metal in an ore, alloy, or other metallic compound, more especially of the quantity of gold or silver in coin or bullion. It differs from analysis thus: The component parts of the mineral or alloy are, by analysis, separated, and an estimate made of their respective quantities; while by assay, it is only the valuable metals that are sought for; as, in the case of silver and gold alloys the inferior metals are dispersed, the quantity being determined by the loss of weight. A gold alloy is assayed by obtaining a certain number of grains, which, after being carefully weighed, are wrapped in sheet-lead and exposed to intense heat in a cupel placed under a muffle. Cupels for this purpose must be very porous, and are simply a small block with a cavity on the upper side to receive the metal. When fusion takes place, the lead is converted into a vitreous oxide, which, acting as a flux, acts powerfully to oxidize and vitrify the inferior metals contained in the alloy, which being changed, are absorbed by the porous cupel, leaving a globule of unoxidable metal behind. The globule will be silver or gold, or a compound of both, which may be separated by the method shown at "Separating Metals from their Alloys." Another method of assaying is described at "Touch-needle." See MUFFLE.

Atmosphere.—See AIR; THERMOMETER.

Avoirdupois Weight.—The system of weights and measures for all goods except precious metals and gems, the grain being the foundation of this as in the case of Troy weight. The weight of one cubic inch of water is 252.458 grains, and 7000 of these grains make one pound avoirdupois, and 5.760 a pound troy. The pound is divided into 16 ounces, and the ounce into 16 drachms. The hundred-weight is, in most parts of the United States, simply 100 pounds avoirdupois, and the ton 20 of such hundredths, or 2000 pounds.

Axis is the straight line about which a plane figure revolves so as to produce or generate a solid; or, it is a straight line drawn from the vertex of a figure to the middle of the base. The axis of a sphere or circle is a straight line passing through the centre and terminating at the circumference on the opposite sides.

In founding, the spindle is an axis around or upon which a sweep-board revolves to produce a solid, as a core by using the sweep's inner edge. When the outer edge of the sweep is used it forms an inclosing surface, or cope. See SPINDLE.

B.

Babbitt Metal.—To make this composition, melt copper 4; then add gradually tin 12, antimony 8, and a further addition of tin 12. When about 4 or 5 pounds of the final addition of tin has been added the heat may be reduced to a dull red, and the remainder added. Or, the copper, tin, and antimony may be melted first in separate crucibles; then poured together into one vessel and the final addition of tin introduced.

The above is a hardening. For lining take 1 pound of hardening and melt it along with 2 pounds of tin, which produces the lining metal for use. It will be seen that the resultant mixture contains: copper 4, tin 96, antimony 8. Banca-tin and the best quality of copper and antimony is to be employed when it is desired to make good antifriction metal. See ANTIFRICTION METALS; ALUMINUM.

Back.—An abbreviation for "Draw-back." See DRAW-BACK.

Backing out is the method of producing a pattern or casting, equal in thickness all over, from a carved wooden block or a rough plaster-cast. The backing out of such blocks by the moulder saves much carving, and will ordinarily produce a more regular thickness throughout. The method is as follows: two copes are pinned to fit one nowel, the block is set face up in one of them, and an extra hard impression obtained in the nowel. This impression is then transferred to the same cope; also rammed extra hard, and when lifted laid face up on the floor—after which the block is drawn from the nowal and thicknessed with a suitably prepared layer of clay. The parting is then prepared and the impression taken in the second cope in a proper manner for casting, as this is the mould-surface or back of the intended object to be cast. It only remains to return the block into the first cope, and, after removing the first hard-rammed nowel-mould, return the flask to receive the final impression, which in this instance must be rammed with the customary care, as this forms the front or face. Both cope and nowel are by this means obtained from the first cope, and must as a consequence be a perfect match at the parting, the space formed by the clay answering to the design back and front.

If it is desired to accomplish this by casting the moulds face up, the block is placed in the nowel face up, and a correct parting, made very hard, formed all round it. The first receives the intended mould-impression, after which the second cope is rammed extra hard thereon, so that a hard working-face may be obtained on which to lay the clay thickness. It is then ready for the nowel proper; and when the latter has been duly rammed and the whole reversed, the dummy cope is removed, clay lifted out, mould finished, and the previously rammed first cope placed over it. As in the former case, the partings in both nowel and cope are obtained from one original, and must consequently match. See THICKNESSING; KETTLES; STATUE-FOUNDING.

Bag.—See BLACKING-BAG.

Bail.—The arched iron yoke, provided with journals, in which the ladle is suspended whilst pouring. See LADLE.

Baking.—A term used in some localities in relation to the process of drying cores or moulds in the oven. See Oven.

Balls.—The following table gives the weight of cast-iron, copper, brass, and lead balls from 1 to 12 inches diameter. To obtain the weight of balls larger in diameter than is given in the table, ascertain the number of cubic inches contained in the sphere by multiplying the cube of its diameter by .5236; then multiply by the weight of a cubic inch of the metal composing the ball, as follows :

For cast-iron and tin, multiply the total cubic inches, as found by the above rule, by .263, and the product will be the weight in pounds.

For copper, multiply the total cubic inches by .317.

For brass, multiply the total cubic inches by .282.

For lead, multiply the total cubic inches by .410.

TABLE SHOWING WEIGHT OF CAST IRON, COPPER, BRASS, AND LEAD BALLS FROM 1 TO 12 INCHES DIAMETER.

Dia.	Cast Iron.	Copper.	Brass.	Lead.	Dia.	Cast Iron.	Copper.	Brass.	Lead.
1	.136	.166	.158	.214	7	46.76	57.1	54.5	73.7
1½	.46	.562	.537	.727	7½	57.52	70.0	67.11	90.0
2	1.09	1.3	1.25	1.7	8	69.81	85.2	81.4	110.1
2½	2.13	2.60	2.50	3.35	8½	83.73	102.3	100.0	132.3
3	3.68	4.5	4.3	5.8	9	99.4	121.3	115.9	156.7
3½	5.84	7.14	6 82	9.23	9½	116.9	143.0	136.4	184.7
4	8.72	10.7	10.2	13.8	10	136.35	166.4	159.0	215.0
4½	12.42	15.25	14.5	19.6	10½	157.84	193.0	184.0	250.0
5	17.04	20.8	19.9	26.9	11	181.48	221.8	211.8	286.7
5½	22.68	27.74	26.47	36.0	11½	207.37	253.5	242.0	327.7
6	29.45	35.9	34.3	46.4	12	235.62	288.1	275.0	372.3
6½	37.44	45.76	43.67	59.13					

Bar.—A flask consists of *sides, ends,* and *bars* (cross-bars). The latter connect the sides, and form spaces in which rammed sand is held securely. When flasks exceed a certain size, the sand's adhesiveness is insufficient for its own support; it is then that bars are introduced to lessen the space, and thus restore their usefulness; in other words a large flask with bars is simply a number of narrow flasks, side by side, and raised a little higher than the sides to admit of a sand junction being made underneath, and thus secure a continuous sand surface. See FLASKS.

Bar Iron See MALLEABLE IRON.

Barium. See STRONTIUM.

Barrel. See TUMBLING-BARREL; CORE-BARREL.

Barrow. See WHEELBARROW.

Basalt.—A rock of igneous origin, usually of a dark green or blackish color, consisting chiefly of the minerals augite and feldspar, with grains of magnetic or titanic iron. It occurs amorphous, tabular, or globular, but, as in the Giant's Causeway, Ireland, it is usually columnar. See AMORPHOUS.

Base-plate. See FOUNDATION-PLATE.

Basic Process.—A process of making steel by blowing the metal in converters lined with dolomite in place of gannister, as in the Bessmer process. Dolomite is a magnesian limestone, which, being well burned and ground, is mixed with tar to give it consistency. This can then be rammed in the converters, or pressed into bricks for lining with. This basic lining absorbs some of the phosphorous present in the iron, the rest being taken up by the lime, which constitutes about 15 per cent of the charge, and is introduced before the molten iron enters the converter. See BESSEMER STEEL; CONVERTER; GANNISTER; DOLOMITE.

Basin is sometimes termed a *pouring-basin*, or *runner*, and is a suitably formed reservoir constructed with sand within a wood or iron box-frame. Its purpose is to receive the metal from the pouring-ladle, and connection with the mould is made by down-runners, which lead from its lowest part, either to the mould direct, or to some system of runners which lead to it. See DOWN-GATE; GATES; RUNNER; BASIN.

Bath. See TINNING; TIN-PLATE.

Bath-metal.—A cheap jewelry alloy, composed of brass 32, zinc 9. See TOMBAC.

Bauxite.—A ferric oxide, usually containing alumina 50.4, sesquioxide of iron 26.1, water 23.5. Some samples have more silica and less iron. The purest is called *aluminum ore*, and is used in the manufacture of that metal. It is very refractory, being practically infusible, although containing over 20 per cent of iron oxide, while 4 or 5 per cent of the latter in some clays renders them easily fusible. Bauxite bricks are made by adding about 8 per cent of clay and plumbago for binding to the calcined bauxite, the result being that as soon as intense heat is applied the plumbago partially reduces the iron and the brick is rendered practically infusible. These bricks are more durable than ordinary fire-bricks, will resist the most intense heat as well as the action of basic slags. They also become harder with use. See FIRE-BRICK; REFRACTORY MATERIALS.

Beach-sand.—See WHITE-SAND.

Bead-slickers.—Tools maae expressly for smoothing the surface of bead-mouldings. See Slicker.

Beam.—The foundry lifting-beam consists of a rectangular beam of wrought or cast iron, or wood, mounted with straps and ring to hang central in the block-hook of a crane. Notches sunk at equal intervals from each end allow of a balanced lift being taken with a pair of slings which fit the beam at one end and the flask-trunnions at the other, by which means the flask can be turned clear over before it is rested. By means of beam-hooks, chains may be hitched at any number of places along the sides. See Slings ; Beam-hook.

A sound oak beam would require to measure four times the thickness of cast-iron to be of equal strength.

The table at page 44 will be found of great service when it is desired to construct a cast-beam for the purpose as described above, or for any other purpose for which cast iron beams are applicable.

Beam-hook.—A link-hook to slide along the beam to any required notch, the hook serving to suspend the chain for lifting with. See Beam.

Beam-sling.—A sling with its upper end forged to fit the beam used, the lower end being made to two diameters; the larger one for passing over the collar of the trunnion, the smaller to fit the body of the same. See Sling ; Beam ; Trunnion.

Bearing.—See Core-print ; Seating.

Bed.—A term applied to numerous things occurring in foundry practice. When a prepared surface is formed in the floor on which to lay the pattern it is usually called a

TABLE,

SHOWING THE WEIGHT OR PRESSURE A BEAM OF CAST IRON, 1 INCH IN BREADTH, WILL SUSTAIN, WITHOUT DESTROYING ITS ELASTIC FORCE, WHEN IT IS SUPPORTED AT EACH END AND LOADED IN THE MIDDLE OF ITS LENGTH, AND ALSO THE DEFLECTION IN THE MIDDLE WHICH THAT WEIGHT WILL PRODUCE. BY MR. HODGKINSON, MANCHESTER.

Length.	6 feet.		7 feet.		8 feet.		9 feet.		10 feet.	
Depth in In.	Weight in Lbs.	Defl. in In.	Weight in Lbs.	Defl. in In.	Weight in Lbs.	Defl in In.	Weight in Lbs.	Defl. in In.	Weight in Lbs.	Defl. in In.
3	1,278	.24	1,089	.33	954	.426	855	.54	765	.66
3½	1,739	.205	1,482	.28	1,298	.365	1,164	.46	1,041	.57
4	2,272	.18	1,936	.245	1,700	.32	1,520	.405	1,360	.5
4½	2,875	.16	2,450	.217	2,146	.284	1,924	.36	1,721	.443
5	3,560	.144	3,050	.196	2,650	.256	2,375	.32	2,125	.4
6	5,112	.12	4,356	.163	3,816	.213	3,420	.27	3,060	33
7	6,958	.103	5,929	.14	5,194	.183	4,655	.23	4,165	.29
8	9,088	.09	7,744	.123	6,784	.16	6,080	.203	5,440	.25
9			9,801	.109	8,586	.142	7,695	.18	6,885	.22
10			12,100	.098	10,600	.128	9,500	.162	8.500	.2
11					12,826	.117	11.495	.15	10,285	.182
12					15,264	.107	13,680	.135	12,240	.17
13							16,100	.125	14,400	.154
14							18,600	.115	16,700	.143

Depth in In.	12 feet.		14 feet.		16 feet.		18 feet.		20 feet.	
6	2,548	.48	2,184	.65	1,912	.85	1,699	1.08	1,530	1.34
7	3,471	.41	2,975	.58	2,603	.73	2,314	.93	2,082	1.14
8	4,532	.36	3,884	.49	3,396	.64	3,020	.81	2,720	1.00
9	5,733	.32	4,914	.44	4.302	.57	3,825	.72	3,438	.89
10	7,083	.28	6,071	.39	5,312	.51	4,722	.64	4,250	.8
11	8,570	.26	7,346	.36	6,428	.47	5,714	.59	5,142	.73
12	10,192	.24	8,736	.33	7,648	.43	6,796	.54	6,120	.67
13	11,971	.22	10,260	.31	8,978	.39	7,980	.49	7,182	.61
14	13.883	.21	11.900	.28	10,412	36	9.255	.46	8,330	.57
15	15,937	.19	13,660	.26	11,952	.34	10,624	.43	9,562	.53
16	18,128	.18	15,536	.24	13,584	.32	12,080	.40	10,880	.5
17	20,500	.17	17,500	.23	15,353	.30	13,647	.38	12,282	.47
18	22,932	.16	19,656	.21	17,208	.28	15,700	.36	13,752	.44

NOTE.—This table shows the greatest weight that ever ought to be laid upon a beam for permanent load; and if there be any liability to jerks, etc., ample allowance must be made; also, the weight of the beam itself must be included.

bottom bed. Sand that has been rammed on the bottom of a cupola or furnace, for the molten metal to rest upon, is the *cupola,* or *furnace-bed.* Open sand-plates are cast on *beds,* constructed by means of two straight-edges,—a parallel straight-edge and a level,—thus: one straight-edge is packed until it agrees with the level; the other is the set at the required distance, and, by means of the parallel straight-edge, each of its ends are made to agree with the level, the proof of which is obtained by trying the level on the second straight-edge, when the level will be exact if the operation has been correctly performed. The sand within the straight-edges is then brought to the requisite density, extending some little above, when another straight-edge, long enough to reach across, will serve to strike off the superfluous sand and leave a bed that will be level in every direction. See BEDDING-IN; SAND-BED; LEVEL; STRICKLE.

Bed-board.—A board on which to ram the nowal part when the bed is formed by the method of rolling-over (see ROLLING-OVER). It may be of iron, wood, or plaster, with dimensions corresponding to outer edges of the flask used. Besides presenting a surface which accurately matches the upper side of the pattern, to prevent any possibility of the pattern being rammed out of shape, it must be made strong enough to lift the body of sand contained, when bed-board, nowal, and bottom-board are secured together for rolling-over; as any deflection will irretrievably destroy what would otherwise have been a correct impress of the pattern. See FOLLOW-BOARD; TURNOVER-BOARD; BOTTOM-BOARD.

Bedding-block.—A block of hard wood, with a smooth under surface and rounded edges, for bedding-down patterns with the hammer. This block should be of such dimensions and shape as will be least likely to damage the pattern when struck with the hammer. See BEDDING-IN.

Bedding-in.—One process for obtaining an impression in the sand, of the lower or under side of the pattern. Simple objects may be pressed, or hammered into a suitably prepared soft bed of sand, while those of a more complex nature must have the sand tucked with the hand, or forced with small rammers into remote parts; supplementing these operations by effectual ramming with the ordinary *peen* and *butt-rammers*—which operation extends to all parts of the *hole* or *pit* in which the mould is being prepared. Should this be neglected, the inside pressure, when the mould is cast, will press the surface back into the soft parts and a swelled, uneven surface will result.

This process may, in some instances, be simplified and made more effective by suitably dividing the pattern and ramming each piece separate, from the bottom upwards. Again, it may be found convenient to form some portion, if not all of the bed, by extemporized strickles and guides before lowering on the pattern for a final ramming. See RAMMING; VENTING; TUCKING; TRAMPING.

Bed-fuel is the fuel resting on the sand-bed or bottom of the cupola and immediately preceding the first charge of iron, the amount of which is regulated according to the diameter of the cupola and the depth of the bottom. If coal be the fuel used, about 15 inches above the tuyeres would be sufficient for bed-fuel, and about 22 inches for coke. See CUPOLA; CHARGING THE COMMON CUPOLA.

Beer.—Owing to the hardening influence of the gluten, starch, albumen, etc., contained in beer, the bottoms of barrels, and sometimes the beer itself, was formerly used extensively for hardening the surface of cores and moulds, being sprinkled thereon before they were placed in the oven to dry. It has, however, been to a great extent superseded by molasses-water, glue-water, and the very numerous patented core-washes which may now be obtained from the foundry-supply dealers. See CORE-SAND; CORE-WASH; MOLASSES; GLUE.

Bees-wax.—An excellent substance for coating iron patterns with, to prevent the sand from adhering thereto. To prepare the patterns, let them be well finished, and sprinkled with dilute acid; after which, when rusted in the atmosphere, they can be cleaned, heated, and the wax applied while hot, spreading it evenly over the surface with a brush. See WAX.

Bell-founding.—The founding of bells is practically the same as for any other similar object, as pans, kettles, domes, etc. Large ones are usually made in loam by first striking a core, by means of a centre-spindle and sweep-board, the latter corresponding to the inner dimensions and form of the bell to be cast. When this has firmly set, another sweep-board answering to the outer contour of the bell is secured to the spindle, and a thickness of sand formed on the core; after which such ornamentation as may be required is secured thereon and a cope is built around, of such strength as the magnitude of the bell demands. The subsequent operations consist of lifting off the cope, taking away the thickness, finishing the moulds, drying, and closing in the pit as for any other casting.

For the common run of bells a more ready way is provided. These are invariably made in perforated cast-iron casings, which enable the founder to strike both core and cope separately, closing them together when dry, binding and casting without any subsequent labor of ramming.

The core-casing should be small enough to allow a wrapping of straw before applying the loam. The rope burns away and leaves ample room for contraction. See CASINGS; KETTLES; SPINDLE.

Bell-metal.—The alloys for large bells are now as various as those for small ones. It was formerly considered that copper 75, tin 25, was the best for all large bells, but it is claimed by many that copper 80, tin 20, is better. Many church-bells are successfully cast from either of the above proportions. The following proportions are about correct: Extra large bells: copper 16, tin 5. Church and large bells: copper 16, tin $4\frac{1}{2}$. House-bells: copper 16, tin 4. Gongs, cymbals, etc.: copper 16, tin $3\frac{1}{2}$. Soft musical bells: copper 16, tin 3.

Another composition introducing zinc and lead for church-bells is: copper 80, tin 10, zinc 5.6, lead 4.6. Clock-bells are also made from: copper 72.0, tin 26.5, iron 1.5. It will be seen that a small proportion of iron enters into the latter alloy; this is common with some founders, and zinc and lead form no mean proportion in the cheaper class of small bells.

Lafond's mixture for small bells and piano-plates is: copper 77, tin 21, antimony 2. This alloy is yellowish white, and can be filed only with difficulty.

A French bell-metal for hand, clock, and other similar-sized bells is: copper 55 to 60, tin 30 to 40, zinc 10 to 15. See ALLOY; BRASS; JAPANESE BRONZE-WORK.

Bellows.—These wind-machines for foundry use are somewhat after the pattern of those used in the home, except that they are usually provided with hinges and made strong. The common ones are used for blowing away superfluous parting sand off the patterns, and loose sand and blackening out of the moulds. Bellows for the bench are made without spout and somewhat shorter. Special bellows, for distributing blackening upward where it cannot be applied with the bag, are now made; as also are sprinkling-bellows for saturating the mould, where necessary, with water, etc.

Belt-core.—It is common to call almost any description of jacket-core by this name. See JACKET-CORE.

Belts for cores.—Leather-belting makes very reliable and handy slings for lifting cores, but, owing to the very inferior means usually provided for binding the ends together when in use, very much of their reliability and usefulness is marred. If very thin steel ends are riveted on, all this annoyance is obviated. The steel, $\frac{1}{64}$ inch in thickness, must be just as wide as the belt, and as short as is consistent with safety. The ends, being both turned with a very short "U," interlock each other.

Bench-moulder.—A moulder, whose work being of a light description, can perform all the operations required for producing it in small wooden or iron flasks, standing up to his work at a suitably provided bench. See SNAP-MOULDER.

Bench-rammer.—A short wooden rammer used by the bench-moulder. It has just space sufficient between the butt and peen ends for the hand to grasp it. It is common for the moulder to use one in each hand.

Bend-pipe.—A common name for all classes of curved pipes that are not distinctively elbows. The moulding of such pipes demands the attention of moulder and pattern-maker more than any other, simply because the constantly varying curves required make it impossible to keep a stock of patterns on hand for the purpose. Hence, all manner of devices for moulding are resorted to, to save pattern-making, and, at the same time, obtain a good casting. See JOBBING-MOULDER; LOAM-PATTERN; TOUCH.

Benzine.—A limpid, oily fluid, resembling oil of turpentine. It is composed of hydrogen and carbon formed during the destructive distillation of coal. It readily dissolves caoutchouc, gutta-percha, wax, camphor, and fats, and is useful for removing grease-spots from silk and woollen. See TAR.

Beryl.—A mineral of great hardness occurring in green and bluish-green six-sided prisms. It is ranked among the gems, and is nearly identical with emerald, but is not so brilliant in color. It is infusible; with borax it fuses into a transparent glass. Its composition is: silex 68, alumina 15, glucine 14, lime 2, oxide of iron 1. See EMERALD; PRECIOUS STONES.

Bessemer Steel.—This process of making steel was patented in 1856 by the inventor, Henry Bessemer, and consists in converting the pig-iron into malleable iron, as a preliminary operation, by blowing air through the mass of molted metal, previously introduced into a converter, until all the carbon, silicon, sulphur, and phosphorus has been burned out, and then converting this into steel by the addition of a small quantity of a peculiar cast iron of known composition, called *Spiegeleisen*. See CONVERTER; SPIEGELEISEN; CAST STEEL; OPEN-HEARTH STEEL.

Bin.—A wood or iron box for storing charcoal, sea-coal, lead, flour, or any other commodity used in the foundry. The providing of such repositories effects a considerable saving over the too common practice of having such things loose around the foundry in barrels.

Binding-plates.—Thin plates cast by the loam-moulder to strengthen weak walls in copes and cores built with bricks. They are bedded, at intervals, on soft loam and the building continued over them. A slot or opening on one side allows of their being set without removing the spindle. If, when the slot is made, they should be considered too weak, extending lugs at that point will serve to clamp or bolt them fast, after they have passed the spindle and are bedded in place. For cores, the lugs are internal; for copes, external. They are often called building-rings. See COURSE; BRICKING-UP; LOAM-MOULDING; HOOP-BINDER.

Binder.—The name given to almost every device used in the foundry for binding moulds together before casting, but in particular to the beams which rest over the copes of green and dry-sand moulds, as well as the covering-plates of loam-moulds, by which the upper portions of the moulds are made secure to the lower by means of clamps or bolts, in order to prevent any possibility of their being raised by the pressure of molten iron underneath them. See PRESSURE OF MOLTEN METAL.

Bismuth.—A somewhat brittle metal, the color of which may be termed yellowish-white. It is a little harder than lead. Bismuth is found natural but impure in different parts of Europe, in the veins or fissures of other rocks; also in combination with sulphur, arsenic, and oxygen. The pure metal is obtained by heating the impure metal, or native bismuth, in inclined cast-iron tubes, where the metal is volatilized and, the vapors condensing, run into receiving-vessels, and finally into moulds, where it solidifies with a crystalline texture.

At a high temperature, bismuth is slightly volatile and oxidizes rapidly. Its fusing-point is 507°, but it alloys with other metals to form fusible mixtures, which melt even below 212°.

The specific gravity of this metal is 9.8.

The fusibility of other metals is increased by bismuth, and its peculiar property of expanding while cooling makes it highly valuable as an ingredient in type-founders' alloys.

A slight addition of mercury imparts greater fusibility to bismuth alloys.

Alloys containing bismuth should always be cooled quickly, to prevent the separation of bismuth.

Gold alloyed with bismuth forms a brassy composition of a brittle nature, and the ductility of gold is impaired even by its fumes.

It is seldom that bismuth is employed alone in the arts, but it forms an important ingredient in many mixtures for solder, type-metal, fusible alloys, etc.

Bismuth is separated from lead by dissolving the mixed metal in nitric acid; add caustic potash in excess, and the oxides of bismuth and lead will be precipitated, but the lead oxide will be at once redissolved by the alkali. The oxide of bismuth can then be separated by filtration, washed, and ignited. See SOLDERS; TYPE-METAL; FUSIBLE ALLOYS; SEPARATING METALS; EXPANDING ALLOYS.

Bitumen.—Besides coal there is found in the earth a class of inflammable bodies—liquids, semi-liquids, and solids—which possess properties very similar. The purest and most fluid of these hydrocarbons is *naphtha*; when of the consistence of oil it is termed *petroleum*; slightly thicker it is *pitch*; after which we have elastic bitumen, and in its hardened state it is called *asphaltum*.

Naphtha dissolves bitumen and caoutchouc. See PETROLEUM; ASPHALTUM.

Bituminous Coal.—See COAL.

Black-flux.—See FLUX.

Blacking.—A general name for all classes of carbon-facings used in foundries. See FACING; BLACK LEAD; CHARCOAL; GRAPHITE.

Blacking-bag.—A coarse linen or worsted bag to hold charcoal-dust or other facing, and by means of which to distribute the same evenly over the surface of green-sand moulds by a process of shaking. The loose dust is afterward pressed close by returning the pattern, or with the moulder's tools. See FACING; PRINTING.

Black Lead.—The name commonly given to plumbago, or India-silver lead-facings. It is called "India silver" because it is mined in India, on the island of Ceylon, and because it yields a polish of a silvery tone. The Jos. Dixon Crucible Company classify the several kinds as: Plumbago-facing for common work; German or Bohemian lead for flat moulding; Ex, Ex, plumbago-facing for stove-plate, printing and copying presses; India-silver lead for light and ordinary job-moulding; "XX," plumbago for heavy cast-iron and steel castings; and Founders' core-wash for cores, loam, and dry-sand work—at prices from 10c. to $3\frac{1}{2}$c. per pound, in the order given.

One kind works with dry sand, and is used as a wash; another works with green sand, and through a shake or blacking-bag; still another, with green-sand, to be laid on the surface with a brush. Some facings require, for perfect lines, a little dusting of powdered charcoal. Some brands will slick with the tools; others not—making it necessary for the parties ordering these facings to specify what use they intend to put them to. Such kinds as admit of easy slicking on green-sand moulds are the most useful; as when this operation is properly done with good material, it will neither burn nor run before the molten metal, but adhere firmly to the sand surface, causing it to part clean from the casting, giving it a uniform bright color. See FACING; GRAPHITE.

Black Sand is sometimes termed "old sand," and is the sand which constitutes what is called the foundry floor. When first introduced into the foundry the new sand is usually of a yellow or brownish color, sometimes red; but by subsequent use for casting purposes, it becomes burnt, or "old." The facing mixtures, containing sea-coal dust, is gradually insinuated among the floor-also; these, along with the constant use of charcoal and lead-facings, cause the change in color of the original sand. For all parts of thin castings, which are far removed from the gates, this old sand, if fine originally, is to be preferred as a facing, because the constant burning to which it has been subjected has eliminated all clayey and other deleterious ingredients; thus forming a surface upon which the molten iron will placidly rest free from the disturbing influences of the gas-producing substances ordinarily found in new-sand. See NEW-SAND; FACING-SAND; FACING.

Black Solder.—Copper 32, zinc 32, tin 4. See SOLDERS.

Black Varnishes.—*For patterns,* alcohol 1 gall.; shellac 1 lb.; lamp-black sufficient to color it. Let it stand in a warm place, and stir occasionally.

For castings, tar oil 20 lbs.; asphaltum 5 lbs.; powdered resin 5 lbs. Heat all togethe rin an iron kettle, and be careful to avoid ignition. See VARNISHES.

Black-wash.—A refractory mixture for coating the surfaces of loam and dry-sand moulds and dry-sand cores, to protect the sand from burning by the interposition of a coat of carbon between it and the molten metal.

The compositions for this purpose are various, but the principal ingredients entering therein are charcoal-dust, silver lead, mineral, and hard Lehigh blacking ; these, in varying proportions, are mixed with thin clay-water to a suitable consistency and applied with a swab or brush. See FACING.

Blakney Cupola.—The Blakney cupola consists principally of a system of tuyeres, by which, it is claimed, the air is so distributed or projected into the furnace as to produce a uniform heat, giving the iron a uniform strength for all kinds of castings. The features peculiar to the above furnace are as follows:

The introduction of a combination of curved tuyeres or chutes placed upon the wall or lining of the cupola, and forming a part of the wall, a proper distance from the bottom and nearly surrounding the inner and outer sides of the wall. The tuyeres are made of cast iron and in sections for convenience of handling. A blank space is left in the rear of the cupola two feet wide, through which the slag is blown, if required.

A chamber or base extending around the cupola incloses the space in which the air is conducted to the tuyeres. The bottom of this chamber, made irregular in form, hollows at suitable intervals to allow the metal to flow to the escape openings, in case it overflows through the tuyeres. The openings are closed with fusible plugs of lead or other material to be melted out by the molten metal.

The blast is conducted to this cupola through one pipe, and, striking the blank space sidewise in rear of chamber, passes all around through the curved tuyeres into the centre of the furnace, the blast striking into the cupola every $\frac{7}{8}$ of an inch horizontal, and $3\frac{3}{4}$ inches perpendicular, or according to diameter of cupola.

As a producer of a uniform grade of iron for the purpose of casting car-wheels it is just what is needed for the different grades of iron to prevent chill-cracking.

This cupola, with its many superior advantages, has also rows of shelves bolted to the shell four feet apart up to the top of the charging-door, so that it will not be necessary to tear out any of the lining except that which is burned out.

Blast is air forced into a cupola or furnace by a blowing-engine, blower, or fan for the purpose of increasing combustion. If heated it is then called hot blast, and cold blast when it enters the cupola or furnace direct from the atmosphere. See CUPOLA; BLOWERS; BLAST-PIPES.

Blast-furnace.—See SMELTING-FURNACE; CUPOLA; CAST IRON.

Blast-gates.—The apparatus for opening and closing pipes supplying blast to cupolas, furnaces, etc.; for use also in exhaust-pipe systems where shavings, dust, smoke, and the like are to be removed, or for regulating the distribution of heated air.

The lever style of blast-gate can be readily manipulated by cords, and is very convenient in cases where it cannot be reached otherwise. The slide style of blast-gate is perhaps as common as any. These should always be made of metal and kept clean; otherwise they become troublesome and inefficacious. It is very important to know that the use of blast-gates to close pipes, when not in use, insures a great saving of power, as a blower requires far less power to drive it with closed connections than with open ones.

Blast-gates are furnished by the manufacturers in sizes from 1½ inches to 30 inches, small sizes being made in composition and the larger ones in iron, and these are always to be preferred to such as are usually provided by the foundry tinker. See CUPOLA; BLAST-PIPES; BLOWERS.

Blast-gauge is an apparatus to be attached to the wind-box of a cupola for indicating the pressure in blast-pipes. They are of simple construction and may be purchased from the makers at prices varying from $10 to $15, according to size and degree of finish. Ordinarily, the blast-gauge consists of a siphon-tube with equal legs, half-filled with mercury, one end entering the wind-box, the other being open to the atmosphere. A stop-cock may be provided between this gauge and the wind-box, so that it may be shut off at pleasure. When the stop-cock is open, the blast pressure acting on the mercury in one leg of the gauge presses it down, and the mercury in the other leg rises. The difference between the two columns is the height of mercury, which corresponds to the excess of the pressure of blast in the wind-box above the pressure of the atmosphere; or, in other words, to the effective pressure of blast in the blast-pipes. If 16 ounces be allowed for every 2 inches of the length of this column, or 1 ounce for every ⅛ inch, the effective pressure of blast, in ounces per square inch, is thus obtained. See CUPOLA; BLAST-PIPES; BLOWERS.

Blast-pipes are conducting-pipes from the blower to the cupola. These should always be made of iron and perfectly air-tight, and sufficiently large to convey the air without undue loss by friction. When the pipes are too small, a greatly increased velocity is required to discharge a given amount of air, with a larger proportional increase of fractional surfaces.

All turns or elbows in conducting-pipes are objectionable in the extreme, and should as much as possible be avoided, as from this cause the direction of the current is changed and the friction greatly increased. Air moving through blast-pipes expends a portion of its force in the friction of its particles along the sides of the pipes, with a consequent reduction in the pressure.

In many cases the blower may be condemned as inefficent when the pipe itself is the real cause of the trouble by reason of its too small diameter, its great length, or the number of bends or elbows it contains. The diameter of the blast-pipe should always be increased in proportion as the length is increased.

The main blast-pipe for cupolas 24 to 29 inches diameter should be not less than 10 inches diameter, 30 to 33 inches, 12 inches diameter ; 34 to 39 inches, 14 inches diameter ; 40 to 45 inches, 16 inches diameter ; 46 to 51 inches, 18 inches diameter ; 52 to 57 inches, 20 inches diameter ; 58 to 70 inches, 22 inches diameter, and 24 inches for cupola's over 70 inches diameter. See CUPOLA; BLAST; BLOWER; COMBUSTION.

Blast Pressure.—The blast should always be delivered at a pressure sufficient to force its way freely through the whole contents of the cupola, and this is effected in cupolas from 20 to 80 inches diameter by a pressure of from 5 to 16 ounces per square inch. See CUPOLA; CHARGING THE COMMON CUPOLA; BLAST-PIPES.

Blister.—A cavity or hollow usually found in the upper surfaces of castings. They are imprisoned gases, which, having no means of escaping before the metal congeals, arrange themselves in various sizes and shapes under a thin film of metal. They are found sometimes on the top side of pipes and columns, and in this case may be caused by the steam from a damp core, which, not having a ready means of escape through the vents, finds its way into the mould. Another fruitful cause of blisters is rusty chaplets and studs, which give off considerable gaseous compounds as the rust decomposes. Blisters are almost certain to ensue when a green sand surface, core, or cope is too damp or wet in spots. Should there be no vents at that particular part to lead away the steam as fast as it generates, it must inevitably find its way into the mould, the result being blisters.

Sometimes blisters are caused by the sulphurous gas contained in the iron itself, which, if it once enter the mould, acts exactly like the gases we have noticed above. Such gas as may be mingled with the iron will naturally ascend to the top if the mould's formation is favorable to its rapid transit in that direction; but, should it be otherwise, the probabilities are that it will be found imprisoned at whatever part of the mould it happened to be when the latter had received its fill of metal. Remote risers do not in the least affect this phenomenon, as the currents of metal leading thereto may, and usually are, far removed from the already formed blisters in congealed parts of the casting. Increased pressure will assist to force mould-gases out at the legitimate vents, but will render small help to expel such as may be contained in the metal itself, when the ordinary processes of moulding is employed. See VENTING; PRESSING FLUID STEEL; RUST; PASTE.

Blistered Steel.—A remarkable modification of iron intermediate between cast and wrought iron, containing less carbon than cast iron, but more than wrought (about 1½ per cent). It is made by imbedding bars of best wrought iron in powdered charcoal in boxes or sand-furnaces which exclude the air, and heating intensely for a week or ten days. The steel, when withdrawn, has a peculiar, rough, blistered appearance, and for this reason is called blistered-steel. See CEMENTATION; CAST STEEL.

Block-moulding.—A device for producing thin, delicate castings, by first obtaining correct impressions in plaster of cope and nowel side of the pattern, upon which the respective parts are rammed separately in flasks which fit interchangeably. By this means all the moulds are exact impressions of the original pattern, as all danger of ramming out of shape is obviated. The match-parts and flasks being all interchangeable, there is no possibility of error. See PLATE-MOULDING; MATCH-PART.

Block-print.—A large core print on a pattern, the impression of which receives a core containing some part of the mould, which if moulded from the pattern would require much more time, besides superior skill to perform it. The core is termed a block core. See CORE-PRINT.

Blower.—The name now applied to designate almost all descriptions of machines for creating an artificial current of air by pressure. It is claimed for the positive pressure-blowers, now in constant use, that they measure and force forward at each revolution a fixed quantity of air, whether the pressure be high or low or the speed fast or slow; and the amount of air delivered can be accurately determined and controlled, and the exact quantity necessary to effect the perfect combustion of a given amount of fuel at a given time supplied with perfect certainty.

The blowing-engine or piston-blower also gives a forced blast, but it is not so good for the cupola as the positive blower, because the blast produced is irregular and comes in puffs with every motion of the piston, making it necessary to provide a large receiver to equalize the blast. This is, of course, both expensive and bulky. This class are sometimes called cylinder-blowers.

The common fan-blower, a rotative blowing-machine, consisting of vanes turning upon an axis, has nothing positive in its operation. The wings merely beat the air, imparting a momentum corresponding with the velocity, but, as resistance is opposed to the blast, the volume is diminished in the ratio of the resistance till a point is reached where the momentum and the resistance are equal, when no air whatever is discharged; but the fan-wheel continues to revolve in the case with great rapidity, absorbing a large amount of power, but doing no work at all. See CUPOLA; BLAST; COMBUSTION.

Blow-holes.—Another name for blisters, but more correctly meaning such holes as are further removed from the surface, or, perhaps, entire holes from the surface down; while a blister is so called because of the thin skin of metal which covers the hole. See BLISTER; VENTING; PASTE.

Blowing.—The rushing, roaring noise created by the forcible ejection of gases at the runners and risers when the vents are insufficient to carry them away, or are accidentally choked, is by the moulders termed "blowing." See VENTING.

Board.—An abbreviation of sweep-board. See SWEEP-BOARD.

Bod-stick.—Another name for bott-stick. See BOTT-STICK.

Bogie.—The name sometimes given to swivelled trucks and carriages used about the foundry or forge.

Bog-iron Ore occurs chiefly in alluvial soils, in bogs, meadows, lakes, etc. It is a mineral of very variable composition, but regarded as consisting essentially of peroxide of iron and water—peroxide of iron 60 per cent, water 20 per cent. Phosphoric acid is usually present in quantities varying from 2 to 11 per cent ; silicic acid, aluminia, oxide of manganese, and other substances which seem accidentally present make up the rest. See ORES.

Boiled Oil.—See OILS.

Boiler-moulding is almost a distinct class of moulding, belonging to what is denominated *hollow-ware work,* although the larger description of boilers are sometimes moulded in loam after the manner of kettles. See HOLLOW-WARE MOULDING ; KETTLES.

Boiling-point.—See EBULLITION.

Borax is procured by heating boracic acid with carbonate of soda, the carbonic acid being expelled and the boracic acid taking its place. This salt has an alkaline taste and reaction, and possesses the property of dissolving many metallic oxides; hence its use as a flux in the welding of metals. It dissolves off the coating of oxide formed when they are heated, thus presenting a clean surface. See FLUX; SOLDERS.

Boshes.—That part of a cupola immediately above the tuyeres. In large cupolas and blast-furnaces this part is gradually contracted from the widest part to the hearth, and the bricks used for this purpose are distinguished as bosh-bricks. See CUPOLA; WATER-BOSHES.

Bott-clay.—The clay used for stopping up the taphole in the cupola. Any good, ordinary clay will answer for this purpose, but it requires more than ordinary care to bring it to the right condition for effective use. If too soft it is impossible to fill the hole with a firm plug, and if too hard it refuses to yield to the form of the hole, so that in either case there is danger, because, as the bottom fills, the pressure increases and the imperfect plug is forced out. Besides being of the right consistency, there should also be mixed with it a quantity of sea-coal; this prevents in a large measure the sputtering usually attendant upon the use of the raw clay. The operation of tapping is expedited also by this admixture of sea-coal, as it prevents to some exten tthe clay from baking hard, and for this reason is more easily picked out with the tapping-bar. See BOTT-STICK; TAPPING-BAR.

Bott-stick, sometimes called a "bod-stick," is the tool used by the cupola-man for plugging the tap-hole with clay after sufficient or all the iron has been allowed to run from the cupola. It may consist of a long iron rod about ¾ inch diameter, one end of which is formed into an eye for ease in handling, and upon the other is forged a flat button, about 2 inches diameter, made with a corrugated face in order that the clay bott which is pressed upon it may adhere thereto. For "stopping-in" over-large ladles it is almost necessary to have an iron bott-stick, but when small ladles are in use, and the hole is opened frequently, a long wood shaft may be substituted for the iron rod by either forming the button on a spike and driving it in the end, which is prevented from splitting by an iron band, or it may be formed on an iron socket made to receive the end of the shaft. The wood ones are much lighter and easier to handle than the iron ones. To use the bott-stick properly, see—first, that the button is cold and wet, a pail of water being kept near by for the purpose; second, that the clay bott is pressed firmly down upon it and worked with the hand into the form of a cone; and thirdly, that the back-hand be slightly raised, pressing the clay into the hole from the upper side. By this means whatever commotion takes place when the molten iron touches the wet clay is in the immediate vicinity of the tap-hole in a downward direction, thus avoiding all the unpleasantness and danger caused by the spray of metal, which is thrown in all directions when the bott is thrust carelessly into the hole with the stick held in a horizontal position. See BOTT-CLAY.

Bottom-part.—The nowel or drag. See FLASKS.

Bottom-plate.—See FOUNDATION-PLATE.

Brass.—A yellow alloy of copper and zinc, much used for furnishing and decorating, as well as for parts of machinery. It is common to include other alloys, as copper and tin in this classification ; these, however, are not brass, but bronze, and will be found described under that head. When brass is manufactured on a large scale, it is usually made to contain: copper 2, zinc 1; but the alloys must necessarily vary according to the purposes for which they are intended. If more than ordinary tenacity is required the alloy must consist of about : copper 16, zinc 4; but if a hard, brittle alloy possessing reduced resisting power is desired, the zinc may be increased to equal quantity with the copper, or even beyond that where, at copper 1, zinc 2, the yellowness ceases entirely, and we have a brilliant bluish-white alloy of so crystalline a nature that it may be crushed in a mortar.

The method of manufacturing brass in large quantities is to heat in crucibles a mixture of calamine, or carbonate of zinc, charcoal, and scrap, or grain copper, in the proportions thus : calamine and charcoal 3, copper 2. The action of the white heat reduces the calamine, and separates the zinc, which, combining with the copper, forms a brass consisting of copper 2, zinc 1.

Common ingot brass is made by the simple fusion of copper 16, zinc 8 ; but, owing to the volatility of zinc, the resultant proportions of the alloy are seldom to be relied upon, and calamine brass is preferred. The vapor of the zinc-ore by the latter mode combines more intimately with the copper.

Yellow brass for filing and machining ranges from : copper 16, zinc 4, to copper 16, zinc 9. Up to this proportion brass remains very ductile and malleable ; beyond it, the crystalline nature asserts itself in proportion as the zinc is increased. Copper and zinc mix in all proportions, but it requires the greatest care in mixing to obtain the proportions aimed for, owing to the zinc's volatility, as before stated.

With reference to the color of brass alloys, copper-red gives place to yellow at copper 16, zinc 4, and maintains about the same hue up to copper 16, zinc 10 ; when it gradually becomes lighter up to copper 1, zinc 2—which as before stated, is a bluish-white with a brilliant silvery lustre when polished.

The fusibility of brass increases with the zinc ; so that the metal from copper 16, zinc 7, up to copper 16, zinc 15, is eminently adapted for running a large class of furnishing and decorative-work ; but before such brittle metal as this is subjected to the various processes of cleaning, dipping, lacquering, and bronzing, it is invariably annealed.

The specific gravity of brass is greater than that deducible from the specific gravity of the metals composing it.

The brass for ornament is prevented from tarnishing by lacquering and bronzing. The former consists of coating with shellac in spirit, with some coloring; the latter process being effected by the application of metallic solutions, after a course of cleansing in acids.

Brass from copper 50, zinc 50, to copper 63, zinc 37, may be rolled into sheets and otherwise worked when heated to a red heat; but, according to Muntz, copper 60, zinc 40, is the best proportion. When brass is made for this purpose it is cast into ingots, then heated and rolled.

Brass is made hard by hammering or rolling, but its temper may be again drawn by heating to a cherry-red and plunging it in water.

Copper-castings are, to a great extent, freed from porosity or honeycombing by the addition of from ½ to 1 ounce of zinc to 16 ounces of copper.

The following compositions are alloys of copper and zinc only, which constitute true brass:

COPPER AND ZINC ALLOYS.

	Copper.	Zinc.
Copper castings are made solid by	16	¼ to 1
Brass gilt for jewelry, etc., bronze color	16	1 to 1½
Heavy Machinery bearings	32	1
Sheet brass, red	16	3
Tough engine brass	20	3
Brass to imitate gold	16	3½ to 4
Bristol brass, solders well	16	6
Brass wire	16	7
Brass castings, ordinary	16	8
Muntz metal (one extreme)	16	9 to 10½
" " (" ")	16	16
Pale-yellow brass for dipping (spelter solder for copper or iron)	16	12
Another dipping-brass	16	14
Spelter solder for brass	16	16
Speculum metal	100	18¾
Mosaic gold	32	33

As a supplement to the above, the author appends the following list of mixtures, which are largely original, and of known excellence for the numerous purposes mentioned:

MISCELLANEOUS MIXTURES FOR GENERAL MACHINERY PURPOSES, ETC.

	Copper.	Tin.	Lead.	Zinc.
Soft Machinery brass	16	....	2	5
Large steps or bearings (common)	16	2	2	2
" " " " (good)	16	3	1	1
" " " " (best)	16	4	....	...
Small " " "	16	2	1½	1
Ordinary D valves	16	2½	2	½
Extra large " "	16	1½	....	1½
Delivery valve-lids	16	2	2	1
Large bells	16	4½	....	..
" "	16	3½	....	....
Small clock-bells	16	3	...	....
General machinery brass	16	2	1	½
" " " (good)	16	2	½	½
" " " (collars, etc.)	16	2½	1	1
Large cocks	16	¼	9	....
Small "	16	1	5	....
Common "	16	1½	6	....
Yellow brass	16	....	....	8
" " (good)	16	....	....	7
" " (better)	16	....	...	6
Brass for cutting-wheels	16	....	....	4
Roller brass	16	2	3	....
Large copper rivets	16	....	....	1
Small " "	16	....	....	½
Lathe-bushes	16	4	....	¼
Pulley-blocks	16	2½	....	....
Wheels	16	2	....	....
Gun-metals	16	1¾	....	....
Connecting-rod steps	13	1½	....	1½
Valve-spindles	16	...	½	3
Valves and seatings	16	....	3	1
Piston-rings	30	4½	....	15
Brass to expand by heat equal with iron	79	6	....	15

For further information on this subject, see ALLOY; BRASS-FURNACE; BRASS-MOULDING; BRASS-TEMPERING; BRASS-SCRAP; BELLS; BRONZE; CEMENTATION; COPPER; SHEATHING-METAL; SOLDERS; LACQUERING; ZINC; GAS-BLAST FURNACE; PORTABLE FURNACE; HARD ALLOY.

Brass-furnace.—The common method of erecting brass-furnaces for melting in crucibles is to build them on one side of the shop. The insides are formed within cast or wrought iron casings, from 18 to 20 inches diameter and about 36 inches high. These are ranged over the ash-pit, and the air is supplied through gratings set even with the foundry floor, through which the air finds its way to the pit below. Usually the tops of the furnaces stand about 9 inches above the floor and are covered while in operation with a cast-iron doomed door. The casings are fire-brick lined to a suitable diameter that will leave the requisite amount of fuel to surround the crucible. A small hole, about 6 inches square, is left near the top, which connects with the flue leading to the chimney. If a row of such furnaces are thus constructed, there should be a separate flue for each, so that one or more of them may be employed at any time without any interference with the draft. The chimney in all cases should be a tall one to encourage the draft.

Portable brass-furnaces, round and square, are now supplied by the dealers. They are simply an iron casing, complete in all respects, except the lining; can be located at any part of the foundry, and connected with the chimney.

The Gas-blast Melting Furnace manufactured by the American Gas Furnace Company is now extensively employed for all purposes of crucible melting. A positive air-pressure maintains perfect combustion of the gas, and cleanliness is secured by the entire absence of soot. The best results are attained in these furnaces by securing perfect combustion and by confining the space to be heated to the smallest possible limits consistent with convenience. These furnaces are made in sizes to suit Dixon's block crucibles from Nos. 0 to 200; special fire-bricks being made for every sized furnace (see Gas-blast Furnace). Very frequently the cupola is employed when a large quantity of metal is wanted. A much better mode, however, is to provide a reverberatory or air-furnace in close proximity to the brass-foundry, or wherever it may be customary to cast heavy brass-work.

The Garrett Furnace, a fire-brick construction after the manner of an air-furnace, is described by the inventor as follows:

"In a shop where any considerable amount of brass is melted, the method of melting in a crucible is wasteful and expensive. The Garrett Furnace not only saves the cost of crucibles, but is also economical of metal, fuel, and labor, besides reducing the time of melting a charge from one half to two thirds. This furnace was especially designed for full gas, but with a slight modification of details it could be used with soft coal or crude oil as a fuel.

There is a slant hole for charging coils of copper wire or material difficult to compress into a small space. Smaller pieces, bars, or plates are introduced through the charging-door. The bosh for the molten metal is located below the melting-chamber, being 33 inches wide by 18 inches high from the bed to the top of the arch, which is composed as shown, and has filling above and between it and the bottom of the charging-chamber, made of fire-clay and sand. The bed of the bosh is undulated being composed of a mixture of fire-clay and sand, which makes it as hard as a crucible and will last from two to seven weeks without repair, according to the work required of it. Below the bosh gas-flues are provided, two 6-inch by 6-inch for gas and two the same size and adjacent for air. The gas is brought to the gas-flues by two $\frac{1}{2}$ inch gas-pipes having valves for regulating the supply, and passes along the flues to a combustion-chamber, 12 inches wide, 36 inches long, where it mixes with air, ascends and passes over the bridge, and is divided into two flames, one larger than the other. The large flame passes over the bosh to the flue, and the other flame passes through the melting-chamber to the flue. Dampers are provided in the flues to regulate the supply of gas, or proportion it for either of the chambers as desired. One flue is 4 inches by 10 inches, and the other is 8 inches by 10 inches, both entering into a stack-flue 16 inches square.

A door is provided to give access to the combustion-chamber and bridge, and another door, gives access to the bosh. See BRASS; PORTABLE FURNACES.

Brass Mirrors.—These mirrors are of classical antiquity, and were made from an alloy known as speculum metal, which produces a very hard metal with great reflecting power; but it is now very seldom met with. A good speculum metal, very white and hard as steel, is composed of equal parts of copper and tin. Copper 7, tin 4, zinc 3, form an alloy of a light yellow color, possessing much lustre. This alloy is sometimes made from copper 2, tin 1, with the addition of $\frac{1}{16}$ arsenic. Lord Rosse's composition was: copper 252.8, tin 117.8. See SPECULUM METALS; ROSSE'S TELESCOPE; BRASS.

Brass Mixtures.—See BRASS.

Brass Moulding.—So far as the actual moulding is concerned there is very little to distinguish it from the ordinary course pursued for producing castings in iron. For the larger castings in dry-sand and loam, exactly similar moulds are made, but for the very light brass castings in green sand it is necessary to have a very fine silex sand, which contains a slight portion of clay. When the sand contains clay in excess it favors the production of the finest work; but there is always danger of blown spots when this is used, only to be remedied by drying the moulds, or introducing more open sand, to permit the gases generated at pouring to escape. It is not necessary to cast brass any hotter than will result in clear, sharp outlines in the casting.

As a rule, most brass castings will be freer from honeycombs, if the metal is forced in at the lowest part of the mould, taking care that suitable vents are provided for carrying off the gas as it generates in the mould.

The fact that all sands taken from the earth must contain more or less vegetable matter, which burns out as soon as the metal strikes it, making a rough and unfinished looking casting, has prompted some dealers to prepare a composition of minerals, crushed and put through a process known alone to themselves, where every trace of vegetable or any other matter not standing a high fire-test is extracted, the sand being usually ground and bolted. See BRASS; FACING-SAND; ROCK-CRUSHER.

Brass Scraps.—Old brass, judiciously selected, may be made to do excellent service. As the regulation mixtures for the several articles made in brass are pretty much the same all over, it is a simple matter to make such choice from the old scraps as will almost answer present needs very often by making such additions as are necessary to bring the mixture up to the required standard in any of the metals which the scrap may be lacking in. Another important feature in using scrap-brass is to remember that, when it is melted over again, more or less of the zinc and lead oxidizes and wastes; this, of course, changes the original proportions, and must be made good by additions of the above metals. For old brass that has been remelted more than once, it is well to add 1 pound of lead to 16 pounds of scrap; a little less will do when the metal has not been recast.

Brass borings and turnings may be melted with little or no waste by packing the crucible full and hard, using a cover and luting it well. Add a little lead when melted. See BRASS; CRUCIBLE.

Brass-tempering.—Brass containing the least zinc is the softest and most easily wrought but, with a proportion of one fourth, brass is still perfectly malleable when cold. Hammering increases or creates elasticity in brass, destroys its flexibility, adds considerably to its durability, and imparts magnetic power. If it is desired to draw the temper again, heat to a cherry-red, and immerse the article in water. See Brass; Tempering.

Brass to Dull.—See Dulled Brass.

Brazing.—Soldering with an alloy of copper and zinc. This operation is usually confined to joining copper, zinc, and iron surfaces, and in order to effect a solid junction the surfaces to be united must be made clean and bright. The brazing alloy, after being granulated, must be wetted with ground borax and water and then dried, after which it must be strewn over the gap or crevice, or between the two pieces to be united, which are then exposed to heat until the solder flows between them. The solder may be rendered more fusible by the addition of a little zinc. See Soldering; Solders; Cast Iron to Braze.

Breast-hole is the hole in front of the cupola, just back of the spout, at which place the tap-hole is formed. Much of the trouble caused by slag gathering at the tap-hole is attributable to the very careless manner in forming the tap-hole. Sand is used for this purpose without reference to its refractoriness, the consequence being that the intense heat gradually melts it into slag, and it issues from the hole at every tap. If the heated fuel in front is made as level as possible, filling all the spaces with pieces of coke before the sand is introduced, and no more than about three inches of a well-dampened and refractory mixture be rammed therein, much if not all of the trouble from slag at that point will cease. See CUPOLA; SPOUT; SLAG; TAP-HOLE.

Bricks.—Good common bricks have about the following composition: silicia $\frac{3}{5}$, alumina $\frac{1}{5}$, lime, magnesia, soda, iron, potash, and water being included in the other fifth. The American brick varies in size from $7\frac{3}{4}$ to $8\frac{1}{2}$ inches long, 4 to $4\frac{1}{2}$ wide, and $2\frac{1}{4}$ to $2\frac{1}{2}$ thick. English bricks average 9 inches long, $4\frac{1}{2}$ wide, and $2\frac{1}{2}$ thick. A too severe fire in the kiln fuses the brick and causes hard clinkers; on the other hand, insufficient burning causes a soft brick unfit for use. See FIRE-BRICK.

Bricking-up.—A relative term for bricklaying, and meant by moulders to imply the process of forming the containing-walls of a loam-mould. Bricks in this instance take the place of flasks, the needed rigidity being imparted by binding-plates which, if necessary, may be further strengthened by bolting the sections together. The sweep-board is the guide for laying, and the bricks are set apart for fine cinders to form passages for the gases. See ROUGHING-UP; SKINNING-LOAM; SWEEP-BOARD; BINDING-PLATES; COURSE; FILLING-IN.

Brimstone.—See SULPHUR.

Britannia Metal.—A tableware alloy, with some resemblance of silver. Articles made from this alloy were formerly made by stamping with dies, but this has been superseded by the more efficient method of spinning. One mixture for this metal is: brass 4, tin 4; after fusing add bismuth 4, antimony 4—this composition to be added at discretion to melted tin. Another is to make up a hardening compound of copper 2, tin 1. This is made separate and used with other ingredients as follows:

BRITANNIA METAL.

	Tin.	Hard-ening.	Copper.	Anti-mony.
Best quality	150	....	3	10
Good "	140	....	3	9
Metal for casting....	210	....	4	12
" " spinning	100	4	....	4
" " registers	100	8	....	8
" " spouts...............	140	....	3	6
" " spoons	100	5	....	10
" " handles	140	....	2	6
" " pillars, lamps........	300	....	4	15

See ALLOYS; TIN; ANTIMONY; COPPER; SPINNING METALS; WHITE ALLOYS.

Broken Castings.—See BURNING.

Bronze.—A mixed metal, consisting chiefly of copper with a small proportion of tin, and sometimes of other metals. It is used for casting statues, bells, guns, and numerous other articles, in all of which the ingredients are of varying proportions. For a description of the various bronzes, see ALUMINUM-BRONZE; PHOSPHOR-BRONZE; MANGANESE-BRONZE; STATUARY; BELLS; DEOXIDIZED BRONZE; VINEGAR-BRONZE; GUN-METAL, and other bronzes. Also, COPPER; TIN; ZINC; FONTAINEMOREAU'S BRONZES; JAPANESE BRONZE-WORK.

Bronzing Liquids. See STAINS FOR METALS.

Brushes.—These implements are now made in infinite variety for foundry purposes. Among the number may be noticed the soft bristles for moulders' ordinary use; blackening brushes of special manufacture for coating vertical moulds; flat English bristle for loam and dry-sand blackening; flat camel's-hair for distributing dry lead on green moulds, as well as for the finer classes of loam and dry-sand finishing, and steel-wire hand-brushes for cleaning castings. An improved steel-wire brush is a rotary, one that may be revolved by power.

Buckling.—The seamy, unsightly scars to be seen on some castings when too much slicking and too little venting have been expended on clayey loam or sand. When due attention to these shortcomings fails to work an improvement, it is evidence conclusive that more fire-sand is needed in the facing-sand. See SLICKER; SCABBED CASTINGS; VENTING; RAMMING; FACING-SAND.

Buckle-chain. See SWIVEL-CHAIN.

Bugs.—The name given in some places to the small shot-scrap made in the immediate vicinity of the cupola, and along the track of the ladles during the time of casting. No description of scrap is so difficult to manipulate as this. If charged in bulk at the commencement, no end of trouble is caused through the accumulations of dirty slag left behind, and which materially impedes the regular working of the cupola throughout the heat; whilst if it be used in small quantities with each charge, there is a possibility of more or less of the fine stuff falling through the openings and finding a lodgment near the tuyeres, or, what perhaps is worse, being carried past the melting-point unmelted, to be again resurrected by the tools of the machinist—a too frequent occurrence where such scrap is used indiscriminately. The best method of utilizing this foundry pest is to choose a time when everything is convenient and before the last charge of good iron has got too low; charge the bugs along with a heavy proportion of some good softening pig or special compound, taking care that an extra charge of fuel is used for the purpose. By running this mixture into pigs, to be remelted, there will be no risks taken, and all annoyances previously spoken of will certainly be obviated. See CUPOLA; CHARGING THE COMMON CUPOLA.

Building-rings. See BINDING-PLATES.

Bullet-mould.—This entire mould consists of a pair of hinged cheeks, with one or more spherical cavities reamed therein, connecting with an ingate through which the melted lead is poured. They must fit exceedingly close when brought together.

Burden.—The burden in the cupola or blast-furnace is supposed to be light when the proportion of fuel to ore or iron is large. When the fuel is proportionately small in the charge, the burden is then called heavy. See CHARGING THE COMMON CUPOLA.

Burning.—A phrase signifying brazing or mending broken castings by melting the joining edges and leaving the space filled with molten metal, which when set unites the parts. The common process consists of pouring a constant stream of hot fluid metal along the fissure or upon the surface until the parts are entirely fused, taking care to leave an excess of metal for subsequent chipping and trimming after it has become cold. See BRAZING; SOLDERING.

Burnt Iron is all such iron as may have been for a lengthened period subject to a heat somewhat below the melting-point, on which account it has become little better than an oxide of iron. Its color is of the various shades of red, such as may be noticed in burnt retorts, grates, fire-bars, etc. Iron of this description should be used sparingly along with a large proportion of high silicon pig, if used at all. Any attempt to reduce such iron without a considerable admixture of good softener is sure to result in pasty and sluggish iron accompanied by an extraordinary amount of slag, which plays havoc with the cupola. The great amount of waste which occurs in melting this class of iron is of such extent as to make the operation a loss almost every way. See CHARGING THE COMMON CUPOLA; CUPOLA.

Butt-rammer is usually a heavy rammer with a flat, round, or square face, forged or cast to a long rod or piece of tubing, with which to complete a course of ramming after the pegging-rammer has forced the soft sand well down on the course immediately underneath. See PEGGING-RAMMER.

C.

Cadmium.—A somewhat rare metal found associated with zinc in nature, and is similar to that metal in its chemical relations. When exposed to the air it tarnishes. Cadmium is a lustrous bluish-white metal; melts and volatilizes at a temperature below redness, and if heated in the air it takes fire and burns to a brown oxide. See ZINC.

Cage Iron.—A skeleton core iron, used for such cores as the jackets of cylinders, etc. See SKELETON CORE IRON.

Calamine.—A native carbonate of zinc, used in making brass. See BRASS; ZINC.

Calcareous Spar.—A carbonate of lime, occurring principally in grayish-white crystals. It is infusible, falls into quicklime before the blowpipe, and effervesces with acids; its composition is lime 57, carbonic acid 43. This mineral is of universal occurrence, and sometimes it is found tinged with various shades of color, owing to the presence of manganese, iron, and other impurities.

Calcination.—The process by which some bodies by the action of fire are reduced to the condition of a calx or cinder. Most of the metals can be reduced to this condition, which renders them easily reducible to powder. By subjecting ores to the action of the fire the volatile parts are driven off, and the water of crystallization dissipated. By this process marble is converted into lime by expelling the carbonic acid and water, and the same may be said of borax, gypsum, alum, and other saline substances which are deprived of their water of crystallization by the process of calcination. There is a difference between calcination and oxidation, fire being a necessary agent in the former case, while metals may be oxidated by acids, heat, or exposure to the atmosphere. See WEATHERING ORES; KILN.

Calcium is a light yellow metal, somewhat harder than lead—very malleable; melts at a red heat and oxidizes in the air. It exists in abundance in limestone, fluor-spar, and gypsum. See LIME.

Caliper.—Caliper compasses are very serviceable tools in a foundry doing general work of a superior order. No consideration of false economy should be tolerated that does not furnish ample means for obtaining correct measurements. These tools especially should be of a reliable character.

They may now be obtained in an endless variety of styles and finish from the supply dealers throughout the country. See GAUGE.

Camel's-hair Brush.—An excellent tool for giving the final touches to finished dry-sand and loam work, as also for use on green-sand surfaces with dry lead. For these purposes they should be double thickness and brass-bound. They are sold by the width at from thirty-five to forty cents per inch. See BRUSHES.

Candle.—See OILS.

Can-hooks.—This excellent device is improperly called "cant-hooks" in some localities. It consists of a double chain, rope, or bar-sling attached to a ring, with ends slightly hooked for gripping the underside of a flange or projecting lug. Very useful for taking a balanced lift where such practice is convenient. See SLINGS; CHAIN.

Cannel-coal.—A dense, compact coal of a highly bituminous nature, used largely for making gas. See COAL; FUEL; PETROLEUM.

Cannon.—A long cylindrical tube for throwing projectiles by the explosion of gunpowder. The date of the invention and the name of the inventor are unknown. It is certain that King Edward employed cannon at the battle of Cressy, A.D. 1346, but records are extant showing that they were known in France as early as the year 1338; and Isaac Vossius asserts that they were used in China seventeen hundred years ago. The earliest cannon were made by hooping iron bars, or of sheets of iron rolled up and fastened together. These cumbersome machines were used for throwing large stones in the manner of the ancients. These were gradually supplanted by brass cannon of much smaller calibre, which threw iron and lead balls; they were first cast of a mixture of tin and copper, which was naturally called gun-metal, but subsequently cast-iron guns came into use on account of their being so much cheaper. See ORDNANCE.

Caoutchouc.—See RESIN; INDIA-RUBBER.

Capacity of Ladles.—See LADLES.

Carbolic Acid.—See TAR.

Carbon.—A simple combustible, which constitutes a large proportion of all animal and vegetable substances. We are familiar with it in the diamond, and the various kinds of charcoal, mineral coal, lampblack, etc. Carbon unites with all the simple combustibles. With iron it forms steel and plumbago, and with copper it forms a carburet. The diamond is the purest form of carbon. See DIAMOND; GRAPHITE; CHARCOAL; CAST IRON; STEEL.

Carbonates.—Compounds of carbonic acid with salifiable bases, composed either of one prime of acid and one of base, or one of acid and two of base. The former are carbonates, the latter bicarbonates.

Carbonic Acid.—This acid is composed of oxygen 72, carbon 28; specific gr. 1.529, air being 1.000. All forms of carbon when burned in the air unite with oxygen to form carbonic acid. It constitutes 44 per cent of limestone. A cubic inch of marble yields four gallons of the gas. Under a pressure of 36 atmospheres at 32° carbonic acid shrinks into a colorless liquid lighter than water. It does not resume the gaseous state when the pressure is removed, but evaporates with great rapidity, one portion absorbing heat from another, and thus freezing it into a white substance like snow. Unlike other acids, it does not unite with water to form a definite hydrate. It is anhydrous in all the three states—gaseous, liquid, and solid. It is incombustible, and a non-supporter of combustion. See GASES; LIQUID; SOLID.

Carbonic Oxide.—See OXIDE CARBONIC.

Carbonize.—To convert into carbon by combustion, or the action of fire, or any other means, as the carburization of malleable iron by the addition thereto of carbon, through solid or gaseous carbonaceous matters. See CEMENTATION; CRUCIBLE STEEL.

Carburet.—The union of carbon with a base, or a combination of carbon with any of the simple substances. It is more commonly termed a carbide.

Card-moulding.—See PLATE-MOULDING.

Carnelian.—A semi-transparent mineral only distinguished by its colors (the various shades of red) from agate, jasper, etc. Finest specimens of this mineral come from India; it has a glimmering lustre and is sometimes found a dark blood-red, passing into a greenish-brown. It is infusible. Its composition is silex 94, alumina 3.5, lime 1.5, oxide of iron 0.75. Carnelian was much preferred by the ancients for engraving upon. See PRECIOUS STONES.

Carriage.—An iron vehicle to run on tracks, which ought to be laid convenient to one or more of the foundry cranes, and from thence inside the oven or stove. In planning carriages for this purpose strict attention should be given to local requirements, not to any particular *one* that may have been seen or heard of elsewhere. For example: Would it be best to make a perfectly flat table? and, if so, how high, and how large in area? Or, should it be provided with fixed or adjustable racks? If so, how high and in which direction, to be most convenient for passing the cores? Again, would it be of service to attach taper-sockets for loam-work spindles, with the view of building on the carriage direct? Finally, is it possible to so combine these or other qualities as to make it the best and most convenient carriage possible for either special or general purposes? See OVEN; SPINDLE.

Carrying-bar.—A stout wooden or iron bar, about 30 inches long, having a depression in the middle. By means of this contrivance, two men stand or walk side by side, supporting the single end of a shank-ladle between them. See SHANK; LADLE.

Carving.—By this term we generally understand the art of cutting figures and designs in wood with suitable sharp instruments made for the purpose. Cutting designs in stone is termed sculpture, and similar operations on metals is called chasing. Patterns for decorative, architectural, and other castings, which were at one time the productions of the wood-carver, are now accomplished in shorter time and at less cost by the modeller. See MODELLING.

Car-wheel Founding.—The manufacture of car-wheel is a special branch of foundry industry, which, in all of its varied phases, demands more than ordinary attention to make good wheels at a profit. The processes of their manufacture are substantially as follows: First, a good, substantial wood pattern, or better, an iron one, with iron core-boxes in which to dry the cores. Second, a set of flasks consisting of cope, with bars to fit one inch clear of the pattern; drag, with separate perforated bottom-plate; and an intermediate chill 4 inches thick, for chilling the tread, with lugs and pins to match both upper and lower parts, and trunnions for reversing. Third, moulding and casting. Fourth, lifting from the sand red hot, and lowering into the annealing-pit, where the wheel cools gradually in about three or four days, when it is taken out, cleaned, tested, and if found sound in every particular, is pronounced a chilled car-wheel.

The "Barr" contracting car-wheel chill is described in *The Machinery Moulders' Journal* as follows :

The ring, which constitutes the ordinary chill, is divided into 96 sections by radial divisions. The sections or blocks are held in position by an outside ring, which is capable of being expanded or contracted, thus causing the blocks composing the chill to be moved, radially, outward or inward. By this means the expansion which occurs in the ordinary chill is entirely prevented, and the inward radial motion of the chill-blocks is such as to extend the time of contact between the chill and the contracting-wheel within, until nearly the full effect of the cooling influence of the chill is obtained. The expansion and contraction of the outside hollow retaining-ring is effected by introducing steam or water.

The operation of the chill is as follows: When the moulder is nearly ready to pour his metal, steam is turned on through the outer ring, causing it to expand, and carrying with it the chill-blocks, thus increasing the diameter of the chilling surface. When the chill becomes so warm that you can barely lay your hand upon it the steam is then turned off. The iron is now placed in position to pour, and the moment the iron enters the gate or pouring-head, cold water is passed through the ring which causes a contraction of the outside hollow sustaining ring and a consequent decrease in diameter of the chilling surface.

This chill has been in use in our foundry for the past year, and during that time our loss from chill-cracks and other causes has been $\frac{1}{2}$ of 1 per cent, while in the old-style chill the loss has been from 3 to 6 per cent.

There is in fact an entire absence of chill-cracks, rough tread, and sweats, and the presence of slag almost entirely prevented. There is a decided improvement in the depth of white iron and its uniformity around the tread; the average variations in the white iron being about $\frac{1}{16}$ inch, while in the old or solid chill I have known it to vary as much as $\frac{3}{8}$ to $\frac{1}{2}$ inch. The quality of gray iron, with its freedom from slag or imperfections, and the general strength of the wheel is enhanced by hotter and faster pouring, which is made possible by the use of this chill. With the old or solid chill the time consumed in pouring a chill is about twenty seconds, and with the contracting chill nine to twelve seconds.

There is only one objection to the Bar contracting chill, and that is the small ridges formed by the spaces between the chill-blocks. These we are compelled to grind off with an emery-wheel. This labor can be lessened by filling these crevices with sharp sand.

Case-hardening is the term applied to the process of converting the external surface of articles or masses of iron into steel, with the view of combining the hardness of the latter with the toughness and comparative cheapness of the former. This may be done by placing iron articles (finished, but not polished), along with animal carbon, as hoofs, leather, skins, etc., that have been partly burned to admit of being powdered, into an iron box, well luted, and subjecting them to a red heat for about half an hour, or even more, according to the depth of hard surface needed, after which plunge the contents into water.

Cast iron may be hardened on the surface by first bringing to a red heat and rolling in a mixture of saltpetre, powdered prussiate of potash, and sal-ammoniac in equal proportions, after which immerse in a bath of water which contains in each gallon, sal-ammoniac 4 oz., prussiate of potash 2 oz.

Small iron articles will be case-hardened by allowing them to remain 30 minutes in a fused liquid consisting of common salt 10, prussiate of potash 1, and subsequently plunging into cold water. An iron pot will serve to fuse in.

Casings are perforated iron shells, provided with prickers for carrying the loam thickness, and with means for lifting and turning over the cope part. When the form of castings is favorable to non-interference with contraction, as in some sugar-pans, crystallizing-cones, and other kindred castings, both inside and outside moulds may be swept with the spindle, closed and cast, without any subsequent ramming in the pit which necessarily attends the ordinary methods. Cylindrical casings are equally as advantageous when the quantity of castings required will warrant the outlay for making them. See BELLS; KETTLES; SPINDLE.

Cast.—A term used among fine-art workers, meaning impressions from sculptures, medals, and other delicate works of art; also, the taking of *casts* from the face and other natural objects. See PLASTER-CAST.

Cast is a common term in the foundry; as, when a piece has been poured, it is said to be *cast;* when a moulder has finished pouring as many moulds as constitute a day's product, he is considered to be *cast off*.

Casting.—The finished or completed product in the foundry.

The act of pouring metal into a mould is called *casting the mould.*

Castings, To Bronze.—See STAINS FOR METALS.

Castings, To Galvanize.—See ZINC-COATING.

Castings, Weight of.—See WEIGHT OF CASTINGS.

Cast Iron.—Cast iron is the product of the iron smelting-furnace. Iron occurs in nature, almost universally, in a state of combination. The mineral masses which it forms with oxygen, carbon, sulphur, and the metals, and from which it is extracted, are called its ores. It is strongly magnetic, and rubs into a black powder. Magnetic iron ore (loadstone) is one of the richest ores of the iron, containing 72 per cent of iron and 28 of oxygen. Specular or red iron ore is very hard, and sometimes presents a polished appearance, brown in color; but its powder is always red—by which means it may be distinguished from the magnetic oxide. This ore contains 63 per cent of iron and 36 of oxygen. Red hematite is much used, being very plentiful, as also is brown hematite, which is found in almost all parts of the world; it contains about 86 per cent of peroxide of iron to about 14 of water. Clay ironstone occurs amongst the coal measures, and contains only about 37 per cent of iron. Bisulphide of iron, or pyrites, occurs in large quantities under different forms. Pyrites is prized chiefly as a source of other substances; it is never worked for its iron.

The richer iron ores yield a good iron by simply heating the broken ore with charcoal in an open fire with blast. The ore is deoxidized, or, in other words, deprived of its oxygen by the carbon of the fuel, and the reduced iron is gathered into a pasty mass called a "bloom," while the earthy impurities contained in the ore combine with a portion of the oxide of iron to form a slag. Very much of the iron is, by this method, lost in the slag, and there is also a great waste of fuel; but the method is so simple that it may be practised by people possessing little knowledge of chemistry, and for this reason it is no doubt the oldest method of extracting iron from its ores.

The metal is not usually obtained pure in the extraction of iron from its common ores, as it contains more or less carbon, which imparts to it a fusible nature; for which reason iron in this state is designated "pig iron," or cast iron. The processes connected with the reduction of the ores consist of, first, calcining or roasting (this is done to expel carbonic acid, water, sulphur, and other volatile ingredients of the ore); secondly, the reduction of the oxide of iron to the metallic state by ignition with carbon; thirdly, the separation of the earthy impurities of the ore by fusion with other matters into a slag; and, fourthly, the carbonizing and melting of the reduced iron. The purest kind of iron ores do not require to be previously calcined, but with most of them it is essential.

Some of the larger examples of blast-furnaces have a width at the boshes of 25 feet, and are over 100 feet in height. These are commonly called smelting-furnaces, because the process of separating the iron from its ore, called reducing, is conducted in them. The top or mouth of the furnace serves for charging as well as for the escape of smoke, etc., and is therefore both door and chimney. The tuyeres at the bottom, like the ordinary cupola, serve to supply the air, which is forced in by means of immense blowing-engines. To economize fuel, the blast is sometimes heated to over 1000 degrees before it is delivered into the furnace. The furnace is sometimes charged with alternate layers of fuel (coal or coke and sometimes charcoal), ore, and limestone. When the heat has become sufficiently intense the carbon of the fuel deoxidizes the iron, and carbonic acid is also expelled from the lime, leaving it caustic. Sand and clay, in greater or less quantities, now remain combined with the iron; the lime, acting as a flux, unites with these and forms a slag. The iron as it melts falls to the bottom of the furnace, from whence it is allowed to flow at intervals through a tapping-hole, which when not in use is kept stopped with sand. The slag flows out over a dam, arranged in such a manner as to retain the molten iron, but to permit the escape of the slag, which floats on the iron as fast as it accumulates in sufficient quantity. As fresh supplies of fuel, ore, and flux are charged at the top, the melted iron is tapped at the bottom; where channels from the tap-hole lead the metal into sows, and from thence into the pigs; the process goes on without stoppage, sometimes for years.

The product of the smelting-furnace is, as has been previously stated, "cast iron," containing from 2 to 6 per cent of carbon, which in the white irons is chemically combined with the iron; while in the gray it is principally graphitic, mechanically distributed through the iron. There are also other impurities contained in cast iron, including silicon, sulphur, and phosphorus, and sometimes manganese. Cast iron is easily distinguished from malleable by its granular texture and brittleness, which precludes all possibility of forging; but it is this very quality that gives it its value as a foundry iron, because it can be so readily remelted and cast into moulds.

It is presumed that cast iron expands at the moment of assuming the solid from the liquid state; this expansion being caused by the particles assuming a crystalline arrangement as the mass solidifies, but that a subsequent contraction takes place gradually as it becomes cold. See WATER-TUYERE; CALCINATION; ORES; SOW; PIG IRON.

Cast-iron pipes are tubes of cast iron for conveying water or other fluids. Elbows, bends, curve, branch, tee, flange, hawse, as well as odd shapes of water and other pipes, etc., all come under the general name of *jobbing pipes,* and are made in almost every foundry. But the *straight-length* socket pipe, of which so many thousand tons, of every dimension almost, are made each year for the water-works systems, are now all made by firms devoted exclusively to the manufacture of that class of castings. The defects formerly existing by reason of the employment of unskilled labor at nearly all the pipe foundries have long since ceased to exist, as the work now emanating from these concerns incontestably proves.

As made by the regular establishments, pipes are all cast vertically in cast-iron casings, having the core on a barrel. The flasks are rammed vertically on fixed foundations, with guide to receive the mandrel or pattern. The cores are accurately struck on barrels, in the customary way, the barrels being provided with ample means for handling and self-adjustment; which leaves little to be done except to elevate the dried core, and lower it into the prepared seat at the bottom of the mould. Moulds and cores are thoroughly dried before casting.

The following table gives the weight of one foot in length of pipes from 1 inch to 22 inches diameter:

Diam.	Thickness.	Weight.	Diam.	Thickness.	Weight.	Diam.	Thickness.	Weight.
Ins.	Ins.	Lbs.	Ins.	Ins.	Lbs.	Ins.	Ins.	Lbs.
1	¼	3.06	3¼	½	18.4	5	⅝	34.34
	⅜	5.05		⅝	23.72		¾	42.28
1¼	¼	3.67		¾	29.64	5½	½	29.4
	⅜	6.	3½	½	19.66		⅝	37.44
1½	⅜	6.89		⅝	25.27		¾	45.94
	½	9.8		¾	31.2	6	½	31.82
1¾	⅜	7.8	3¾	½	20.9		⅝	40.56
	½	11.04		⅝	26.83		¾	49.6
2	⅜	8.74		¾	33.07		⅞	58.96
	½	12.23	4	½	22.05	6½	½	34.32
2¼	⅜	9.65		⅝	28.28		⅝	43.68
	½	13.48		¾	34.94		¾	53.3
2½	⅜	10.57	4¼	½	23.35		⅞	63.18
	½	14.66		⅝	29.85	7	½	36.66
	⅝	19.05		¾	36.73		⅝	46.8
2¾	⅜	11.54	4½	½	24.49		¾	56.96
	½	15.91		⅝	31.4		⅞	67.6
	⅝	20.59		¾	38.58		1	78.39
3	⅜	12.28	4¾	½	25.7	7½	½	39.22
	½	17.15		⅝	32.91		⅝	49.92
	⅝	22.15		¾	40.43		¾	60.48
	¾	27.56	5	½	26.94		⅞	71.76

Diam.	Thickness.	Weight.	Diam.	Thickness.	Weight.	Diam.	Thickness.	Weight.
Ins.	Ins.	Lbs.	Ins.	Ins.	Lbs.	Ins.	Ins.	Lbs.
7½	1	83.28		1	122.62		1	161.82
8	½	41.64	12	½	61.26	16	½	80.87
	⅝	52.68		⅝	77.36		⅝	101.82
	¾	64.27		¾	93.7		¾	123.14
	⅞	76.12		⅞	110.48		⅞	144.76
	1	88.2		1	127.42		1	166.6
8½	½	44.11	12½	½	63.7	16½	½	83.3
	⅝	56.16		⅝	80.4		⅝	104.82
	¾	68		¾	97.4		¾	126.79
	⅞	80.5		⅞	114.72		⅞	149.02
	1	93.28		1	132.35		1	171.6
9	½	46.5	13	½	66.14	17	½	85.73
	⅝	59.92		⅝	83.46		⅝	107.96
	¾	71.7		¾	101.08		¾	130.48
	⅞	84.7		⅞	118.97		⅞	153.3
	1	97.98		1	137.28		1	176.58
9½	½	48.98	13½	½	68.64	17½	½	88.23
	⅝	62.02		⅝	86.55		⅝	111.06
	¾	75.32		¾	104.76		¾	134.16
	⅞	88.98		⅞	123.3		⅞	157.50
	1	102.09		1	142.16		1	181.33
10	½	51.46	14	½	71.07	18	⅝	114.1
	⅝	65.08		⅝	89.61		¾	137.84
	¾	78.99		¾	108.46		⅞	161.9
	⅞	93.24		⅞	127.6		1	186.24
	1	108.84		1	147.03	19	⅝	120.24
10½	½	53.88	14½	½	73.72		¾	145.2
	⅝	68.14		⅝	92.66		⅞	170.47
	¾	82.68		¾	112.1		1	195.92
	⅞	97.44		⅞	131.8	20	⅝	126.33
	1	112.68		1	151.92		¾	152.53
11	½	56.34	15	½	75.96		⅞	179.02
	⅝	71.19		⅝	95.72		1	205.8
	¾	86.4		¾	115.78	21	⅝	132.5
	⅞	101.83		⅞	136.15		¾	159.84
	1	117.6		1	156.82		⅞	187.6
11½	½	58.82	15½	½	78.4		1	215.52
	⅝	74.28		⅝	98.78	22	⅝	138.6
	¾	90.06		¾	119.49		¾	167.24
	⅞	106.14		⅞	140.4		⅞	196.46

To find the weight of a pipe, let the following rule be observed: To the inner diameter add the thickness of metal; multiply by 3.1416 for the circumference, and the product by the thickness. This gives the number of inches contained in the end section of the casting, which, when multiplied by the length, gives the total cubic inches, which, if multiplied by the weight of a cubic inch of the metal used, will give the total weight. See Columns.

Cast Iron, To Braze. — Clean the parts to be joined and tin them well. They may be now placed together in the sand, or elsewhere, and melted brass poured over them. See Soldering.

Cast Iron, To Chill. — Use soft-water, 10 gallons; salt, 1 peck; oil of vitriol, ½ pint. Heat to a cherry red and dip, continuing to dip until hard enough. See Case-hardening.

Cast Iron, To Soften.—Water 4, aqua-fortis (nitric acid) 1; steep for 24 hours.

Cast Iron Mixtures.—See Mixing Cast Iron.

Cast Steel.—See Crucible Steel.

Catalan Forge.—A simple kind of open-hearth furnace, once common in Catalonia, Spain, for producing malleable iron; some few are found there still, as well as in some other parts of Europe and America. In their crudest form they consist of a simple hole in the ground, in which are contained the ignited charcoal and the substances to be heated; the fire being urged by a blast of air blown in through one or more nozzles or tuyeres, from either a rude bellows or a *tromp*. See Tromp.

Cement.—These substances are generally employed in a semi-fluid or pasty state to unite bodies in close adhesion, the latter condition being the most favorable for bringing the opposing surfaces into intimate contact.

Marine Glue.—Glue 12, water enough to dissolve; add yellow resin 3; melt, and add turpentine 4, and mix thoroughly together.

Cement for Lamps.—Rosin 3, caustic soda 1, water 5, boil; then add half its weight of plaster of Paris. Sets in $\frac{3}{4}$ of an hour; not permeable to petroleum.

Cement to Resist a Red Fire, Water, and Oils.—Equal parts of sifted peroxide of manganese and zinc white; soluble glass, sufficient to form a thin paste. See SOLUBLE GLASS.

Another: Pulverized litharge 5 lbs., fine Paris white 2 lbs., yellow ochre 4 oz., hemp cut in shreds $\frac{1}{2}$ oz.; this is ready for use when it has been mixed to the consistency of putty with boiled linseed-oil.

Liquid Glue.—Glue, water, and vinegar, each 2 parts. Dissolve in water-bath, and add alcohol 1 part.

Cement for Steam-boilers, Steam-pipes, etc.—Red or white lead, in oil, 4 parts; iron borings, 2 or 3 parts (soft), or iron borings and salt water, and a small quantity of sal-ammoniac with fresh water (hard cement).

For Holes in Castings.—Sulphur in powder, 1 part; sal-ammoniac, 2 parts; powdered iron turnings, 80 parts. Make into a thick paste. The ingredients comprising this cement should be kept separate and not mixed until required for use.

Cement for Stopping Holes in Cast Iron.—Iron filings, 15 parts; sal-ammoniac, 2 parts; sulphur, 1 part; ground or powdered stone, 2 parts; add water until it is about the consistency of common paste; it is then ready for use.

For Making Canvas Water-proof and Pliable.—Yellow soap, 1 pound, boiled in 6 pints of water; add, while hot, 112 pounds paint.

Cement for Rust-joints (Quick-setting).—1 pound sal-ammoniac in powder, 2 pounds flour of sulphur, 80 pounds iron borings (made to a paste with water).

Stone and Iron.—When stone and iron are to be cemented together, use a compound of equal parts of pitch and sulphur.

For Cisterns and Water-casks.—Melted glue, 8 parts; linseed oil, 4 parts; boiled into a varnish with litharge. This cement hardens in about 48 hours and makes tight joints.

Rice Glue, or Japanese Cement.—Rice flour; water, sufficient quantity. Mix together; then boil, stirring it all the time.

Cementation is a chemical process consisting of surrounding a body in the solid state with the powder of some other body or bodies, and exposing the whole for a time to a degree of heat insufficient to melt the contents. By this means iron is converted into steel when packed in powdered charcoal, and green bottle-glass into porcelain by sand, etc. See BLISTER-STEEL.

Centre. See SPINDLE; LOAM-MOULDING.

Chain.—A chain consists of a series of iron links welded one within the other. The very critical and particular uses made of chains in a foundry and elsewhere should suggest the propriety of devoting more attention to their careful preservation. The fewer their number the greater probability of a right selection and legitimate use. The tensile strength of good chain iron is about 41,000 lbs., but in order to maintain that high state of efficiency chains must not be subjected to the barbarous system of hammering one sees sometimes in order to release a few kinks. Another vile method is to take heavy lifts when one or more of the chains have been purposely shortened by twisting. A few fractured chains, and mayhap a life lost, would be of infinitely greater cost than a handy set of swivel-chains, by which means an even lift can be obtained as precisely as may be desired. Instead of being thrown down on the damp floor, chains should always be hung up and carefully protected from rust. An occasional heating to a dull red in a charcoal fire, followed by a long protracted cooling while shielded from the atmosphere, is of great service, and tends to restore the quality of ductility. Hard knocks, overstraining, lifting with twists, moisture, sudden changes of temperature are all favorable to crystallization, and hence fatal to the well-being of chains (see SWIVEL-CHAIN). For strength of chains and ropes, see ROPES.

Chain-slings.—See SLINGS.

Chalk is nearly a pure carbonate of lime; it effervesces with acids and burns to quicklime. In England it forms in beds sometimes more than 100 feet high. The solid stone is used for building with. It is an excellent lime for cement and a good polishing substance. See LIMESTONE.

Chalk Composition.—For obtaining impressions of simple objects, as medals, etc., or for forcing into well-oiled moulds, as busts, statuettes, etc., this composition is very good. It is composed of powdered chalk and thin glue worked to the consistency of putty, which, when allowed to dry, becomes almost as hard as marble. All that is needed is to press the composition hard down into all the cavities of the mould, and the impression is perfect. See PLASTER-CAST.

Change-hook. See DOUBLE HOOK.

Chaplet.—A chaplet proper consists of a stem of indefinite length, terminating at one end with an increased flat surface, which renders it less likely to be thrust into the core by pressure or weight. If this plate end is forged out of the whole piece the chaplet is a good one, and may be relied upon ; but a riveted end is an abomination for more reasons than one. In the first place they are apt to slip through unless the shoulder is enlarged, and that is not sufficient to prevent the head from flying off when struck; consequently, whether they are home-made or purchased from the dealers, the solid ones are to be preferred. By means of a match-plate very many excellent chaplets for ordinary purposes may be made of cast iron; for many jobs they are infinitely superior to wrought iron, and very much cheaper.

Chaplet is the general term for almost every device for holding down or supporting cores and sections of moulds ; even springers are recognized as a species of chaplet, and so called in many parts (see SPRING-CHAPLET), and solid studs of almost every description go by this name.

Two important features in this connection are rust and lack of material. Both of these conditions are fatal to a mould—the former because of the large amount of gas evolved when the rust decomposes; the latter because of their too frequent use in parts where the current of metal dissolves the stud, leaving the part without support.

Both studs and chaplets are incorrectly called *anchors* in some foundries. See ANCHOR.

Charcoal.—Charcoal is what remains of wood after it has been exposed to a strong heat while protected from the access of the atmospheric air. Charred bituminous coal produces what is termed coke. See COKE.

Charcoal-facing.—The dust of pulverized charcoal. See FACING.

Charge.—The amount of metal, fuel, flux, etc., introduced into the furnace at one time, either as one of a number of charges to constitute a whole heat, as in a cupola, or, as the whole quantity charged at once, as in a reverberatory furnace.

Too much intelligence cannot be brought to bear on the operation of charging the cupola, as not only may there be a substantial saving effected in the quantity of fuel used, but time in melting may be shortened, as well as hotter iron produced when the true proportions of fuel to iron has been once accurately determined. Commence with 9 pounds of iron to 1 of fuel above the bed-charge, and continue this for one day, noting well the length of time taken to melt the heat, as well as the temperature of the iron melted; then gradually decrease or increase the amount of fuel, as occasion demands, until the smallest percentage possible is reached, after which the whole labor of charging is reduced to a positive science, demanding only accurate weighing of the materials used every day to insure satisfactory results at every heat, providing the requisite blast-pressure is maintained on every occasion. See CUPOLA; RATIO OF FUEL TO IRON; CHARGING THE COMMON CUPOLA.

Charging-doors are the doors used for closing the mouth of the cupola after the charge has been thrown therein. It is a great mistake to provide a too limited hole through which to charge the iron and fuel; when this occurs, the operations are sure to be faulty, as the cupola-man cannot place the alternate layers of fuel and iron with the regularity necessary for even melting. Very much of the irregularity in melting, so prevalent almost everywhere, could be prevented if a capacious aperture was provided with close-fitting doors, which latter should be kept closed after the charge is in. See CUPOLA; CHARGING THE COMMON CUPOLA.

Charging-hole.—The mouth of a cupola. See CHARGING-DOORS.

Charging-platform (*scaffold*).—The stage upon which fuel and iron is stored for convenience in charging. Usually the platform is built about 3 feet below the charging-hole and immediately in front of the latter. Position and capacity are two important features. The former should be chosen with reference to possible future developments,—such as additional cupolas, improved facilities for raising material, etc.,—while the latter in all cases should be of strength sufficient to bear *with perfect safety* all the materials for one day's heat, and ample in area to do this without in any sense interfering with the charging operations. See CUPOLA; CHARGING THE COMMON CUPOLA.

Charging the Common Cupola.—The following table of common straight cupolas, from 24 to 84 inches diameter inside of lining, all of which have a bed depth of 10 inches, show what amount of fuel is required for the bed, first charge of iron, and succeeding charges of fuel and iron. Also blast-pressure and tuyere area required to melt a given quantity of iron per hour, as well as the total melting capacity of each cupola designated. All the figures are based upon what may be considered as *safe* practice under *ordinary* conditions. A proportionate increase or decrease of bed fuel is necessary when the depth of sand-bed differs either way from 10 inches, as given; and any increase of burden in order to obtain improved ratios of melting must be introduced gradually. The results as per table are absolutely certain when the power is adequate and blast-pipes, etc., sufficiently capacious and free from leaks.

The total melting capacities given represents what may be expected irrespective of any system of slagging, or other means ordinarily adopted for continuous melting:

Diameter Inside of Lining.	Depth from Sand-bed to Under Side of Tuyere.	Weight of Fuel on Bed.	First Charge of Iron.	Succeeding Charges of Fuel.	Succeeding Charges of Iron.	Number of Tuyeres 6 In. Diameter, or their Equivalent.	Blast Pressure.	Melting Capacity per Hour.	Total Melting Capacity.
In.	In.	Lbs.	Lbs.	Lbs.	Lbs.		Oz.	Lbs.	Lbs.
24	10	300	900	50	500	1.5	6	1,500	6,000
30	10	570	1,700	176	1,584	2.6	7	3,000	12,000
36	10	840	2,520	260	2,340	3.3	8	4,820	18,280
42	10	1,110	3,330	428	3,852	5.8	10	7,550	30,200
48	10	1,380	4,140	554	4,986	6.8	12	10,760	43,040
54	10	1,650	4 950	680	6,120	10.7	14	13,850	55,400
60	10	1,920	5,760	806	7.254	13.7	14	16,940	67,760
66	10	2,190	6,570	932	8,388	15 4	14	21,200	84,800
72	10	2,460	7,380	1,058	9,522	19.	16	26,070	104,280
78	10	2,730	8,190	1,184	10.656	26.	16	31,800	127,200
84	10	3,000	9,000	1,310	11,790	31.	16	37,530	150,120

See Ratio of Fuel to Iron; Blast-pipes; Slag.

Cheek.—A portion of mould carried separate in the side of a flask, or on a *drawback* plate. The cheek parts of a flask are those between the cope and nowel, as in a three-part flask; it is *cope, cheek,* and *nowel.* See Drawback; Flasks.

Chemical Analysis in the Foundry.—See Analysis.

Chill.—The heavy cast-iron casing or former which is placed to give shape to the casting, and, by its rapid absorption of heat, produces a hard chilled surface there. This mode of chilling or hardening is the one pursued for treads of wheels, rolls of various kinds, and many other purposes. See Car-wheel; Rolls; Steel-castings; Case-hardening.

China-clay is prepared by washing a white decomposed granite found in the southwestern part of England and other places. It is prepared by first breaking into pieces and allowing streams of water to carry it to pits, where, having settled to the consistence of cream, it is run into moulds to be subsequently kiln-dried. It is then cut into convenient-sized blocks and shipped for the manufacture of porcelain, earthenware, paper, etc., as well as for numerous other purposes in the iron industries, such as the manufacture of crucibles, etc. This is the *kaolin* of the foundry, being the name given by the Chinese to a similar clay found in China and used by them in making porcelain. See FELDSPAR; KAOLIN; DAUBING.

Chinese White-copper.—See WHITE ALLOYS.

Chinese Pakfong.—See PACKFONG; WHITE ALLOYS; GERMAN-SILVER.

Chinsing.—See DRESSING.

Chipper.—Castings, when lifted out of the sand, are freed from burnt, adhering sand by the *cleaner;* after which, by means of hammers, chisels, and files, all superfluous metal, as heads, gates, fins, etc., are removed by the *chipper.*

Chipping-piece.—A facing of extra metal, allowed on parts of a casting for fitting purposes. When at the top they may connect with the pattern; but when chipping-pieces are required at the bottom or anywhere intermediate, they must be pinned on the pattern temporarily, and the pins removed while ramming proceeds. The pieces can then be withdrawn or *picked out* after the pattern has been drawn from the sand.

Chloride.—Compounds of great importance are formed by a combination of chlorine with metals and other substances. Most of the chlorides are soluble in water, and metals enter into as many combinations with chlorine as they do with oxygen. Chlorides melt at ordinary temperatures, and are more easily dissolved and fused than are their corresponding acids. Chlorides usually decompose when heated in a current of hydrogen, the result being hydrochloric acid and the pure metal. Simple ignition will decompose chlorides of noble metals, leaving the uncombined metal. If chlorides are heated with black oxide of manganese and sulphuric acid, the chlorine is eliminated.

Chlorine abounds in the mineral world, chiefly in the metal sodium, in salt, etc., and is prepared by heating black oxide of manganese with hydrochloric acid—which forms a yellowish transparent gas $2\frac{1}{2}$ times heavier than air. Under a pressure of four atmospheres it is condensed into a liquid slightly heavier than water and which remains unfrozen at 220°. This gas unites with oxygen to form five compounds: with hydrogen it forms hydrochloric acid; with nitrogen, an explosive of great power, called *perchloride of nitrogen;* and it forms several chlorides with carbon.

Chocks.—See Chucks.

Chromium Steel.—The effect of this substance is analogous in some features to that of manganese; in others to that of carbon upon steel, imparting a fine close texture and increasing hardness and brittleness.

Chucks are pieces of wood, slightly wedged, to be driven fast between the bars of a flask to impart stiffness to the bars; or, for driving down below the straight bars to form a continuation of the latter, as it were, into parts which extend below the joint, and which must be lifted out along with the flask. By this means a plain flask may be made to correspond to any and every form of joint conceivable, and the task of carrying a deep lift is much simplified. This useful device is often called chocking.

Churning.—See FEEDING.

Cinder.—See SLAG; MILL-CINDER.

Cinder-bed.—Sometimes called a coke-bed; a means by which all vents are provided with a sure outlet, from the mould, through the spaces formed by the cinders, and out at the vent-pipes. See VENTING.

Cinder-pig is pig-iron obtained by treating in the blast-furnace rich slags and cinders along with ores or pig. See MILL-CINDER.

Cire-Perdue Process.—A method of producing statuary, etc., by modelling a wax figure on a prepared core, inclosing the wax with suitable composition, drying the mould and melting out the wax, and finally filling the space with metal. See STATUARY-FOUNDING.

Cisterns.—A tank, artificially constructed for holding liquids. Foundry cisterns should be spacious and of sufficient number to accommodate every need. Their efficiency is enhanced when provided with a ball-cock which will automatically maintain a certain height of water at all times, with no possibility of flooding the foundry floor.

Clamp.—A device for drawing together and securely holding two or more objects, such as two parts of a flask, core-box, etc. Besides the ordinary ones of cast and wrought iron which may be seen at all foundries, there are a considerable number of patented devices, some of which have very ingenious modes of adjustment. The Diamond Adjustable, with automatic lock, Hawley's Sliding Clamp with excentric head, are among the many truly good inventions which are supplied by the foundry agents. Called a "cramp" sometimes.

Clay is a term of uncertain application to all kinds of earth or soil which, when moistened, become plastic and tenacious. Common clays are not easily distinguishable as mineral species; but it is apparent that nearly all have their origin in the decomposition of other minerals, chiefly consisting of alumina in combination with silica and water. See FIRE-CLAY.

Cleaner.—A moulder's tool, and frequently styled a "lifter." It is an important implement, made in different lengths and widths, principally from steel. It consists of a long flat blade, to slick or smooth the sides of confined webs; one end, being forged to a toe at right-angles with the blade, serves to lift out loose sand from such webs, and also to smooth the bottom. See SLICKER.

The workman who removes sand and cores from castings is usually styled a cleaner. See CHIPPER; SAND-BLAST.

Cleaning-barrel.—See TUMBLING-BARREL.

Clearance.—See ALLOWANCE.

Closing.—This term in the foundry means the operation of placing all the parts composing the entire mould in their respective places. A green-sand mould is frequently spoken of as "closed" immediately the cope or top part has been placed thereon.

Coagulate.—To change from a fluid to an inspissated state; to concrete, to clot, to thicken.

Coal.—The bituminous coal is a substance of vegetable origin, apparently formed from plants by a slow decaying process, going on without access of air, and influenced by moisture, heat, and pressure. As is the case in all vegetable matter generally, it is composed of carbon and hydrogen, with small proportions of oxygen and nitrogen, together with more or less earthy and saline substances, spoken of commonly as inorganic matter. On being heated in the air it is almost consumed, leaving the inorganic components as ashes; but when heated out of contact with the air, viz., subjected to destructive distillation, the volatile hydrogen is driven off, with some carbon, either as a gas or as a tarry liquid, and the residue is coke, containing carbon only, to some extent contaminated with the impurities originally present in the coal.

Anthracite coal, whilst having been formed similarly to the bituminous, has evidently been subjected to some sort of natural distillation, by which it has been deprived of nearly all the hydrogen, nitrogen, and oxygen of the original wood. To some extent it is coke, formed as it were by natural agencies.

The specific gravity of anthracite coal is 1.536, and of bituminous 1.280.

One cubic foot of anthracite coal weighs 96 pounds; of bituminous, 80 pounds.

The space required to stow away one ton of anthracite coal is 40 cubic feet; for bituminous, 44. See COMBUSTION; FUEL.

Coal-dust.—Commonly called *sea-coal facing* is ground from bituminous coal that has been selected for its freedom from slate, sulphur, or any other substance of a deleterious nature. When this dust is mixed with the sand, it breaks up and separates the fusible elements contained therein, and that which is not separated is more or less impregnated with the gas produced. Fusing of the sand is by this means partially prevented by reason of the hydrogen and carbon which the sea-coal contains. Experience teaches just how much coal-dust is required for this purpose; but it is seldom that more than one of coal to six of sand can be used, as any higher percentage will produce a too open mixture which results in streaked blotches on the castings, caused by the molten iron searching out the surplus coal and consuming it. See FACING-SAND; FACING.

Coal-oil.—See PETROLEUM; TAR.

Coal-tar.—See TAR.

Coating Metals.—Iron castings may be coated with gold or silver by first cleaning and then boiling, in a porcelain vessel, containing water 12, muriatic acid (sp. gr. 1.2) $1\frac{1}{2}$, iron vitriol 2, zinc 1, mercury 12. A layer of mercury is soon deposited on the iron, upon which the gold amalgam may be distributed. For silvering, the iron must be first coated with copper, and the silver applied in the leaf or by means of amalgam. See ZINC COATING; TINNING; SILVERING; GILDING.

Cobalt.—This substance bears in many respects a close resemblance to nickel, and is often found associated in nature with that metal. It is white, brittle, and tenacious, having a high melting-point; specific gravity, 8.5. Its principal ores are white cobalt, consisting of cobalt 44, arsenic 55, sulphur 0.50. All the ores of cobalt contain more or less nickel. See ARSENIC; NICKEL.

Cohesion is that power by which the particles of bodies are held together. The absolute cohesion of solids is measured by the force necessary to tear them asunder. See TENACITY; STRENGTH OF MATERIALS.

Coke is the residue resulting from the destructive distillation of soft or bituminous coal, and may be classed as an impure sub-variety of carbon, which, from a chemical point of view, may be classed either with graphite or charcoal, or perhaps between the two. It is made in ovens or in heaps, where the volatile matters are expelled, leaving the coke we use for melting purpose.

About 2240 pounds of bituminous coal is required to produce from 1000 to 1400 pounds of good dry coke.

The manufacture of illuminating gas necessitated the use of retorts, into which bituminous coal principally is charged and heated to redness by an external fire. At a moderate heat tar and oil are produced, but at a high temperature gases are formed in large quantities. The principal products of this destructive distillation are coal-tar, steam, ammonia, sulphide of hydrogen, carbonic acid, carburetted hydrogen, olefiant gas, and a solid, friable, carbonaceous mass, which is known as gas-coke.

Coke specially manufactured for smelting purposes, of a good quality, is far superior to any kind of coal for melting in the cupola, as it melts faster and produces hotter iron. The best qualities are distinguished by their hardness, emitting a ringing sound when struck; a freedom from what is called smut, this being only partially burned at such parts—exposing a dark gray, fine cellular mass when fractured, with a silvery gloss overspreading the whole outer surface.

The specific gravity of coke is 1.000; one cubic foot weighs 62½ pounds, and the space required to stow one ton is 72 cubic feet. See COAL.

Coke-fork.—A very effective and useful substitute for the shovel in handling coke generally, and for charging the cupola in particular. Being made with from 10 to 14 long steel prongs, they take nothing but clean coke, leaving the dirt behind, and thus saving the use of a riddle.

Cold-blast. See Hot and Cold Blast.

Cold-short.—Iron or steel is termed "cold-short" when it fractures at the edges if rolled or hammered at a temperature below a dull red heat.

Cold-shots, also called "cold-shuts," are seams which, on flat castings, are sometimes formed by local accumulations of dirt and dust. Another source of cold-shots is when the metal enters in straggling and divergent streams, leaving portions of metal to partially congeal at places before the whole surface is covered. At the final meeting the junction is an imperfect one, because of the difference in temperature of the two portions of metal. Castings, poured vertically, that have heavy adjoining parts, will sometimes show very deep scars of this nature, because of the dead stoppage which occurs whilst such parts are being filled. This happens sometimes in cylinders with heavy connections; the partial stoppage gives time for the surface scum to congeal, and metal simply flows back and covers it. When all the gating is from the top, this casualty is not likely to occur. See Faint-run.

Cold-tinning.—See Tinning.

Column.—A pillar or post, usually made either round or rectangular in form, and employed as supports for roofs, entablatures, or other superstructures. The members of a column are *capital,* shaft, and base, with an abacus for the capital, and sometimes a plinth for the base.

Columns are of wood, stone, cast iron, malleable iron, and steel. Made of the latter they are now constructed in segments, riveted together, and shipped as promptly sa cast iron ones are made in the foundry. The change from cast-iron to steel has seriously affected the architectural foundry interests and many firms are at present suffering severely on account of the innovation.

The following table shows the weight of one foot in length of square columns one inch thick, and the number of inches contained in end section of each column, by which means the weight of one lineal foot of any other casting answering to the total inches given is obtained at once.

Dim. of col. in inches.	6×6	7×7	8×8	9×9	10×10	11×11	12×12	13×13	14×14	15×15
Weight of 1 foot in lbs.	63	75	87	100	113	125	138	150	163	174
No. of inches con. in sec.	20	24	28	32	36	40	44	48	52	56

Dim. of col. in inches.	16×16	17×17	18×18	19×19	20×20	21×21	22×22	23×23	24×24
Weight of 1 foot in lbs.	187	200	213	225	238	250	263	275	288
No. of inches con. in sec.	60	64	68	72	76	80	84	88	92

TABLE SHOWING THE WEIGHT IN POUNDS OF ONE LINEAL FOOT OF ROUND COLUMNS ONE INCH THICK.

Outside diam. of column in in.	4	6	8	10	12	14	16	18	20	22	24
Weight of on ft. in length in lbs.	30	49	69	89	108	128	148	167	187	206	226

Colliau Cupola.—The lower portion of the "Colliau" Cupola is composed of two sheet-iron shells, the inner shells being made very heavy and of the same size as the stack proper; the outer shell encircles the inner one and is made air tight, forming the wind-chest, which varies in size according to the size of furnace. In the outer shell are arranged two doors or shutters held in position by tap-bolts, also made air tight, which may be removed and again replaced after cleaning, should any dirt or slag accumulate in the wind-chest.

Opposite each tuyere also is a sliding air-tight gate with peep-hole, and in the bevel top is furnished a brass nipple to connect hose from blast-meter into the wind-chest or chamber. The blast is introduced through two flanged openings, one on either side as shown, and reaches the melting point through two sets of six tuyeres each, arranged to concentrate the blast.

The tuyeres are so constructed that the melted iron in its downward course cannot pass through them into the air-chamber.

The furnace, as a whole, is simple in its construction. There is no complicated machinery or parts to get out of order, and consequently does not require any more attention or repairs than a common cupola.

Combustion means the process of burning, and usually consists in the union of the oxygen of the atmosphere with the constituents of the combustible substances. The combustion of coal is caused by this oxygen passing into a state of chemical union with the carbon and hydrogen contained in the coal; carbonic acid and water-vapor being formed thereby. In all ordinary cases of combustion the amount of heat set free depends upon the amount of oxygen brought into action, rather than on that of the body burned. Hence, the combustible which united with the most oxygen while burning gives off the most heat. Thus, hydrogen in burning, takes up weight for weight, three times as much oxygen as carbon does, and gives off three times as much heat as a consequence. The complete burning of a combustible body requires the consumption of the same quantity of oxygen whether the process be rapid or slow, the amount of heat being the same in both cases. From this it is seen that the intensity of the heat is governed by the rapidity of the combustion.

Heat would be liberated from the burning of a pound of coal in ten minutes—six times as fast as if its combustion occupied an hour. This explains why the blacksmith blows his fires, and also why blowing-engines are employed at the cupola, blast-furnace, etc.; the time of combustion is shortened by their use, with a corresponding increase in the degree of heat obtained; besides, this extreme blast serves to expel from the fire all products of combustion which would retard it if allowed to gather therein. However, it may be borne in mind that too much air is detrimental to the burning process, as it serves to convey away the heat, thus cooling the fuel and hindering the rate of combustion.

It is thought by many, that the more air is forced into the cupola, the more rapid will be the melting. From the above it will be seen that this is true only to a certain extent. Time is required to elevate the temperature of the air supplied to the point that it will enter into combustion; if more than this is supplied it absorbs heat rapidly, reduces the temperature, and, as we have seen, retards combustion.

The importance of supplying the exact quantity of air, neither too much or too little, cannot be overestimated. See Charging the Common Cupola; Cupola; Blast-gauge; Blowers.

Common Pewter.—See Pewter.

Compound.—To mingle or unite two or more ingredients in one mass, or a substance composed of two or more elements joined by chemical affinity.

Compressed Castings.—This process is for making fine and artistic castings in brass, bronze, German-silver, aluminum, etc., and consists of preparing hard moulds containing the impress of the articles to be cast, the outside edges of which are square, so that they may be packed one on the other, and, when so packed, the gate of each leads to a central sprue. These are closely packed in an air-tight box. An opening in the cover-plate of the box directly connected with the sprue leads into a cylindrical reservoir containing the molten metal. This cylinder is lined with asbestos felt, the hole into the sprue being also covered with it, preventing the exit of the metal from the reservoir until the proper time. A piston, covered also with asbestos, fits closely into the cylinder, and pressure may be applied to it by hand through the action of a lever, rack and pinion, a screw or by other means. The reservoir being filled with the proper quantity of molten metal and the piston entered into the cylinder, connection may be opened between the mould and the vacuum-tank, causing the air in the mould to be drawn out, and at the same time pressure of any required degree may be applied to the piston. This pressure bursts that portion of the asbestos lining that lies immediately over the hole in the cover-plate, and the metal is instantaneously shot into every portion of the matrix in the mould.

Compressed Steel.—See Pressing Fluid Steel.

Concave and Convex Moulds.—See Medals.

Congelation.—The transition of a liquid to a solid state in consequence of the abstraction of heat, or through the effect of pressure. Metals, oil, water, etc., congeal when they change from a fluid to the solid state. In the foundry, it is common to term these phenomena as "setting," "freezing."

Contraction.—See SHRINKAGE.

Converter.—A pear-shaped vessel resting on trunnions, and provided with hydraulic apparatus for the purpose of rotating the same through an angle of 180°, or thereabouts. It consists of an outer casing of wrought-iron plates, held together by rivets, and is suspended by means of a strong steel band carrying two trunnions which is secured on the body of the converter at its widest part. The trunnions run in bearings connected with uprights, one of them being solid, and the other hollow ; the latter serves as a passage for the blast, and carries a gear-wheel.

It is important that the lining of a converter be material of the most refractory character. Sometimes fire-brick is used, but chiefly *gannister*, which is found to be better for this purpose than any other substance. The bottom of the converter is flat and contains a tuyere-box, or cylindrical chamber connected by a curved pipe with the hollow trunnion. The tuyeres are round, tapered fire-bricks, each containing seven holes ½ inch in diameter. From 5 to 7 of these tuyeres are used, their lower ends protruding through a guard-plate in the top of the air-chamber ; the vertical position being maintained by stops which bear against horizontal arms that can be moved aside when any of the bricks are to be replaced, thus saving the necessity of removing the bottom of the converter. To turn the converter, a direct acting water-pressure engine is provided, the piston-rod of which carries a rack which gears into the wheel on the trunnion. See BESSEMER STEEL ; GANNISTER.

Conveyers.—Conveying machinery is now to be found in successful operation in mills, mines, breweries, packing-houses, sugar refineries, coal-yards, boat-landings, brick, tile, and stone yards, in some machine-shops, but in very few foundries. The increasing demand for moulding machinery has made it absolutely necessary that some form of conveyer be used in the foundry, not only to carry the enormous quantity of sand used to the moulders, but to carry it hence from off the foundry floor to be tempered and screened for use, and by this means utilize the space for moulds that would otherwise be required for storing and mixing sand. The endless open-trough conveyer, made of roller carrier chain, or some of the many forms of spiral conveyers, are eminently adapted for this purpose.

Cope.—(1) The top part of a set of flasks (see Flasks). (2) The brick structure in which the outer surface of a loam-mould is formed. Usually a cope is built to a uniform thickness of one brick lengthwise, and, if necessary, are further strengthened with binding-plates set therein at intervals. See Binding-plate; Cope-ring; Loam-moulding.

Cope-ring.—A cast-iron ring for the purpose of carrying the cope of a loam-mould. The inside diameter is made large enough to clear a tapered seating formed below, or past the mould at the bottom, the impression of which is carried in the brick cope built upon the ring. See Seating; Guide; Loam-moulding.

Copper.—This useful metal has been known from the earliest times. With tin it no doubt formed the first metallic compound, and was extensively employed by the ancients in the production of ornaments, statuary, domestic utensils, and implements of war. Pliny informs us that the Roman supply was drawn from Cyprus, the metal being called *cyprium* for that reason. The latter word was corrupted to *cuprum*, from whence is derived the English, copper.

The color of copper is a brilliant red, its specific gravity 8.788, its tenacity only somewhat below that of iron, and higher than either silver or gold. Copper melts at 2550°; its malleability and ductility is high, takes a remarkable degree of polish, ranks next to silver as a conductor of electricity, is hardly affected by dry air, but, on exposure to a damp atmosphere, a green carbonate gathers on its surface.

This metal is widely distributed throughout nature, occurring in ores, soils, and waters—in fact, it is almost as universal as iron. In Lake Superior the metal occurs native, and in some instances irregular masses exceeding 100 tons in weight are found.

Out of nearly a dozen different ores *cuprite,* or red oxide, contains the most metal—about 80 per cent when pure—the rest yielding smaller quantities. Chrysolica, a hydrated silicate of copper found in Chili, Missouri, and Wisconsin, yields only 30 per cent. The Cornish ores consist of copper pyrites, a sulphide of copper and iron.

There are three ways of obtaining copper from its ores, the dry, or pyro-metallurgical, the wet, or hydro-metallurgical, and the electro-metallurgical; but the two former are the methods generally employed. The dry method, or smelting, is invariably pursued when the ores contain over 5 per cent of copper; for a lower grade than this the wet process only is profitable. Swansea and Lancashire are the chief copper-smelting centres in Great Britain. The ores are selected with a view to special treatment, according to their character. The first operation is calcining in reverberatory furnaces, where the ore is spread 8 inches deep on the bottom and subjected to the action of air and fire at a dull-red heat, being frequently turned over to expose every part to their combined influence for from 12 to 24 hours, according to the proportion of sulphide of iron, silica, etc., contained in the charge. The sulphur by this action is partly burned off and forms sulphurous and sulphuric acids; partially volatilized in the pure state; arsenic volatilizes and is oxidized; and some sulphur from the copper and iron forms oxides by combining with the oxygen. The calcined ore is then fused in the reverberatory *ore-fusing furnace*, which is provided with a hopper through which to effect the charging, the charge usually consisting of calcined ore 2600, metal-slag from previous operations 800, cobbing 250. About five hours' hard firing reduces this to a fluid mass, which, after being well skimmed, is tapped into perforated iron boxes, which are suspended in cisterns 50 inches square and 80 inches deep, full of water. At this stage the compound analyzes at : copper 33, sulphur 29, iron 33, and is termed granulated or coarse metal. It is subsequently recalcined, in a similar manner as for the ore, in 4-ton charges. About 24 hours, at a gradually increasing heat, up to a bright red, prepares the metal for running off into *cubs*, where it is treated to another bath of water, after which it is again fused, and by this treatment the silica and oxide of iron combine to form slags, which are skimmed off and the metal again tapped, but in this case it is run into sand-moulds. The resulting compound is now called blue metal, and consists of copper 58, sulphur 20, iron 12.

It is now ready for a further treatment by *roasting*, in charges of 3 tons. The roasting furnace is provided with side charging arrangements and additional air-holes in the bridge, through which a free current of air is admitted, passing over the fused mass, which is kept in a semi-fluid state for about 24 hours, during which time much more of the sulphur has been driven off, and the iron turned into slag by its union with silica, the latter being constantly skimmed off as it is formed.

At this stage, when other impurities have been driven off, it has become a sulphide of copper, and must receive still another 24 hours' roasting to eliminate the sulphur, after which it is again tapped into sand-moulds, forming, according to quality, the several kinds of copper known as *blister, coarse, pimpled,* and *bed* copper. Ingots showing a smooth, hollow surface indicate the presence of tin, and are called *bed;* a pimply surface indicates sulphur; scales of oxide on the surface indicate the blister quality, which is esteemed as ready for refining, and, in this state, consists of copper 98.1, iron .7, manganese, cobalt, and nickel .3, arsenic and tin .4, sulphur .2.

The Siemens Regenerative Furnace is esteemed as the best for refining. Its form is reverberatory, almost like the roasting-furnace, except that the bed inclines towards the reservoir at the end, where, by means of a door, the refined metal may be skimmed off and dipped out. When the metal has collected, it is subjected to polling by thrusting a piece of green oak to the bottom and holding it there. Dipping tests by the refiner indicate when the metal has attained the proper degree of fibre. When the polling ceases the surface is at once covered with charcoal, and a little lead added if the copper is required for rolling or forging; but no lead is employed when the best quality of commercial copper is made. See REFINING.

The *wet* process of grinding and roasting, by which means sulphuric acid is formed, and attacks the oxide of copper. The sulphate resulting from this treatment is dissolved, and the copper precipitated by peroxide of iron.

Dilute sulphuric acid and muriatic acids scarcely act upon copper; boiling oil of vitriol attacks it, with evolution of sulphurous anhydride. Nitric acid, even dilute, dissolves it readily, with evolution of nitric acid.

Copper unites readily with almost all other metals in certain proportions, and not a few of its compounds are of the highest importance in the arts; it may be said that copper is even more important and valuable as a constituent element in a large number of alloys than it could possibly be as a pure metal. It is somewhat difficult to make castings free from blow-holes with pure copper. An excellent remedy for this is to flux with about one ounce of zinc to each four pounds of copper.

Copper combines easily with gold in all proportions, with the result of increased fusibility and hardness; but the ductility is impaired as the hardness increases, its greatest degree of hardness occurring when the proportion of copper is $\frac{1}{18}$. The increased fusibility of the alloy admits of its being used as a solder for gold.

Bronze, brass, and German-silver are the principal alloys in which copper enters as a chief ingredient. With zinc, it forms *brass;* with lead, *pot, metal;* with zinc and nickel, *German-silver;* with zinc, tin, and arsenic, *tombac;* with tin, *bronze.*

The *aluminum bronzes* consist of pure copper alloyed with from $1\frac{3}{4}$ to 10 per cent aluminum. *Phosphor bronze* has from $2\frac{1}{2}$ to 15 per cent tin and from $\frac{1}{4}$ to $2\frac{1}{2}$ per cent phosphorus, according to what it may be required for.

Besides these there are the very numerous and excellent copper alloys for manufacturing purposes, in which the three metals, tin, zinc, and lead, are mixed with it in varying quantities; and others again in which sulphur, bismuth, antimony, cobalt, nickel, silver, iron, etc., are employed in small proportions. See Brass; Bronze; German-silver; Zinc; Lead; Pot-metal; Tombac; Aluminum-bronze; Phosphor-bronze; Silver; Alloys; Solders; Fontainmoreau's Bronzes; Music-metal.

Copperas (Green copperas).—The commercial name for sulphate of iron, a compound of the protoxide of iron with sulphuric acid. It is largely manufactured from iron pyrites, which furnishes by oxidation both the acid and the base. It is often a beautiful mineral, the crystals being a very perfect shape. See SULPHUR.

Core.—The inner portion of a mould, partially or wholly surrounded with metal. It may be composed of greensand, dry-sand, loam, or iron; the latter usually consisting of a tapered chill with some covering of carbon, as tar, etc., to protect it from the action of the molten metal.

The Anti-chill Core Compound Company, Peoria, Ill., explain their core as follows:

"Instead of the present process of using a sand core, we use a metal core made of cold-rolled steel shafting of the same size as the shaft on which the casting is intended to be run or used, turning out the castings ready for use, thereby saving from 50 to 75 per cent on the dollar in machine-finishing labor, such as boring, drilling, key-seating, feathering, etc., required when the sand core is used. This metal core before using, is coated by dipping into our compound, which prevents the molten metal from adhering to the core, and also prevents all chilling, blowing, straining, cracking, etc., of the iron or casting."

Core-arbor.—A central rectangular beam, or core bar, to which are cast on, or bolted thereto, wings which correspond in their conformation to the shape of mould or core to be made thereon. Such arbors are employed for carrying the cores of pipes and columns, round or square, especially when made in greensand. See CORE IRON.

Core-barrel.—A tube or cylinder of cast or wrought iron, provided with a gudgeon at each end, on which to revolve while the core is formed upon it. The common barrel has holes cast or drilled at intervals throughout its length, to permit a free escape for the gases, which, when the casting is poured, are copiously emitted from the straw rope and surrounding loam. See ORDNANCE; VENTS.

Core-box.—A general term applying to all devices for forming cores, but more correctly to those which the pattern constructs out of wood. A matrix may be formed in the sand in which to ram a core, or a brick cope can be constructed in loam for that purpose. Contrivances of such a character can scarcely come under the head of core-boxes, yet they answer the same end. See SPINDLE.

Core-compound.—A substitute offered by various patentees for flour, resin, molasses, sawdust, or other substances commonly employed for stiffening, hardening, and venting cores. It is claimed for most of these compounds that they give body to the sand, burn without smoke or smell, are always uniform and ready for use; that they do not blow, they rap out easily; and, last but not least, that they are cheaper than any of the several things mentioned above. There certainly is one advantage in these prepared compounds: once the exact quantity for effective use is ascertained, the too common annoyance of too much or too little flour, etc., is obviated to the sensible advantage of all concerned. See FLOUR; ROSIN; MOLASSES; VENTING.

Core Iron.—A core iron may consist of a cast grate with pricker extensions for binding all parts of the entire core to one common core iron; or, it may be one of many which, being set and rammed within the sand contrariwise throughout the core, partially answers the purpose of a grate or other contrivance—in which instance they are often designated as "tie-rods," from the fact that, in dry cores especially, the sand clings to the inclosed iron and partakes of its strength. See CORE-ARBOR.

Core-lathe is the arrangement employed for covering a core-barrel with the requisite material and fashioning a core upon its outer surface. It consists of a pair of stands or trestles having V-shaped notches or semicircles on their upper edges in which to rest the trunnions of a core-barrel, or perhaps to receive a turned depression in the core-barrel itself. A handle or crank at the end serves to revolve the barrel while the core-maker pays out the straw rope upon it. A subsequent coat of clay, followed by another of loam, is fashioned by means of a sweep-board or templet at the back, the ends of which rest on the trestles. The core is thus shaped to the outline of the board, the diameter being regulated by the distance at which it is placed from the axis. See CORE-BARREL.

Core-nails.—A cheap description of cut-nails made specially for foundry purposes. Many founders seem to be ignorant of the existence of these useful substitutes for the best nails, and permit the inordinate use of finishing and other nails, which, although they cost much more, are not even as good for the purpose as common ones. See NAILS.

Core-oven.—See OVEN.

Core-plate.—A plate of either cast or wrought iron, on which to convey green cores to the oven. A very good plate for this purpose is made by riveting light angle-iron to thin sheet iron. These are much superior to cast iron, and cost no more to make.

Core-print.—A tapered boss on a pattern or model, indicating the place where a hole corresponding with it in size and shape must be made in the casting. A print of this description is frequently termed a "seating." These prints should always be as large as the intended hole, at the point of contact with the pattern, tapering a little from thence outwards, just sufficient for a clean draw from the sand.

That end of the core which enters the print is called the "print-end."

When castings, as columns, pipes, etc., are cast horizontally, the prints which guide and support the core in that position are naturally styled "bearings." See SEATING.

Core-sand is sand possessing qualities that will favor the production of a good sound core with the minimum quantity of gas-producing substances in its composition; and that will leave the casting clean and free from scars, with comparatively no expense for labor. To that end sands should be chosen which contain the least possible proportion of alumina and organic matter. The requisite consistency can be temporarily imparted by substances which, while they stiffen the core sufficient for handling, are acted upon by the molten metal, burning the artificial substance out, and leaving the sand as incohesive as it was in its original state. Silica sands, beach, and river sands, are eminently useful for this purpose, and even indifferent clayey sands may be much improved, if subjected to the process of washing, to eliminate foreign substances therefrom before using. See SAND-WASHING; FLOUR; MOLASSES; GLUE.

Core-stove.—An oven in which to dry cores. See OVEN.

Core-wash.—A special manufacture, intended to supersede the ordinary blackings mixed in the foundry.

This wash is a preparation of black lead and other materials. It makes a hard skin or veneer on the mould, which does not rub off nor run before the molten metal while the latter is flowing into the mould, and consequently the castings come out "sound, smooth, and perfect." The wash is applied with a brush to the mould, and when a very smooth surface is desired on the castings, it is applied before drying and smoothed with a slicker; while for ordinary work the wash can be used before or after it is dried, while the mould is still hot, and without smoothing.

For very heavy work two or even three coats may be applied, to insure the best results. See FACING.

Corrosion.—The act of eating or wearing away by slow degrees, as by the action of acids on metal and other substances.

Corrosive Sublimate is the chloride of mercury, and is formed by sublimation from a mixture of sulphate of the protoxide of mercury and common salt. It has a disagreeable, acrid taste, and is extremely poisonous. It is a white, transparent substance, dissolves in 16 parts of cold and 3 parts of boiling water, and crystallizes from a hot solution in long, white prisms.

Corsican Furnace.—A smelting-furnace similar in nearly all respects to the Catalan Forge. See CATALAN FORGE.

Corundum.—A mineral almost equal to the sapphire in hardness, and for that reason it is employed, like emery, for polishing metals and hard stones. It is pulverized, mixed with glue, and other gum compositions, and moulded into all forms of wheels for grinding and polishing every variety of articles produced in the metal industry.

The colors of corundum are various, including green, blue, red, inclining to gray, of a shining lustre, translucent or opaque; specific gravity, 4; fusible only by the compound blowpipe. The composition of corundum is: crystalline alumina 85.5, silex 7, oxide of iron 14. It is found in the East Indies, China, the United States, and other places. The Chinese varieties are called *adamantine-spar*. See EMERY; PRECIOUS STONES.

Cottar.—A wedge-shaped, malleable-iron or steel key, used for drawing flasks together. See PIN, and COTTAR.

Course.—A row or layer of bricks in a loam-mould is termed a *course of brick*.

A *binding-course* is one row of bricks set *end in*, to rest on the inner and outer course.

Crossing the *course* means to break the joints by setting the succeeding courses so that each brick shall be equally divided upon the two bricks upon which it is laid. Very strong moulds may be built by a strict observance of this rule, often rendering it unnecessary to make binding-plates. See BINDING-PLATES; LOAM-MOULDING.

Covering-plate.—A cast plate of any desired form provided with prickers for carrying the rammed sand or swept loam on its surface. Its use is principally in loam-moulding, as a final covering part, after cores and cope have been closed together in their respective places. Also called *top-plate*. See PLATE; PRICKERS ON PLATES; LOAM-MOULDING.

Crab.—A portable crane or winch, with gear-wheel on the barrel-shaft, in which a pinion is made to work by means of cranks at each end of the pinion-shaft. See CRAB; CRANE.

Cramp.—A common name for any device for holding two or more articles together—as a flask-clamp. See CLAMP.

Crane is a hoist having the capacity of moving the load in a horizontal or lateral direction. They are classed as *rotary* and *rectilinear*, and are termed *hand* when operated by manual power; *power*, when driven by power derived from a line of shafting; *steam, hydraulic,* or *pneumatic*, when driven by steam, water, or air, under pressure carried to the cranes by pipes from a fixed source. *Swing-cranes* rotate, but have no trolley movement. *Jib-cranes* rotate, and have a trolley traveller on the jib. *Column-cranes* are the same as jibs, but rotate round a fixed column that supports a roof or floor above. *Pillar-cranes* rotate on a pillar secured to a foundation. *Pillar-jib-cranes* are similar to the latter, but are supplied with a jib and *trolley*. *Derrick-cranes* are similar to jibs, excepting that guy-rods hold the mast-head instead of roof-beams. *Bridge-cranes* have a fixed bridge across an opening, with a trolley traversing the bridge. *Tram-cranes* consist of a truck or short bridge, which travels longitudinally on overhead rails, but having no trolley. *Travelling-cranes* consist of a bridge moving longitudinally on overhead tracks, and a trolley moving transversely on the bridge. *Gantries* are an overhead bridge, carried at each end by a trestle travelling on longitudinal tracks on the ground, and having a trolley moving transversely on the bridge.

The overhead tramrail system of the Yale & Towne Company are a marvel of exactness and efficiency where it is desired to move loads that must be suspended during the operation. These are constructed for both indoor and outside use. The track is composed of "I" beams; special facilities are provided for curving and fitting, switches and turntables being supplied when necessary. The system thus admits of extension and use in the same manner as a surface railroad. A special form of trolley is arranged to run freely on the lower flange of the suspended track, and is provided with four wheels, two on each side, carried in a flexible frame, so that they adapt themselves to the irregularities of the track and pass easily around curves. These trolley-cranes are constructed to carry over ten-ton loads. The above-named company have done much to bring crane engineering to the high state of efficiency now attained; others also have not been slow to note the ever-increasing demands and requirements of this advanced age.

The *Ridgeway Balanced Steam Hydraulic Crane* is a model of simplicity and effectiveness; it is attached to the ordinary steam supply, yet it is a true hydraulic crane, requiring no pumps or accumulators, and no water is consumed. The load is attached directly to the piston-rod, and the cylinder supplied with steam, water, or compressed air by a hose.

Walking cranes consist of a pillar or jib crane mounted on wheels and arranged to travel upon one or more rails. *Locomotive cranes* are similar to the latter, but are provided with a steam-engine and boiler capable of propelling and rotating the crane, and of hoisting and lowering the load. See Iron Carrier.

Crane-ladle.—See Ladle.

Crank—sometimes called the *crane-handle*—is a short arm or lever turned at right angles. One side is made round and smooth, to revolve easily in the hands while rotating the hoisting and other motions of the crane; the other angle terminates with a swaged hole to fit the squared end of the shafts which carry the gearing. See Crane.

Cross.—A four-winged iron beam, provided with a central ring for suspending in the crane-hook. The wings or arm-ends for some distance are evenly notched to receive beam-hooks or slings. By this means each of the four slings is suspended vertically, and clear of the cope or core, separate lugs being provided under which to insert the slings. See SLINGS; BEAM-HOOKS; BEAM.

Crow-bar.—A steel or iron bar, with one end forged to a wedge. Bars of this kind are usually employed for chiselling, digging, and lifting. When it is desired to make a lever of such bars, for pinching at the backs of wheels, etc., the end should be formed with a "heel," some slight distance back from the point which acts as a fixed fulcrum. See LEVER.

Crown-plate.—The plate which covers in the core of a loam-mould, as a pan, kettle, or condenser core, or any casting where the metal flows over the top when the mould is filled.

When the arch of a kettle core is turned with bricks entirely, the last courses of bricks are termed the *crowning-courses*. See COURSE; KETTLE.

Crucible.—A melting-pot for melting brass, cast iron, steel, etc., as well as for a numerous variety of chemical purposes. The common crucible is made of clay, and designed to withstand a strong heat. The best of this class are the "Hessian" crucibles, which contain a proportionate quantity of sand, mixed with clay of a highly refactory nature.

The ordinary crucible is made from two parts Stourbridge clay and one part very hard coke—the coke to be well ground and the two ingredients well mixed and tempered together.

Crucibles for melting steel must be made from the best ingredients, and should show a special toughness during the high temperature required for steel-melting. If soft, they are apt to crush under the pressure exerted by the tongs with their load of 75 pounds of molten steel. The materials generally employed are fire-clay, burnt and raw, graphite, and ground coke. The burnt fire-clay is simply old crucibles, etc., perfectly freed from slag and scoria and ground into a fine powder.

The Mushet crucibles for melting steel are made from Stourbridge clay 5, kaolin 5, ground crucible 1, ground coke 1½. These crucibles are from 16 to 19 inches high and 6 to 8 inches diameter. Many steel melters make their own crucibles, claiming that they can suit the crucible to the kinds of steel they are making.

Krupp uses his crucibles but once for steel. They are then ground, and mixed with plumbago to make other crucibles with, the latter substance being the only ingredient used.

Black-lead crucibles were first made by Joseph Dixon, founder of the present company in Jersey City, in the year 1827. They became at once the standard at home and abroad, and continue so to be to the present day. They are made of this material from ¼ pound to 1000 pounds capacity, and are for melting steel, brass, gold, copper, silver, German-silver, pure nickel, white metal, etc., and also for file-tempering.

Black-lead crucibles are all annealed before shipping, but immediately on arrival they should be unpacked and stored in a warm, dry place to expel any moisture that may have been absorbed in the transit. To provide against possible accident, it is always wise to re-anneal. Before placing in the hot furnace, the temperature of a crucible should be slowly raised to at least 212° F., or a little above the temperature of boiling water.

All clay crucibles, new or old, should be gradually heated, mouth down, up to a red heat before charging, and, whether in the preparatory heating, or subsequent firing for melting, the crucible should always be well covered with fuel; otherwise the unequal temperatures induced by carelessness in this particular will result in a broken pot. If clay crucibles could be kept constantly in use without allowing them to become cold alternately, there is no reason why they should not last from 15 to 20 meltings, especially if they are kept clear from scoria, and repaired occasionally with a paste made from silica, fire-clay, and coke-dust. Lifting-tongs should always be made to fit the crucible snugly, at as many places as convenient, to prevent splitting. By exerting the pressure unequally on the sides of a crucible very many accidents occur ; especially is this to be observed in regard to large ones.

Crucibles should always be returned to the furnace mouth downwards, after the heat is through, so that the cooling may occur gradually.

The best graphite crucibles should last from 20 to 30 meltings, and, whilst they may be less liable to fracture from sudden changes in the temperature, it is well to observe, in some measure at least, the directions given for clay ones. The above instructions refer to brass-melting only. See STOURBRIDGE CLAY; KAOLIN; PLUMBAGO; GRAPHITE; FIRE-CLAY; HESSIAN-CRUCIBLE; CRUCIBLE-TONGS.

Crucible-furnace. — See BRASS-FURNACE; CRUCIBLE STEEL.

Crucible Steel.—Crucible or cast steel was first invented by Huntsman, of Sheffield, England, in 1740. He succeeded in effecting the complete fusion of blister-steel in crucibles—using the common crucible-furnace and heating with coke surrounding the pot. This was finally poured into cast-iron ingots for the production of homogeneous steel. Whilst the above represents the manufacture of homogeneous steel by melting blister-steel alone in crucibles, there are other methods extensively practised for the production of steel in crucibles by fusing carbon, black oxide of manganese, or spiegeleisen in small proportions along with bar iron or puddled steel. A crucible mixture for tool cast steel is as follows:

Swedish bar iron	50	pounds.
Cast-steel scraps	30	"
Ferro-manganese	$\frac{1}{2}$	"
Charcoal	$\frac{1}{2}$	"
Salt	$\frac{1}{2}$	"

See Blister-steel; Puddle-steel; Steel.

Crushed-joint.—See Fin.

Crucible-tongs.—See Lifting-tongs.

Crusted-ladle is caused by the formation of scoria and oxide of iron on the surface of molten metal as it cools in the ladles. This, if allowed to remain unprotected from the cooling action of the atmosphere, forms an impenetrable upper crust, through which in time it becomes impossible to pour the metal, resulting sometimes in the whole mass having to be remelted. A plentiful use of broken charcoal mixed with dust of the same acts as a preventative of this by shielding the surface from the action of the atmosphere, and supplying a constant heat thereto as the charcoal is gradually consumed. When it is desired to keep metal in a ladle for a considerable length of time, let the surface be kept well covered with the charcoal, especially around the outer edge, where it is necessary to watch particularly, as it is at that part where the crust first commences to form. If the edge is broken occasionally, and the supply of charcoal kept constant, the operation of preserving the metal in a good fluid state will be helped considerably.

Crystallization.—The particles of many substances, when loosened either by melting, solution, or otherwise, so as to permit freedom of motion, tend to arrange themselves in regular geometrical forms, which are termed crystals. The name *crystalloids* is given to all substances which have this marked tendency, and to such as do not crystallize the name *colloid,* or glue-like, is given.

Crystalloids are represented by such substances as water, metals, acids, sugar, etc.; while albumen, jellies, etc., are examples of colloids. Crystalloids incline to take compact, angular forms, while the colloids assume rounded outlines, and are of a soft, gelatinous, and yielding nature.

The former bodies predominate in the inorganic world, the latter in the organic. It is found that almost all bodies when cooled take the crystalline form, though this may not be perceptible at first. The spaces left between the crystals which form are completely filled up by the portions which solidify afterwards, so that fracture reveals only a general crystalline structure, just as we find it in cast iron, zinc, etc., when broken. Common glass, wrought iron, flint, glue, etc., are amorphous bodies, without any form of crystalline structure; these all fracture in any form or direction, are not so hard, and are more soluble than are substances of a crystalline nature.

Crystalline carbon is represented in the diamond, while amorphous carbon finds its examples in common lamp-black and charcoal. A crystal is a piece of matter that by the action of molecular forces has assumed a definite geometrical form of some kind, with plain faces.

Some metals as soon as cast are tenacious and uncrystalline, but become brittle, with traces of crystallization, when heated and cooled repeatedly. Small as the amount of freedom given to the particles by heating and cooling, yet it seems sufficient to determine a tendency towards the crystalline condition. By continuous hammering, metals are changed from a ductile to a brittle, crystalline state, as is proved by the workers in copper, who must frequently anneal the metal as they hammer it into shape; otherwise it would become so brittle that it would fly into fragments.

Owing to the fact that crystallization does take place, even in solids, if the particles are left free, bells after a time alter in tone; cannons, from constant firing, lose their strength; and thus, by the constant jar and vibrations, as well as hard blows, chains, slings, etc., made from wrought iron gradually change from the tough and fibrous into the crystalline, which weakens them and increases their liability to fracture. See AMORPHOUS; STEEL.

Cube. — A regular solid body with six equal square sides or faces, each of which is parallel to the one opposite to it. It is a form of frequent occurrence in nature, especially among crystals. See CRYSTALLIZATION, AMORPHOUS.

Cubic Foot of Metals, Weight of. — See WEIGHT OF METALS.

Cubic Inch of Metals, Weight of. — See WEIGHT OF METALS.

Cupola.—A cupola is simply a foundry melting-furnace. Those now in common use are usually composed of an outer wrought-iron shell, inside of which is built a lining of fire-bricks carefully set in their fire-clay, as close together as possible, and in close proximity to the shell.

Cupolas may be from two to eight feet in diameter up to the charging-door, according to requirements, beyond which point they can assume a conical shape for the chimney. Formerly all cupolas rested on a solid foundation of brick or stone-work; but they are now, as a rule, supported on four iron columns, by which means the residue may be dropped clean out of the inside when through melting, instead of raking it out, as must be the case when a solid bottom is used. This is accomplished by providing hinged iron doors under the bottom, which, when the heat is over, may be dropped and thus allow the slag and cinders to fall through into the pit below.

For the former, a large breast-hole must be provided at the bottom, either front or back of the cupola, through which to rake out the cinder, etc.; but for the improved ones a hole about seven inches square is all that is required, to which is attached the spout for leading the molten iron into the ladles. The spout and tap-hole are invariably made good with sand or fire-clay mixture for each heat.

In some instances, for very small cupolas, the blast enters therein through one or two pipes; but for larger ones a continuous belt or wind-box encircles the cupola, out of which as many tuyeres as may be considered necessary are served, the wind-box being simply a continuation of the main blast-pipe leading from the blower or fan, which, if up to the required capacity and skilfully managed, will be regulated to supply a blast of such volume and pressure as will ensure perfect combustion of the fuel with sufficient rapidity to produce the intensity of heat required for melting the metal which has been charged.

See, under the following list, for details of cupola construction and management:

Bed-fuel.
Blast.
Blast-gate.
Blast-gauge.
Blast-pipe.
Blast-pressure.
Blowers.
Bott-clay.
Bott-stick.
Breast.
Bugs.
Burnt-iron.
Carbon.
Carbonic Acid.
Carbonic Oxide.
Carrying-bar.

Cast Iron.
Charge.
Charging-door.
Charging-hole.
Charging the common cupola.
Coal.
Coke.
Coke-fork.
Combustion.
Crusted-ladle.
Cupola.
Daubing.
Drop-bottom.
Eye-piece.
Fan.
Fire-brick.
Fire-clay.
Flame.
Flux.
Fuel.
Grades of Pig-iron.
Greiners cupola.
Grouting.
Hard Iron.
Height of cupola.
Hood.
Hot-blast.
Ladles.
Lighting the cupola.
Lining ladles.
Lining the cupola.
Oxygen.
Pig-iron.
Piston-blower.
Pressure-blower.
Pressure-gauge.
Ratio of fuel to iron.
Repairing the cupola.
Sand-bed.
Scaffolding.
Scrap.
Shank.
Silicon.
Slag.
Softeners.
Soft-iron.
Spout.
Tapping-bar.
Tuyeres.
Wind-box.

Cupro-manganese.—See MANGANESE-COPPER.

Curb.—An iron casing, in which to ram moulds that are made in loam. They may be whole or in sections, according to size and convenience, and are of great service when the moulds are shallow and it is not desirable to sink a pit. They may be employed in the pit also, in order to limit the amount of sand to be rammed round a mould to the smallest amount possible consistent with safety. By this means much time and labor is saved. Those in common use are simply boiler plate, riveted together if whole, and bolted if in sections. Improved sections are made that lock together with steel-pins, so that it becomes the simplest matter possible to alter the diameter to an unlimited extent. The most convenient depth for curbs is from 15 to 18 inches. See Pit; Loam-moulding; Ramming.

Current.—Current is spoken of in the foundry in its relation to the flow of metal as it leaves the furnace, or as it flows from the ladle into the mould. It is also applied to the forced stream of molten metal as it issues from the gates and flows over the mould's surface. The current of metal, like all other fluids, is strongest at its source—for which reason there is always the greatest danger of abrasion nearest to the gates or runners; hence special attention should be expended to make such parts of a mould more rigid and refractory than is necessary elsewhere. See Gates; Runner; Cutting; Scabbing.

Curved-pipes.—See Bend-pipe.

Cut-off.—A cut-off in founding is somewhat different to that in engineering, and means to arrange a riser in such a manner as will prevent the full head of pressure from being exerted on the mould. To do this effectually and with absolute certainty, the riser should instantly indicate when the mould is full, at which point the head-pressure in the running basin is at once checked by ceasing to pour. What remains in the basin flows through the casting, and out at the riser, which, being lower, tends to "cut off" just as much pressure as the difference in depth measures. See Riser; Weighting-copes; Pressure of Molten Metal.

Cutter.—A sharp, curved tool for carving gates in the sand. Some are made exclusively for this purpose in steel or brass; others are merely a sharp-edged piece of tin or copper-plate that may be bent to any desirable shape. At best, such tools as "gate cutters" can only be called a make-shift; the cleaner and more artistic method of forming gates is to ram them along with the pattern. See Gates.

Cutting.—The result of violent attrition of molten metal on unprotected and unsuitably prepared mould surfaces. When, because of dampness, steam forms more rapidly than it can escape through the vents, it forces its way through the surface and lifts a portion of the mould's skin with it, forming a scab at that place. This by some is improperly termed a "cut" place. Cutting means a forced displacement of the surface caused by undue abrasion, or impact. The former happens when a large quantity of metal is urged over a surface not sufficiently unyielding in its nature to resist it successfully; the latter when such surfaces are subjected to a fall of metal high enough to break them. See Scabbed Castings; Current; Gates; Runners.

Cylinder-blower.—See Blower.

D.

Dabbers.—A foundry name for the projections or prickers cast on covering plates for loam-work. See Prickers.

Dam.—A reservoir or tank used for *collecting* or *gathering* a large quantity of metal to cast heavy castings. Whilst constructed in various ways, the main features consist in making it strong to maintain the metal, and of such materials as will conduce to its preservation in a good condition for casting with. A thoroughly well-dried loam and brick construction within suitable curbs is the best, taking care to have it as hot as possible when the metal enters, and keeping from 4 to 5 inches of dry charcoal on the surface. The mode of emptying the dam is usually by a shutter, which hermetically closes the outlet whilst it is being filled, and is raised by means of a controlling lever, so that the metal may be delivered at any desired speed. See GATHERING METAL; CURBS; SHUTTER.

Damascus Steel.—A steel originally made in Damascus. It is composed of layers of very pure iron and steel, worked with great care by heating and extraordinary forging, such as twisting, doubling, etc. See STEEL.

Damper.—A very useful and profitable device in a foundry oven, when intelligently managed. A right knowledge of its use saves both time and money to the founder. Frequently none are employed; and not unfrequently, at places where dampers were originally intended, they have been allowed to lapse into desuetude through sheer and unwarrantable neglect. Let a good-sized chimney, controlled by a full damper, be placed if possible central with the oven at the roof, and one on each side, diagonally, at the bottom, with these. Careful attention will discover in what manner to best rid the oven of steam, at the same time losing no heat. By constant application to find a satisfactory solution of the above problem, ovens with absolutely no record may easily have their value increased a hundredfold. See OVENS.

Dampness.—The requisite degree of dampness in moulding-sand is a matter of great importance to the moulder. If too moist, steam is generated by the hot metal quicker than the vents will allow it to escape, and scabs will inevitably ensue. If not damp enough, it lacks consistency and fails to preserve its shape in the mould, being easily disturbed during the ordinary operations of moulding, and yielding too readily to the abrading action of the molten metal. See VENTING; SCABBED CASTINGS.

Daubing.—The clay mixture usually made by the cupola-man for repairing bad spots in the cupola and for lining the inside of ladles. Too frequently these mixtures are made by those who possess no knowledge whatever of the requirements in the case; the result being that the metal boils when it enters the ladles, and cupolas are prematurely worked out and always amiss for the want of a rightly mixed daubing for keeping them in good working shape.

A good daubing for ladles is made from equal quantities of good moulding and fire sands, mixed well together in a dry state, to be afterwards brought to the right consistency for use by the addition of thick clay-wash made from common clay.

Daubing for repairing the cupola should be of a much stronger nature, and, what is of equal importance, should be properly applied and not thrown on the walls carelessly in thick lumps that only fall away into the stock as soon as the extreme heat is brought to bear upon it, leaving the part it has vacated entirely unprotected and very materially impeding the regular action of the cupola.

A good daubing for cupolas is: Fire-clay (not common clay), 50 parts; fire-sand, of a good siliceous kind, 25 parts; and ground fire-bricks, 25 parts—to be mixed well together when dry, and brought to the right consistency with water. This should be rubbed on evenly, as thin as possible; and should the patching require to be more than one inch thick at any part, it is much better to cut some of the backing away and insert new bricks.

Some have an idea that salt mixed with the sand and fire-clay for this purpose acts beneficially. I think this bad practice may have originated in a misconception of its right use in the stone and earthenware manufactories, where salt is extensively employed as a glazing agent, its volatility at furnace heat combining with other qualities to fit it for this use. No doubt it has been thought by those who were only partially instructed in these matters that a permanent glaze, similar to that produced on the earthenware, might be imparted to the walls of the cupola by the use of salt; but if they will remember that salt fuses at a red heat, they will at once realize that any salt used for cupola purposes must constitute a slag-forming agent, at every heat, until every vestige of salt has been melted out. See REPAIRING THE CUPOLA; CUPOLA; SEA-WATER.

Davy's-lamp.—See SAFETY-LAMP.

Dead-metal.—Metal that has lost heat to such extent as to have become too sluggish to flow smoothly and give a sharp impression of the mould. See FAINT-RUN.

Decarbonize.—To deprive any substance of its carbon. This word is synonymous with decarburize, and means to take the carbon from—as decarbonizing steel or iron. See DECARBONIZING PROCESSES.

Decarbonizing Processes.—The process of decarbonizing takes place in puddling and boiling furnaces when cast iron is, by heating, deprived of its carbon, and thus made malleable. But there are many special decarbonizing and desulphurizing processes by which these superfluous elements are eliminated from cast iron. See MALLEABLE IRON; PUDDLING.

Decimals Changed to Parts of a Pound Avoirdupois.—The following table converts each decimal of a pound, of 16 ounces, into ounces and drachms, and is very serviceable when it is desired to change the formulas that are stated in decimal proportion :

Decimal.	Oz.	Dr.	Decimal.	Oz.	Dr.	Decimal.	Oz.	Dr.	Decimal.	Oz	Dr.
.003		1	.128	2	1	.253	4	1	.378	6	1
.007		2	.132	2	2	.257	4	2	.382	6	2
.011		3	.136	2	3	.261	4	3	.386	6	3
.015		4	.140	2	4	.265	4	4	.390	6	4
.019		5	.144	2	5	.269	4	5	.394	6	5
.023		6	.148	2	6	.273	4	6	.398	6	6
.027		7	.152	2	7	.277	4	7	.402	6	7
.031		8	.156	2	8	.281	4	8	.406	6	8
.035		9	.160	2	9	.285	4	9	.410	6	9
.039		10	.164	2	10	.289	4	10	.414	6	10
.043		11	.168	2	11	.293	4	11	.418	6	11
.046		12	.171	2	12	.297	4	12	.421	6	12
.050		13	.175	2	13	.300	4	13	.425	6	13
.054		14	.179	2	14	.304	4	14	.429	6	14
.058		15	.183	2	15	.308	4	15	.433	6	15
.062	1	0	.187	3	0	.312	5	0	.437	7	0
.066	1	1	.191	3	1	.316	5	1	.441	7	1
.070	1	2	.195	3	2	.320	5	2	.445	7	2
.074	1	3	.199	3	3	.324	5	3	.449	7	3
.078	1	4	.203	3	4	.328	5	4	.453	7	4
.082	1	5	.207	3	5	.332	5	5	.457	7	5
.085	1	6	.210	3	6	.335	5	6	.460	7	6
.089	1	7	.214	3	7	.339	5	7	.464	7	7
.093	1	8	.218	3	8	.343	5	8	.468	7	8
.097	1	9	.222	3	9	.347	5	9	.472	7	9
.101	1	10	.226	3	10	.351	5	10	.476	7	10
.105	1	11	.230	3	11	.355	5	11	.480	7	11
.109	1	12	.234	3	12	.359	5	12	.484	7	12
.113	1	13	.238	3	13	.363	5	13	.488	7	13
.117	1	14	.242	3	14	.367	5	14	.492	7	14
.121	1	15	.246	3	15	.371	5	15	.496	7	15
.125	2	0	.250	4	0	.375	6	0	.500	8	0

Decimals of 1, or Unity, Changed to Fractions.—The following table affords a ready reference for obtaining the vulgar equivalents of the decimal fractions of 1, or unity :

$\frac{1}{64} = .015625$	$\frac{5}{16} = .3125$	$\frac{11}{16} = .6875$
$\frac{1}{32} = .03125$	$\frac{3}{8} = .375$	$\frac{3}{4} = .75$
$\frac{1}{16} = .0625$	$\frac{7}{16} = .4375$	$\frac{13}{16} = .8125$
$\frac{1}{8} = .125$	$\frac{1}{2} = .5$	$\frac{7}{8} = .875$
$\frac{3}{16} = .1875$	$\frac{9}{16} = .5625$	$\frac{15}{16} = .9375$
$\frac{1}{4} = .25$	$\frac{5}{8} = .625$	$1 = 1.0000$

Deliver.—This term applies to the withdrawal of a pattern from the sand. It is said to *deliver* ill or well according to the condition of the mould it has been the means of forming. See PATTERN; DRAFT.

Delta-metal.—A gun-metal of great density and strength. Its composition is: copper 56, tin 1, zinc 41, iron 2. The wrought iron must be alloyed with the zinc in due proportion, and introduced as an iron-zinc alloy, in known proportions, in the customary manner. This alloy is similar to sterro-metal. An addition of lead (0.40 per cent) makes the composition more ductile and soft, and it is then called Tobin-bronze. Delta-metal can be forged or rolled at a dull-red heat, and may be drawn or hammered to a certain limit when cold. Castings made from this alloy are remarkable for their soundness, and have a tensile strength of from 40,000 to 50,000 pounds per square inch. See BRONZE.

Density is the proportionate quantity of matter in bodies of a given magnitude; thus, if a body contain more matter than another, both being of the same bulk, the former is said to be more dense than the other. The quantity of matter is measured by the weight, and thus density and specific gravity come to be proportional to one another. Platina, which is about 21 times the weight of water, long passed for the densest body, but iridium is even more dense. Rare is opposed to dense; the rarest body known is hydrogen, which is about 14½ times rarer than atmospheric air. Density of bodies is increased by cold and diminished by heat. See SPECIFIC GRAVITY.

Deoxidation.—A term applied to the process of withdrawing the oxygen from a compound.

Deoxidized Bronze.—The claims made by the Deoxidized Metal Company, Bridgeport, Conn., for their special manufacture of bronze is as follows :

Deoxidized bronze is deoxidized copper alloyed with tin in any proportions desired. Thus making deoxidized bronze of any mixture stronger, tougher, denser, harder, and yet of greater elastic limit than the same mixtures of metal not deoxidized. See copy of test made by the U. S. Navy Department at Watertown Arsenal, Aug. 24, 1889, between bronze of the proportions of—

Copper	88
Tin	10
Zinc	2

made by deoxidized Metal Company of above proportions, and deoxidized ; and bronzes of same proportions made at the Navy Yards at Portsmouth, N. H., Norfolk, Va., and New York, N. Y., but not deoxidized. This report shows that taking the average of the samples from the different Navy Yards, the deoxidized samples show a superiority of—

$65\frac{8}{10}$ per cent in tensile strength.
58 " " " elastic limit.
18 " " " transverse strength.
44 " " " hardness.
60 " " " compression.
23 " " " elastic limit, under compression.

As our price in ingot metal is less than 15 per cent greater than the same would be not deoxidized, it will be perceived that purchasers benefit themselves about 50 per cent in using deoxidized bronze, instead of making their own alloys—besides making surer casting. It is also proper to say, that deoxidized bronze of above mixtures with the zinc omitted is 15 per cent greater in tensile strength than with it, as shown by tests at Watertown Arsenal, made September 22, 1888.

Deoxidized copper and bronze is superior to all copper and bronze not deoxidized. See DEOXIDIZED COPPER.

Deoxidized Copper.—The following is a statement by the Bridgeport Deoxidized Metal Company in regard to their processes with copper :

Deoxidized copper is Calumet and Hecla Lake copper, the purest and best copper in the world, from which the suboxide of the copper and the oxygen has been removed by our processes—thereby rendering the copper denser, stronger, tougher, and purer; enabling us to make solid castings of deoxidized copper 20 per cent denser, 35 per cent stronger, 50 per cent tougher, and 5 per cent better conductivity than the same copper not deoxidized, as per certificates and testimonies following :

Comparative analyses made at School of Mines, New York, of Calumet and Hecla Lake copper, with the same copper deoxidized :

CALUMET AND HECLA LAKE COPPER.

Constituents.	No. 1.	2.	3.
Metallic copper	99.854	99.63	98.10
Suboxide of copper	0.293	0.324	1.95
Iron	0.015	0.011	....
Tin	0.021	....	....
Silver	0.012	0.024	0.03
Phosphorus	trace	....	trace

Arsenic, nickel, zinc, lead, antimony, sulphur—none.

DEOXIDIZED LAKE COPPER.

Constituents.	
Metallic copper	99.80
Suboxide of copper	0.07
Iron	0.01
Tin	0.01
Silver	0.02

Arsenic, lead, phosphorus, antimony, sulphur, aluminum, zinc, nickel, cobalt—none.

MEAN OF THE ANALYSES OF LAKE COPPER.

Metallic copper	99.19
Suboxide	.85

DEOXIDIZED COPPER.

Metallic copper	99.89
Suboxide	.07

Taking the mean of the results of tests by tension, the deoxidized bronze shows a superiority of 65.8 per cent in tensile strength and 58 per cent in elastic limit over the Navy Yard bronzes, with 53 per cent less elongation and 36 per cent less reduction of area.

All the Navy Yard bronzes when fractured showed large crystals of both copper and tin. The specimens from the Deoxidized Metal Company, on the contrary, show in fracture a very fine, even grain of lavender color, and were fine specimens of castings.

Short sections of tensile specimens have been forwarded by express to the bureau, which will show the appearance of the fractures in both the deoxidized and Navy Yard bronzes.

TESTS BY COMPRESSION.

The deoxidized specimens showed a superiority over the other bronzes of 60 per cent in strength and 23 per cent in elastic limit.

All specimens broke by triple flexure.

Deoxidized bronze as furnished for the above tests is remarkably close grained and homogeneous. It turns well in the lathe and is susceptible of high polish. It does not tarnish by exposure to the atmosphere as readily as the other bronzes tested, all of which have been exposed to like conditions since July 14th of this year, the deoxidized specimens being still intact, while the others are perceptibly tarnished. See COPPER.

Dephosphorizing Process.—See BASIC PROCESS.

Deposit.—A body, or substance precipitated, or thrown down from a solution by decomposition. See PRECIPITATION.

Derrick.—See CRANES.

Diagonal.—A straight line joining two angles, not adjacent, of a rectilinear figure.

Diameter.—A line, which passing through the centre of a circle or other curvilinear figure, divides it or its ordinates in two equal parts. Also, the length of a straight line through the centre of an object, from side to side, as the diameter of a cylinder, fly-wheel, etc.

Diamond.—The purest form of carbon known. It is a crystal of the greatest purity and hardness known. Several localities in India, the island of Borneo, and Brazil furnish this beautiful substance. Diamonds possess a very high refractive and dispersive power, by which they flash the most varied and vivid colors of light. The diamond is a non-conductor of electricity, and resists the action of all known chemical substances. It is infusible and unalterable even by a very intense heat if air be excluded; but when burned in oxygen gas, the combination forms carbonic acid gas, hence its composition is pure carbon. Heated to whiteness in a vessel of oxygen it readily burns, yielding carbonic-acid gas; hence its composition is pure carbon (specific gravity, 3.5). A diamond is of the *first water* when perfectly colorless.

Artificial diamonds are made from a paste composed of pure silica 100, red oxide of lead 150, calcined potash 29, calcined borax 11, arsenious acid 1. This composition fuses at a moderate heat, and if the alkali is expelled by the continued fusion it acquires great brilliancy. See PRECIOUS STONES; CARBON.

Diamond and Brilliant Imitations.—To make metal imitations of these precious stones, procure a glass rod and grind the end to the form of whatever it is intended to imitate. Dip the ground end of the rod into *reflector metal*, which has been previously freed from scum; the metal will adhere to the ground surface and form a hollow cap of extreme brilliancy which answers to the design ground on the end of the rod. See REFLECTOR METAL.

Dies, To harden.—In order to produce an equal degree of hardness throughout the entire surface of a die, it has been found best to let fall a copious stream of water from a reservoir placed above, directly upon the centre of the die. This is a superior method to direct immersion, as the rapid formation of steam at the sides of the die, consequent on the later mode, prevents free access of the water for removing the heat with the expedition requisite for obtaining a hard surface at the centre. See TEMPERING; STAMPING.

Dipping.—A process by which a bright surface is imparted to the alloy or metal after it has undergone the process of pickling, scouring, and washing. Dipping consists of immersing the article in pure nitrous acid for a moment, but no iron or wood implements are to be used. Brass tongs are best for this purpose, and the vessels should be earthenware.

If the work appears coarse and spotted after dipping, the dip must be repaired by adding sulphuric acid; should it be too smooth after it has been dipped, add muriatic acid and nitric till it shows the right appearance. Dips should be kept stirred, and not allowed to settle whilst using. See STAINING METALS; PICKLING; ORMOLU DIPPING ACID; QUICK DIPPING-ACID; LACQUERING.

Distillation.—Is vaporizing a liquid by heat in one vessel, and condensing it by cold in another; the object being to separate a liquid from non-volatile substances dissolved in it, as in distilling water to purify it from foreign matter, or to disunite two liquids which evaporate at different temperatures, as water and alcohol.

Dog.—A double-ended hold-fast, made by pointing the turned ends of an ordinary wrought-iron clamp. Useful for drawing the halves of core-boxes together, and numerous other purposes in the foundry.

Dolomite.—Magnesian limestone, a mineral consisting of carbonate of lime and carbonate of magnesia in somewhat varied proportions, the former usually preponderating with about 20 per cent carbonate of iron. See BASIC-PROCESS; LIMESTONE.

Double-hook.—Sometimes termed a *change-hook* and *ram's-horn.* The latter name is suggestive of its shape, which consist of two hooks, turned outwards, forged to a third one immediately underneath, which is central and turned at right angles to the double hooks above.

It is used for passing loads that are slung on the lower hook, from one crane to another, by simply inserting the block-hook of another crane into the idle-hook and hoisting until it is lifted free of the other.

Down-gate, or "*down-runner,*" sometimes termed an "upright," is the runner immediately connected with the runner basin, and leads to the casting direct, or by means of draw-gates, etc. See DRAW-RUNNER; UPRIGHT-RUNNER; GATES.

Draft.—An allowance of taper on a pattern, or the parting of a joint; the object being to obtain a free separation of mould and pattern-surfaces which, if left straight, would ceate friction and cause damage to the mould. See TAPER.

Drag.—The bottom, or nowel-part of a flask. See FLASKS.

Drain.—A hole sunk beneath a mould in the pit when there is danger of water accumulating there. A well can be sunk some distance away, into which the water will flow, to be expelled by means of a pump. Cinder-beds may be made to answer as drains by laying them on a slant and providing a well at their lowest point for the water to collect in. See CINDER-BED.

Dram is the same as drachm. The avoirdupois dram is equivalent to $27\frac{1}{3}\frac{1}{2}$ grains troy; the apothecaries' dram is equivalent to 60 grains troy.

Draw.—A term synonymous with shrink, and used by some to express certain conditions connected with the phenomenon of shrinkage. Holes or depressions caused by natural shrinkage are often called "drawn" places. See SHRINKAGE; FEEDING; SINKING-HEAD.

Draw-back.—A portion of mould, which owing to some peculiarity of form in the pattern, or because of some difficulty presented in closing or finishing the mould, must be slided back or lifted away altogether. When this occurs in moulds that are made entirely in flasks, some portion, or all of a cheek-part, is made to answer by attaching inside bars, or a connected bottom-plate to carry the sand. But, when the mould is all contained in the floor, a plate with lifting-handles is cast, on which to carry away the desired part. The plate is termed a *drawback* plate. See CHEEK; FALSE CORE.

Drawback Plate.—See DRAWBACK.

Draw-gates are so called because they are set between the pattern and a *down-gate,* a slight taper permitting of their being withdrawn either towards the mould or in the opposite direction, whichever is the most convenient. See GATES; DOWN-GATE.

Draw-hooks is a simple iron or steel hook for drawing or lifting patterns from the sand. Ordinarily, a common eye at the opposite end answers for lifting by, but an excellent combination of steel hook and raw hide mallet may now be obtained; also a steel hook provided with a spherical head of hard rubber, both of which afford a handy means for rapping small patterns as well as drawing them.

Drawing Air.—A common but incorrect term for the violent commotion occurring at the down-gate, when, because of the too limited area of basin-runner, where it connects with the down-gate, there is not a sufficient body of metal to keep it full, and thus check the escape of expanded air from the mould. See DOWN-GATE.

Drawing-down.—When the cope part of a casting shows an unevenly buckled surface, with shell-scabs in parts, it is technically spoken of as "drawn-down," or "drawn-in." Although this phenomenon is not unknown in loam and dry-sand work, it is chiefly in green-sand copes that it occurs. Very damp copes with no vents are apt to be drawn down as above described, because of the rapid generation of steam, which can find no other means of escape. Especially is this the case when the mould is long in filling.

Sand with too much clay is always liable to buckle if subjected to a long-continued heat, as the skin dries-into a cake, expands, and buckles, sometimes falling off in flakes before the mould is full.

Silica, or fire-sand, comparatively free from lime, brought up to the requisite degree of consistency by a slight admixture of clay, will invariably hold together under the severest trials, if well vented with a small wire, in order to lead the steam from the surface to the outside. In important cases it is a wise precaution to cover the cope-vents with loose sand. Vents, if left uncovered, permit a too free escape of air from the mould, and the cope surface is to that extent robbed of such support as the compressed air within gives to it. See VENTING.

Dresser.—A local term for a *cleaner* or *chipper* of castings ; usually it means a man that can perform both operations. See CHIPPER; CLEANER.

Dressing.—The preparatory finishing and fashioning which a loam-mould receives before the final blackening takes place. The mould is moistened with water, dressed with *chinsing-sticks,* and finished with the requisite tools See FINISHING.

Drill.—A tooı provided for boring vents and gates through hard dry sand and loam. An ordinary brace and bit, or an ancient bow-drill, are suitable tools for this purpose; the latter making a very efficient one.

Drop.—When a portion of mould falls from an overhanging surface, it is spoken of as a "drop."

Drop-gates are gates which connect with the casting from the runner basin vertically. They may be so placed for mere convenience, or with the view of obtaining a clean casting by constructing a basin above that may be instantly filled with metal, and thus allow the casting to fill from the bottom, with no possibility of dirt entering the mould. See Gates; Venting.

Drying-kettles.—Perforated iron pans for drying moulds with. Another description of kettles for drying pan-copes that are struck in casings, and other similar purposes, is readily made by connecting two cast rings with vertical rods and crossing the bottom ring with loose bars. Instead of a ring for the bottom, a whole grate may be cast, if preferred in that manner. See Lamp; Lantern.

Drying-stove.—See Oven.

Dry-sand Facing.—Sand prepared exclusively for facing the surface of a dry-sand mould. Whilst there are, no doubt, many good mixtures for this purpose, the following will always be found reliable and trustworthy, as it works well in finishing, requires little or no venting, may be rammed very hard, and will not be seriously affected, so far as the mould is concerned, if it should not be thoroughly dry. Silicious or fire sand 8, moulding-sand 2, flour 1. Let the above ingredients be prepared medium dry, and mix for using with clay-water. The sands mentioned should be equivalent to the Jersey grades. See Facing-sand; Facing.

Dry-sand Moulding.—The art of preparing dried moulds, either in flasks, to be subsequently dried in the oven, or in the floor, when the drying must then be accomplished by suitably improvised means before casting. Moulding in dry-sand admits of exceedingly large and intricate castings being made with much less risk than in green-sand. Moulds rammed in flasks may, when dry, be placed in any desired position for casting, without any possibility of damage; hence cylinders and all similar castings are moulded in dry-sand, and placed in a vertical position for pouring.

Dry-sand facing is used on the surface, but the flasks may be rammed with common sand off the floor. Usually the moulds are blackened and finished whilst green, and subsequently dried, closed, and cast. See DRY-SAND FACING; GREEN-SAND MOULDING; LOAM-MOULDING.

Ductility.—That property or texture of bodies which renders it practicable to draw them out in length while their thickness is diminished without any actual fracture of their parts, as drawing into wire. Gold is the most ductile of the metals, after which, in their order of value, as follows: silver, platinum, iron, copper, zinc, tin, lead, nickel, palladium, cadmium. See METALS; MALLEABILITY; STRENGTH OF MATERIALS.

Dulled-brass.—The dead appearance, by the French styled "*mat*," is obtained on brass by observing the following: Immerse in nitric acid 200, sulphuric acid (sp. gr. 1.845) 100, salt 1, sulphate of zinc 2. Very large objects should have a mixture of nitric acid 3, sulphuric acid 1, water 1, sulphate of zinc $\frac{1}{2}$. Repeat the dipping and well-rinsing till the desired color is imparted. See DIPPING.

Dumb-vent.—A vent from a hollow core led to some distance by means of an underground flue, where there will be no possibility of sparks igniting the gas and causing an explosion. See VENTING.

Dummy-block.—A brick and loam model around which to form a jacket or other core by means of the spindle and sweep-board, the latter being the means for forming the dummy-block also. When the core has been dried the block is picked out piecemeal, leaving the jacket-core standing; hence the name. See JACKET-CORE.

Dump.—A name given to the dirt or foundry waste-heap.

Dusting-bag. — A blacking-bag. See BLACKING-BAG.

Dyeing-metals.—See STAINS FOR METALS.

E.

Earths.—The solid matters of the earth, including rocks, etc., are composed principally of combustible elements, as aluminum, potassium, magnesium, calcium, and carbon, in combination with oxygen. The fact of the rarity of these metals in a free state is due to their extreme combustibility. The earths proper do not change vegetable colors; in acids they are soluble, and may be subsequently precipitated from their solutions by potash, soda, or ammonia. The alkaline earths, as barytes, strontia, lime, etc., are soluble in water, and have the property of neutralizing the strongest acids, and changing vegetable colors in general. The mineral elements composing the chief mass of soils are derived from the breaking-up of the various rocks by the action of heat, frost, air, and moisture. According to the composition of the rocks so will the soil be that is derived from them: clayey when from argillaceous rocks, calcerous from lime, and sandy from siliceous rocks, besides which must be included organic substances, a portion of liberated alkalies and alkaline earths, etc. See ALKALI.

Earthenware.—See POTTERY-MOULDING; PORCELAIN.

Ebullition.—When water is heated bubbles of vapor form at the bottom, rise to the cooler water above, and are condensed. As the heat continues, however, these bubbles reach the surface and escape into the air, causing the agitation called boiling or ebullition. The boiling-point of a liquid is determined by the temperature at which ebullition takes place. Water boils at 212°, sulphuric ether at 96°, alcohol at 176°, oil of turpentine at 316°, sulphuric acic at 620°, mercury at 662°.

Eccentric-clamp.—An arrangement for lifting finished stonework, which might be made useful in the foundry for lifting cores of some descriptions, and thus obviate the necessity for hooks and staples. The weight of the object turns eccentrics, which bind rubber-faced plates firmly against the sides. The width is adjusted by turnbuckles at the sides.

Edge-smoother.—A moulder's tool for finishing angles. The two sides of this smoother, acting together, bring the edge up sharp and true.

Effervescence.—The commotion produced in fluids by some part of the mass suddenly taking the elastic form and escaping rapidly in numerous bubbles.

Elastic Gum.—See INDIA-RUBBER.

Elasticity, or spring, is a property of bodies to resume their original form, immediately the force by which they may have been deflected from it is removed.

Elastic Moulds.—These moulds are for the purpose of obtaining casts, in plaster or wax, from medals and other objects having parts that are undercut. The moulds are made by surrounding the object with a barrier of clay as high as the thickness of mould required, and, after oiling the surface, filling the space with melted glue, which, when cold, can if necessary be cut in suitable pieces for delivering smoothly. The pieces, when put together again, form the mould in which to run the plaster or wax. If the undercutting is not too deep, these moulds will yield sufficient to admit of ordinary flat casts being taken whole, without cutting. See PLASTER-CASTS; UNDERCUT.

Electric Crane.—A substitution of the dynamo-electric machine for the steam or other methods usually employed for the purpose of working cranes. These cranes have met with almost universal favor, and are a marvellous improvement on some antiquated specimens which have been removed to allow of their introduction. They are eminently adapted for foundry purposes. See CRANES.

Electric Furnace.—The Siemens Electric Furnace is used for melting metals that are of a highly refractory nature, using a guarded crucible. It is compact, needs no chimney, is more economical, and melts more rapidly, besides excluding air from the crucible.

Electro-plating.—The process of covering one metal with a thin film of another by the aid of electricity. See PLATING.

Electrotype.—A cast of metal upon a mould by galvanic action. A wax impression of the type or engraving is coated with black lead, washed with solution of sulphate of copper, and dusted with iron-filings, which leaves a film of copper on the surface, after which it is suspended in a bath of : sulphate of copper 2, sulphuric acid 1, water to stand it at 140° Beaumé, and connected with the negative electrode of a battery. The sulphate of copper is decomposed when the circuit is closed, the metallic copper going to the negative plate, which is the plumbago-mould.

The deposit or shell is afterwards *backed* with molten type-metal. See STEREOTYPE; TYPE.

Elements.—Modern science considers matter as existing in four forms—imponderable, gaseous, liquid, and solid; while by elements are understood the simple component ingredients of bodies under whatever form they are recognized by the chemists. The number of these elements is about 64, some of which have been known from ancient times—gold, silver, copper, tin, lead, iron, and mercury in particular; others are of more recent date. The elements are divided into two classes, the metallic and non-metallic —the former numbering 52, the latter 13. Below is given a table of the elementary substances now known, in alphabetical order:

METALLIC.

Aluminum	Cerium	Gold	Manganese
Antimony	Chromium	Indium	Mercury
Arsenic	Cobalt	Iridium	Molybdenum
Barium	Copper	Iron	Nickel
Bismuth	Didymium	Lanthanum	Niobium
Cadmium	Erbium	Lead	Osmium
Cæsium	Gallium	Lithium	Palladium
Calcium	Glucinum	Magnesium	Platinum

Potassium	Sodium	Thorium	Vanadium
Rhodium	Strontium	Tin	Yttrium
Rubidium	Tantalum	Titanium	Zinc
Ruthenium	Tellurium	Tungsten	Zirconium
Silver	Thallium	Uranium	

NON-METALLIC.

Boron	Fluorine	Nitrogen	Selenium
Bromine	Hydrogen	Oxygen	Silicon
Carbon	Iodine	Phosphorus	Sulphur
Chlorine			

Four of these elements—chlorine, hydrogen, nitrogen, and oxygen—are gases, and fluorine is probably a gas also. Two are liquids at ordinary atmospheric temperatures, viz., mercury and bromine. The element gallium recently found in certain zinc ores is also said to be a liquid, the remaining elements are all solids. A description of the chief elements will be found in their respective order throughout this work. See METALS.

Elevator.—A mechanical contrivance for lifting sand, coal, ores, grain, etc., from the floor, or from prepared boxes, to a higher elevation to be there deposited by means of strong belts carrying a series of buckets travelling over drums placed at each end of the distance travelled; lifting the material at the bottom turn, and depositing at the top. See HOIST; CONVEYER.

Embroidery Impressions on Cast Iron.—Impressions of lace embroidery and similar objects can be produced by following the instructions given by Mr. Outerbridge in a paper read at a meeting of the Franklin Institute, which is substantially as follows: First, carefully imbed the object to be operated upon in charcoal-dust confined in a cast-iron box. After securing the lid heat slowly in the oven, and when the moisture has all escaped increase the heat until the blue smoke escaping from the box ceases. The box is then heated up to a white heat and so kept for two hours, and then allowed to cool. By holding the object in a gas-flame it will be discovered whether it has been thoroughly carbonized or not; if the operation has been successful it will not glow when removed from the flame. The object, after thorough carbonization, is secured to a green-sand surface, and the metal cast over in the ordinary manner. If care is exercised, a number of impressions may be taken from the same substance. See HAND-WRITING IMPRESSIONS IN CAST IRON.

Emerald is cut and polished for the best jewelry; it is known from beryl by its deeper and richer green. The finest of these stones come from the neighborhood of Peru. Emerald fuses with difficulty into a porous glass. Its composition is: silex 64.5, glucine 13, alumina 16, lime 1.6, oxide of chrome 3.25; specific gravity, 2.70. See BERYL; PRECIOUS STONES.

Emery is an impure kind of corundum, gray to dark-brown in color. Most of this substance is artificially colored a dark, rich brown for commerce, and for all common purposes, as emery-cloth, is usually adulterated with iron-slag, garnet, etc. It is opaque, of slightly glistening metallic lustre; hardness equal to corundum, and of about the same specific gravity and composition as the latter. Even the sapphire and oriental ruby, the hardest substances next to the diamond, can be cut and polished with emery. See CORUNDUM; PRECIOUS STONES.

Emery-wheel.—A disk of corundum, or emery composition, keyed to a mandrel and rotated by a pulley and belt; used principally for grinding and polishing metals. See CORUNDUM; EMERY.

Enamel.—A shining, vitrified substance employed as an indestructible coating to various articles of taste and utility. The basis of all enamels is a perfectly transparent and fusible glass, which is subsequently rendered either semi-transparent or opaque by admixture with metallic oxides.

Engine for Blower.—It is always best to have the blower driven by an independent engine, as by this arrangement the annoyance and consequent loss caused by the breaking-down of any portion of the driving machinery which is common for all purposes is saved, and as these annoyances generally occur when the blast is in full swing the value of an independent engine is wonderfully enhanced. An experimental knowledge of the above facts has resulted in the production of a blower and engine combined, which machine is becoming more popular every day. See BLAST; BLOWER ; CUPOLA.

Entablature is that part of an architectural design which surmounts the columns and rests upon the capitals. In this sense the term is applied by engineers to similar parts of machinery-framing wherein such designs are intruded.

Equipment. — General appliances, tools, and machinery necessary for conducting a foundry or other manufacturing establishment.

Evaporation generally signifies the dissipation of the volatile parts of a compound body. Natural evaporation is the conversion of water into vapor, which, in consequence of becoming lighter than the atmosphere, is raised considerably above the earth, and afterwards, by a partial condensation, forms clouds. See VAPOR.

Exhaust Tumbling-barrels.—The advantages of this useful adjunct to foundry operations is thus described: Not alone does this machine do away with the horrible clatter and din in the milling-room, but it also keeps the room clear of dust, besides accomplishing an actual saving of twenty-five per cent in time in cleaning the castings.

The staves of the machine are made of two-inch well-seasoned oak timber, lined with hard steel plates. Each stave is so bolted that, no matter where the machine stops, the staves can be taken out and replaced without trouble. As soon as the sand is loosened from the castings and is pulverized sufficiently fine for the exhaust to lift it, it is immediately carried away to a box or receptacle which may be placed at any point in or out of the mill-room. This taking away the dust is where the saving of time in cleaning is accomplished.

These barrels are substantially made and nicely finished, and have a very attractive appearance. The barrels are operated by belt to the first one, and the rest are run by friction bearings. As many barrels as are needed can be placed side by side and operated by the same belt. Any one barrel can be stopped or started at will by turning a wheel-handle which raises or lowers the barrels from contact with the friction wheel. They are the most complete, easiest-running, most noiseless, cleanest, and most satisfactory tumbling-barrels that can be made.

The foundry-supply companies furnish these machines either octagon or square shaped, as well as exhaust-fan for carrying away the dust. See TUMBLING-BARREL.

Expanding Alloy.—Lead 9, antimony 2, bismuth 1. This alloy is useful to fill holes in castings, as it does not contract and become loose like lead or cast iron. What are termed expanding alloys invariably contain bismuth and antimony in some proportion. This special quality has rendered these metals valuable for type-metal composition, etc. See BISMUTH; ANTIMONY; TYPE-METAL.

Expansion is the enlargement or increase of bulk in substances, chiefly by means of heat. This is one of the most general effects of heat and is common to all bodies whether solid, fluid, or in the aëriform state. Expansion by heat varies greatly. The following table gives the linear expansions of several useful metals from 0° to 100° C., the length at 0° being taken as unity:

Metal.	Expansion 0° to 100°.
Platinum, cast	.000907
Gold, cast	.001451
Silver, cast	.001936
Copper	.001708
Iron	.001228
Cast steel	.001110
Bismuth	.001374
Tin	.002269
Lead	.002948
Zinc	.002905
Cadmium	.003102
Aluminum	.002336
Brass (copper 72, zinc 28)	.001879
Bronze (copper 86, tin 10, zinc 4)	.001802

See CONTRACTION; SHRINKAGE.

Explosion.—A sudden and violent expansion of an aërial or other elastic fluid, by which its parts are separated with a loud noise. See VENTING.

Eye-bar.—A common chisel or pointed bar with an eye forged at the opposite end—a useful implement in a foundry.

Eye-bolt is an ordinary bolt with a round or oval eye at one end to receive a hook, rope, or chain. Bolts of this class may be put to an infinite variety of uses in the foundry, if general arrangements for lifting cores, flasks, etc., are made favorable to their adoption. A welded ring in the eye changes it into a ring-bolt.

Eye-piece.—A circular disk of iron containing a central sheet of mica, usually placed opposite to each tuyere, on the wind-box of the cupola; its object being to permit a view of the inside through the transparent mica. It works on a pivot, so that if necessary it may be moved aside and access had to the inside of the cupola if it is desired to remove any accumulated slag from the tuyere. See CUPOLA; SLAG; TUYERE; WIND-BOX.

F.

Facets.—The flat surfaces which bound the angles of crystals. See CRYSTALLIZATION.

Facia.—A broad, flat, projecting part of a building, as the bands of an architrave, larmier, etc.

Facing.—Foundry facing, employed for intimately mixing with the facing-sand, or spreading upon the surface of moulds, to prevent the molten metal from penetrating the sand, as well as to impart a smooth, fine skin to the surface of the casting. When properly used it is an unmistakably good help in making smooth and clean castings, profitable alike to the moulder and the employer. Facings are composed of finely ground and bolted fireproof substances, principally carbon, as charred wood, coal, graphite, etc. They are now so well understood by the manufacturers that, by making application and stating for what description of casting it is to be used, founders can be supplied with a facing exactly suitable. See BLACKING-BAG; SEA-COAL; GRAPHITE; FACING-SAND.

Facing-sand is the sand used for facing or covering the surface of the mould, and necessarily that with which the metal is brought into immediate contact when the casting is poured. Sand for this purpose should possess properties that will enable it to resist pressure and heat from the molten metal as well as permit free and uninterrupted egress to the gases which are generated. Hitherto this subject has been left to mere chance, trying first one sand and then another, with the usual loss and disappointment which attend such methods, until the right substance has at last been found. It is now positively known just what sand will give a clean casting, free from adhering sand. To be a positively good moulding-sand it must contain no substance that will act chemically upon the molten metal, nor should the high temperature of the metal affect it adversely. The difficulty in meeting these conditions is apparent when we consider that the higher the temperature of molten metal the fewer become the substances that will successfully resist it. Three per cent of metallic oxides in sand seriously diminishes its refractory qualities, and one per cent of lime present measurably lessens its value as a good moulding-sand, as the carbonate is acted upon by the intense heat and caused to give off carbonic-acid gas, which disturbs the surface of the mould during its escape, causing honeycombed and rough surfaces on the castings.

Should caustic lime be present, its fluxing properties will manifest themselves by melting into the form of a slag and adhering to the surface of the casting.

Sands which contain the largest proportion of silica, from one to three per cent of magnesia, with as much alumina as will impart cohesiveness and plasticity, are under almost all circumstances the best for facing-sand. Lime should not be present in even the smallest proportion. It is seldom that sand with the above proportions can be found in nature, but a chemical knowledge of these matters enables us to choose such grades as will, by suitable admixture and blending of two or more kinds, produce a mixture containing known proportions of the elements necessary for meeting all emergencies.

Facing-sand is termed strong or weak according to the amount of alumina or clay which enters into its composition; and the same term is applied with reference to a high or low percentage of coal used in the mixture. See ANALYSIS; VENTING; DRY-SAND FACING; OLD-SAND; ROCK-SAND.

Faint-run.—The opposite of sharp and clearly-defined impressions on the casting. When fine carving, tracing, and other outlines on a casting are blurred, presenting shining, imperfect edges and cold-shot marks, the casting is pronounced as *faint-run.* Some of the chief causes for this are unequal distribution of the runners, a too free use of carbon facing, wet or hard sand, dull metal, lack of porosity in the sand, or perhaps a combination of two or more of the causes mentioned, all of which it is the easiest matter conceivable to avoid when the intelligence is made equal to the exigency. See COLD-SHOT; VENTING.

Falling-doors.—Hinged doors attached to the underside of a cupola, which, when the metal has all run out, may be suddenly dropped, permitting the slag and cinders to fall out into the pit below. See CUPOLA.

False-core.—A technical term used chiefly by moulders of fine art work, statuary, etc., meaning loose pieces of mould, or *drawbacks*, that must be formed at the undercut portions of a model or pattern.

These false-cores are rammed carefully in their several places, and separating joints formed on their exterior surfaces, the impression of which being taken in the main section, or cheek of the mould, forms a seating into which they are subsequently fitted and secured, when they are withdrawn from the model. See DRAWBACK; STATUARY-FOUNDING; MODELLING; PLASTER-CAST; UNDER-CUT.

Fan.—A rotative blowing-machine, consisting of vanes turning upon an axis, to force a current of air into a furnace or for the purpose of exhausting. See BLOWER; BLAST.

Fats and Fatty Acids.—See OILS.

Feeding.—The process of supplying hot fluid metal to the interior of a casting, to compensate for the gradual shrinkage as it passes from a fluid to a solid state. The head, occupying an elevated position, imparts pressure; the feeding-rod, being kept hot, serves to maintain communication with the interior by preserving a passage through which the molten metal is forced by reason of the pressure exerted at the feeding-head above, where the supply is kept constant until the mass has solidified. This process is by some improperly termed *churning*. See FEEDING-HEAD; FEEDING-ROD; RISER; SHRINKAGE.

Feeding-head.—In some localities this is called *shrink-head* and *sinking-head*. It is a continuation of the *rising-head* to some distance higher than the latter is usually made, and is generally formed of sand within an iron box. If the proportion of feeding-head be equal to the casting, the latter will be effectually fed with metal sufficient to make good the depreciation from shrinkage; but if the riser must necessarily be much smaller, proportionately, than the casting, it will congeal, or *set*, ahead of the latter with the result of unsoundness, if the feeding-rod is not resorted to. See FEEDING; FEEDING-ROD.

Feeding-rod.—A wrought-iron rod, from $\frac{1}{4}$ to $\frac{3}{4}$ inch diameter and of a suitable length, for use in keeping open the communication betwixt riser and casting. When it is necessary to feed castings, these rods should be kept clean and hot, occasionally changing the one in use for a clean one that has been previously heated. By this means the hole can be kept free until the casting has completed its shrinkage; otherwise the hole congeals prematurely, and the casting suffers in consequence. See FEEDING.

Feldspar.—Feldspar is a principal constituent of many rocks. Clays seem, very generally, to have resulted, at least in great part, from its decomposition. *Kaolin*, or China clay, is considered to be decomposed feldspar. See KAOLIN; ROCKS.

Fenton's Anti-friction Metal. — Grain-tin 8, purified zinc 7, antimony 1. Another: copper 10, tin 10, zinc 10. See ANTI-FRICTION METAL.

Fern-leaf Impressions in Cast Iron.—See EMBROIDERY IMPRESSIONS IN CAST IRON.

Ferro-manganese.—Pig-iron containing from 25 to 75 per cent of manganese, employed extensively in the manufacture of mild steel by the Siemens, Bessemer, and crucible methods. See MANGANESE; SPIEGELEISEN; OPEN-HEARTH STEEL.

Fettler.—A local name for a chipper or cleaner. See DRESSER.

Fettling.—A puddler's term for preparing the puddling-furnace hearth with a mixture composed chiefly of old furnace-bottoms, crushed and mixed with tap-cinder and scales. See MILL-CINDER; MALLEABLE IRON; PUDDLE-STEEL.

File-cleaner.—A piece of wire card, 6 by 4 inches, nailed to a piece of wood is a good file-cleaner. Such a contrivance is also a much better rasp for soft cores than files. This card may be procured from an old carding-engine in the cotton-factories.

Fillet.—A rounded corner on a mould. There is less danger of shrinkage flaws when corners are filleted. Flexible metallic filleting, any size required, may be obtained at a nominal figure, so that no pattern need be left without. When fillets are left to be carved off by the moulder it costs twice the amount for labor, and, unless the operation is performed by a good mechanic, the result is invariably a botched job.

Filling in.—Setting the inside courses of bricks by the loam-moulder. In heavy walling and solid cores the faces or outer courses are built strong, but the filling-in courses are set wide apart and the spaces filled with fine cinders to lead away the gases. This is a very common term in a foundry. Placing sand inside a flask or any other receptacle, as a riddle, sieve, etc., is usually called *filling in.* See BRICKING UP.

Fin.—Metal that flows past the casting in a thin ridge at the joining edges of a mould. In some cases the edges are purposely pared down to prevent any possibility of the two edges meeting. Especially is this rule to be observed in loam and dry-sand work, where in the event of too close contact the mould is damaged by a *crushed joint*. The term *crush* is common when any part of a mould is damaged by undue pressure, etc.

Fine-art Moulding.—This branch includes moulding of statuary, groups, figures, busts, etc., in bronze by the *cire perdue* and other processes common to the art, besides the general work connected with clay and wax modelling, taking plaster and wax casts, etc. See MODELLING; PLASTER-CAST; STATUARY-FOUNDING.

Finery-furnace—also called a *refinery*—consists of a rectangular hearth formed by the junction of four troughs, through which cold water circulates to prevent them from fusing. A bottom is formed within the troughs with prepared sand, with a droop towards the tap-hole. The blast enters the hearth through tuyères which incline at an angle of about 28°. Above the hearth is a chimney about 17 feet high, built on four pillars in order that the air may have free access to the fire on all sides. The tap-hole is at the lower end of the hearth, and through it the metal and slag run out on plates, where it is at once cooled by copious streams of water. This sudden cooling of the molten mass causes the carbon to combine chemically and produces a silvery-white metal. This is the preliminary process before puddling the iron in the reverberatory furnace. See MALLEABLE IRON; PUDDLING-FURNACE.

Finger-piece.—A tongue or narrow strip attached to the sweep-board by the loam-moulder, when he forms a perfectly true loam-bed on the brickwork, on which to rest a bracket or any other piece of pattern which is to form a part of the finished casting. The moulder marks his true depth by means of a square held against the spindle; and the finger-piece may then be screwed fast and true to the line.

This is very superior practice to the common one of attempting to bed such work on soft loam, as, after the bed has been struck, it may be made firm almost immediately with a charcoal fire in an old riddle or lamp. See LOAM-MOULDING; SPINDLE; SWEEP; LAMP.

Finishing.—This term refers generally to all the processes connected with preparing a mould for casting after the pattern has been withdrawn; but especially to manipulations with the regular moulder's tools, such as smoothing over the blackening after it has been brushed or swabbed over dry-sand and loam moulds. See DRESSING; LOAM-MOULDING.

Finishing-loam.—See SKINNING-LOAM.

Finishing-rolls.—See MALLEABLE IRON; ROLLS.

Fire-brick.—A brick made of fire-clay, and other refractory materials for use in cupolas and other furnaces, and for that reason must be capable of sustaining intense heat without fusing. See REFRACTORY MATERIALS; FIRE-CLAY.

Fire-bridge.—A hollow cast frame, encased in fire-brick, which is built between the hearth and the grate of a reverberatory furnace. See REVERBERATORY FURNACE.

Fire-clay is the kind of clay which, when mixed with other refractory ingredients, is used for the manufacture of fire-bricks, crucibles, glass pots, retorts, etc., which require to withstand intense heat. It is found abundantly near the surface of the ground, but chiefly in the coal measures. Fire-clay to be of value should be comparatively free from ferrous oxide (or combination of iron with oxygen), calcium carbonate (or substances such as limestone, chalk, marble, etc.), and iron pyrites, because at very high temperatures these bodies would combine with the silica of the clay with the formation of fusible vitreous silicates. See REFRACTORY MATERIAL.

Fire-sand is the name given to all foundry sands that are composed principally of coarse grains of quartz, intermixed with more or less alumina or clayey sand. Because of the highly refractory nature of these siliceous sands they are usually termed "fire-sands." See FACING-SAND; REFRACTORY MATERIAL.

Flame is the luminous phenomenon produced by the combustion of gases and is, hence, fire in motion. Substances which burn with flame are either gases already or they contain a gas which is set free by the heat of combustion. But flame does not necessarily produce light. In the burning of pure oxygen and hydrogen there is intense flame, but the light is so weak that it can scarcely be seen. If we sift a little charcoal-dust into this non-luminous flame, the particles of solid carbon are instantly heated to incandescence, a bright flash of light resulting. Therefore the conditions of illumination are, first, an intense heat, and, second, a solid placed in the midst of it, which remains fixed and gives out the light.

The lighting power of a gas depends upon the proportion of carbon it contains, the particles of which become glowing hot before being consumed. See COMBUSTION; HEAT; CARBON.

Flange-smoother.—A moulder's tool, curved to fit the flanges of pipes, etc., and smooth the edge. See SLICKER.

Flasks.—The iron or wooden moulding-boxes in which sand matrices or moulds are formed for the production of castings.

When a mould is formed in the floor, only one flask, cope, or top part is needed to cover with, consisting of frame and bars ; this may be cast in one piece, or it may be made up of sides, ends, and bars, all separate ; in which case the ends and bars must be bolted or wedged in their respective places.

In such a cope, stops for guiding-stakes, trunnions for turning over by, and handles or ring-bolts for lifting with, are all that is needed for the complete flask. Lugs and pins added to such a flask would convert it into a cope, only requiring a nowel, or bottom part, to complete a set, being then called a pair of flasks. Intermediate cheeks make it a set of flasks, three-part, four-part, etc., according to the number of cheeks interposed betwixt cope and nowel.

By fitting all such flasks to standard templets they become interchangeable, making it a simple matter to fit any kind of job when the cheeks are made of various depths.

The business of making small flasks for brass-moulders is now a special one, and the dealers in foundry supplies can furnish them with pouring-holes in any position desired. They are also drilled with standard templets, faces planed, pins turned true and bolted to the lugs with nuts. Being interchangeable, they are readily replaced when necessary. See Bar ; Floor-moulding ; Stakes ; Cope ; Trunnion ; Ring-bolt ; Lugs ; Pins ; Nowel ; Cheek.

Flat-head Nails.—Nails of malleable cast iron with extra-large heads, and from 1½ to 6 inches long, suitable for chaplets. They are also useful in a foundry for many other purposes. See Chaplet.

Flint.—Flint is a compact homogeneous substance of a steel-gray color, sometimes brown or black. In composition it consists of almost pure silica, with traces of iron, lime, and alumina. From the earliest times flint has been employed as a fire-producer, especially with a steel implement in the yet familiar form of "flint and steel." Flint enters largely into the composition of fine earthenware, for which purpose it is reduced to powder after it has been calcined and thrown into cold water. See QUARTZ.

Floor-moulding is moulding an object on the floor by the process of "bedding in"; or possibly on the floor in flasks, as distinguished from moulding on the bench. The former method is *floor-moulding*, the latter *bench-moulding*. See BEDDING IN; ROLLING OVER; BENCH-MOULDER.

Flour.—A name given in a general way to all the finer descriptions of pulverized grain or peas, which when unfit for food finds its way into the foundry, to be there employed for mixing with sands, blackings, and facings in order to impart artificial strength to those substances by binding the particles together with the gluten it contains. The gluten of wheat-flour is extremely tenacious and elastic; the value of flour as a toughener of sand depends upon this substance, which, when dried, has a birdlime or glue-like aspect which imparts a fibrous, tough, and elastic quality to sands which would otherwise be lacking in these important essentials. This, of course, admits the use of sands absolutely free from alumina, being by this artificial stiffening made to perform duties that would be possible only with sands containing alumina in considerable proportions. Alumina hardens in the core when cast, and is difficult to remove; gluten burns away, leaving the sand free. See CORE-SAND; CORE-COMPOUND; MOLASSES; GLUE; GLUTEN; STARCH.

Flow-off Gates.—See Cut-off.

Fluid.—A body whose parts yield to the slightest force when impressed, and by yielding are easily moved against each other. Fluids may be divided into elastic and non-elastic. Elastic fluids are those which may be compressed into a very small compass, but resume their former dimensions on removing the compressing force. These are distinguished as airs or gases. Non-elastic fluids are those which occupy the same bulk under all pressures, or, if compressible, it is only in a slight degree—as water, oils, etc. These are denominated liquids, except in the case of metals when melted. The physical nature, laws, and effects of non-elastic fluids at rest constitute the science of hydrostatics, and when in motion, of the science of hydraulics; those that relate to elastic fluids appertain to pneumatics. See Solid.

Fluid Alloy.—If sodium 4, potassium 2½, be mixed together, an alloy having the appearance and consistency of mercury will result, which remains liquid at the ordinary temperatures like that metal. See Mercury; Alloy; Sodium.

Fluor-spar Flux.—Fluor-spar or calcium fluoride is a brittle, transparent to sub-translucent mineral with a perfect octahedral cleavage, a vitreous, sometimes splendent lustre, and specific gravity of 3.12. It decrepitates, tinges the flame dull red, and fuses into an enamel before the blowpipe. Fluor-spar is used for the production of hydrofluoric acid in etching on seals and glass, and it is extensively used in the smelting of lead and copper as a flux. It is found in metalliferous veins, also in granite, slate, limestone, etc.

A very small quantity of fluor-spar in the cupola makes the slag more thinly liquid and poorer in iron than does limestone. It saves labor, preserves the cupola, and keeps it clean. To some extent fuel is saved by a judicious use of this flux, and at the same time it facilitates the separation of phosphorus and sulphur from the iron. While limestone is to some extent a dephosphorizing agent and active flux, and is cheap also, it must be admitted that it is also dirty and difficult to get along with in the cupola. For a heat of five tons, ten pounds of fluor-spar to the ton would be sufficient; for ten tons, fifteen pounds to the ton; and for twenty-five tons, twenty pounds to the ton. When dirty iron is being melted and aided by this flux, it is absolutely necessary to employ a slag-hole to allow the contaminating accumulations to run off. See FLUX; CUPOLA; CHARGING THE COMMON CUPOLA.

Flux is a general term given to the substances employed in the arts which cause or facilitate the reduction of a metallic ore and the fusion of the metal. White flux is an intimate mixture of 10 parts dry carbonate of soda and 13 parts dry carbonate of potash, and is used for withdrawing the silica or combined sand from mineral bodies.

Black flux is prepared by heating in close vessels ordinary cream of tartar, with an intimate mixture of finely divided charcoal, by which means the carbonate of potash is obtained.

Limestone is employed as the flux in the smelting of iron ore. Fluor-spar, borax, protoxide of lead, are also fluxes. See ALLOY; SOLDER; CAST IRON; FLUOR-SPAR FLUX; SLAG.

Follow-board.—A turn-over board on which to ram the nowel. When the pattern has a flat face a plain, true board suffices; but should there be any deviation from a plain surface, the board is shaped to fit, so that the pattern may rest firmly at every part and not be injured by the pressure exerted when the ramming takes place.

The value of these boards is enhanced by forming in or on the board whatever projections or depressions are needed to make a completed parting when it has been turned over, leaving little or nothing to do but lay on the parting-sand and proceed to ram the cope. See ROLLING OVER; MATCH-PART; MATCH-PLATE.

Fonderie à Calabasse. — A small Belgic iron-foundry for the production of light castings at short notice. About four 500-pound heats may be taken daily from a furnace very similar in appearance to an ordinary ladle, with trunnions that rest upon standards, and furnished with handles for turning. The ladle is placed under a hood against the wall, and, when it is desired to melt, it is lined with loam and surmounted with a sheet-iron extension, also lined and provided with a hole at its lower edge for introducing the blast-pipe. A hand-fan, equal to 1000 revolutions per minute, enables them to obtain very hot metal. When the fuel, which fills both ladle and extension, has been brought to a glowing heat by a soft blast, the metal is charged, and the full force applied until all is melted, when the extension is lifted off, slag and cinder removed, and the metal is ready for the moulds. The percentage of fuel is high, but the convenience is great, and the simplicity of the whole apparatus furnishes a good opportunity for those with small capital, or for special purposes at any foundry. See CUPOLA.

Fontainemoreau's Bronzes. — Zinc predominates in these bronzes, with copper, cast iron, and lead in varying proportions, according to the quality desired. It is an excellent alloy for casting into metal moulds, the metal being rendered more homogeneous by that mode of casting. The crystalline nature of the zinc is changed by the addition of these alloys, being hard and close-grained, like steel, although it yields to the file better than either copper or zinc. The proportions of those which have been found best for general use are as follows :

Zinc.	Copper.	Lead.	Cast Iron.
90	8	1	1
91	8	1	
92	8		
92	7		1
97	3		
97	2½		½
99	1		
99½			½

See Bronze; Alloy; Copper; Zinc.

Forge-cinder.—See Mill-cinder.

Fork.—See Coke-fork.

Former.—A strickle or templet, sometimes termed a *sweep* and a *strike*, with which to form a mould or core by drawing it laterally, along a guideway, the outlines of which correspond to the shape of the object to be moulded; the former itself determining its vertical height and conformation. The semicircular board which is travelled along the edge of a pipe-core plate to make a half-core is a *former*. See Loam-patterns; Strickle.

Foundation-plate.—The bottom or base plate which carries the whole mould, and to which all other parts of the mould are made secure; for which reason it is important to make them of sufficient strength for the purpose. For loam-work they should be made to correspond with the outer boundary of brickwork surrounding the casting, and all connections, as lugs, staples, bolt-holes, etc., must necessarily stand beyond that limit. See LOAM-WORK; PLATE.

Founding is the art of forming in loam, or sand, a mould of any given design, which is subsequently filled with molten metal and allowed to solidify, the resultant casting being a copy in metal of the design or model furnished. The place where these operations are performed is called a foundry. See FOUNDRY.

Foundry.—Foundries are distinguished by either the metals employed or the class of castings made, as iron, steel, brass, statue, type, bell foundries, etc.; casting the finer metals, as gold, silver, and the infinite number of alloys of these and other metals, being necessarily conducted on a smaller scale. See FOUNDING.

Fountain-runner is a running-gate supplied from a source below the point at which the metal enters the mould, and may be formed by either connecting a vertical runner from the casting down to a horizontal one below, or by a tapered cylindrical half-ring, having one end touching the casting and the other in proximity to the main runner at the joint. It is then termed a *horn-gate.* Such runners are serviceable when it is desired to fill a mould easily, and with as little friction as possible. See GATE; RUNNER.

Free Sand is sand which, owing to its freedom from alumina, is without the power of cohesiveness, as stone-sand, beach-sand, river-sand, etc. See FACING-SAND; CORE-SAND; FLOUR.

Freezing.—A technical term for the particular state of molten metal when it is losing its fluidity, or changing from the liquid to the solid state. See CONGEAL; SETTING.

Front-plate.—A cast-iron plate to which chest, port, and exhaust cores are secured sometimes, when a cylinder on which the steam-chest is to be cast is made in loam. Also a plate to cover the breast of a cupola when the hole is made large enough for drawing the cinders and slag when done melting, as must be the case with all cupolas having solid bottoms. See CUPOLA; BREAST; SPOUT.

Fuel.—Fuel is a term of general application to all combustibles employed for producing heat. The two elementary bodies which produce the heating power of fuels, both natural and artificial, are hydrogen and carbon ; and as there is little or none of the former element contained in anthracite, peat charcoal, wood charcoal, or coke, we may therefore regard these as carbonaceous fuels. But wood, peat, and most varieties of coal contain hydrogen as well as carbon, and in their combustion these two substances combine to produce volatile and combustible hydrocarbons, which are volatilized previous to being consumed; while a purely carbonaceous fuel evolves no volatile matter until combustion has been effected. See COMBUSTION; COAL; COKE; PETROLEUM; PRESSED FUEL; LIQUID FUEL.

Furnace.—A suitably provided chamber where fire is produced by the use of fuel, as for melting metals, smelting ores, etc., the former being a cupola, the latter a smelting furnace. When the fire receives no other support than a natural draught, it is termed a wind or air furnace ; when a forcible current of air is injected by means of a fan, blower, or engine, it is a blast-furnace; and a reverberatory furnace when the flame in passing through towards the chimney is thrown down by a low arched roof upon the materials to be operated upon. See CUPOLA; REVERBERATORY FURNACE; BLAST-FURNACE; BRASS-FURNACE; also many other furnaces, in their respective order.

Fusibility.—Except in a few instances, all solids which can bear a high temperature without suffering a chemical change may be melted. Even carbon has been partially fused before the oxyhydrogen blowpipe. Most solids when heated to fusing-point change at once into perfect liquids; whilst otners, such as platinum, iron, glass, etc., pass through an intermediate pasty condition before they are perfectly fluid, making it difficult to determine the exact fusing-point. See MALLEABLE IRON.

Fusible Alloys.—Fusible alloys are composed principally of bismuth, tin, and lead, and the proportions in which they are alloyed determine the temperature at which they will melt. An alloy of bismuth 8, lead 5, tin 3, when fused together, melts at 212° F.; one of bismuth 2, lead 5, tin 3, like the other, will melt in boiling water, or 212° F.; and one of lead 3, tin 2, bismuth 5, melts at 197° F.

Wood's patent fusible metal, cadmium 3, tin 4, lead 8, bismuth 15, melts at 150° F. Other fusible alloys which bear a particular name will be found in their places.

As all fusible metals, including lead, tin, zinc, antimony, bismuth, etc., and their alloys, melt at a much lower temperature than iron, ladles or pots of that substance may be used for melting them in without any intervening lining. See BISMUTH; TIN; LEAD; ANTIMONY; CADMIUM; ALLOYS.

G.

Gagger.—A turned piece of rod iron for binding the surface sand firmly to the cope. If the surface below the joint extends but a little way, a three-inch turn at one end is sufficient; the long end resting against the bar is pressed firmly thereto by the rammed sand, and the sand below the bars is sustained by this means; but if the lift is deep, the other end of the gagger must be turned at right angles also, one inch being enough in this case, the object being to hang the gagger on the flask-bar, at the same time allowing it to rest upon a slight thickness of soft sand at the bottom. By this means it becomes impossible for the hanging sand to pull the gagger out.

The former is termed a *plain*, and the latter a *hooked* gagger. See Bar; Flasks.

Galvanized Iron is made by coating clean iron with melted zinc. The iron is first subjected to a thorough cleansing in pickle containing 1 per cent of sulphuric acid, after which it is scoured well in clean water and then dipped in a bath of melted zinc, the surface of which is covered with sal-ammoniac in order to dissolve the oxide which gathers on the surface of the molten zinc. The best quality is made by first depositing a thin film of tin upon the iron by galvanic action. See Zinc-coating; Tinning; Pickle.

Gannister.—A highly refractory siliceous rock, used very extensively in the several processes connected with the manufacture of steel and in the production of steel castings, but especially as a lining for the Bessemer converters. Ground quartz, sand, and fire-clay are mixed with this substance in varying proportions; but the silica, about 90 per cent, is cemented to some extent by the argillaceous matter it contains, making it in some instances sufficiently cohesive for ramming around a plug, and thus forming a solid lining in converters and steel-melting furnaces without any admixture of alumina, etc., in which case the shrinkage is materially reduced and the original shape retained under very intense heat. See CONVERTER; REFRACTORY MATERIALS.

Gas.—A name given to all permanently elastic fluids and airs. Gases have no cohesion, in consequence of which, their particles tend to recede from each other and would expand into space—so far as is known—if they were not restrained by the pressure exerted by the atmosphere upon the earth's surface. In gas, as in liquid, the particles are in a condition of equilibrium,—with this difference, that in a liquid the equilibrium exists between the attractive and repulsive forces in the liquid itself, but in the gas between the excess of the repulsive forces in the body and an external pressure. Gases are therefore fluids in consequence of this condition of equilibrium which endows the particles with perfect freedom of motion. Gases are also compressible and elastic. The solid, liquid, and gaseous conditions of bodies depend upon temperature and pressure: for instance, mercury becomes solid at 40° below zero F.; from that temperature to 662° F. it is a liquid, and a gas when the temperature exceeds that. If sufficiently cooled and pressed all gases would probably become liquids, as many of them which are permanent at ordinary atmospheric pressure and temperature become liquids on increasing the pressure and diminishing the temperature, and some even solidify when cooled sufficiently. But some gases, such as oxygen, hydrogen, nitrogen, carbonic oxide, and nitrous oxide, cannot be liquefied. See AIR; THERMOMETER; FLUID.

Gas-blast Furnace.—The only prerequisite demanded for the gas-blast furnace, manufactured by the American Gas Furnace Company, is a positive air-pressure. This obtained, it will confer an even and controllable temperature, more even distribution of heat in a given space, greater speed of operation, saving of space, greater convenience, and a substantial reduction in the cost of fuel over all other methods. Melting-furnace No. 5, which consumes 200 feet of gas per hour, is described as follows :

This furnace is used for melting metals in black-lead crucibles, Nos. 15 to 20. They are in use for gold, silver, copper, and brass, as also for making tests and smaller melts of iron, steel, glass, etc. The linings are heavy and durable, and firmly bound by iron bands drawn together by clamps. Every part of the furnace is interchangeable, and easily replaced.

The combustion chamber consists of the bottom and the cylinder, both firmly secured to the distributing-ring. The burners penetrate the "bottom" lining, and are easily detached and replaced if necessary. The bottom is held in position by the iron platform, which is easily dropped down to replace the lining. The cylinder is secured to the distributing-ring by hinged bolts. The cover is hinged to the shaft, so as to lift clear of the furnace top when swung to either side. The "feed-hole" in cover is sufficiently large to give free access to the crucible without removing the cover, thus confining the heat while feeding the crucible. The small cover closes the feed-hole.

The crucible stands upon a conical fire-brick support, which is easily repaired. A channel through the bottom of the chamber affords an outlet for the products of combustion, and in case of accident the metal runs out of it into a drip-pan. By means of outlets for the products of combustion, at both the bottom and top of the furnace, the greater heat can (in a measure) be made to act upon either the bottom or top of crucible. When the vent on top is tightly closed, the greatest heat will be below, while the partial opening of the cover will draw it upwards.

The air-supply pipe is laid *close* to the floor, or comes up to furnace from under the floor when practicable. This is a precaution against the intermixture of gas and air in the blast-pipe, when the blower is accidentally stopped.

The gas supply required is the size of "Union" *G*. The consumption of gas varies according to quality of gas and degrees of heat required. Taking ordinary city gas as a criterion, the No. 5 furnace will require from 200 to 250 feet of gas per hour and melt 40 lbs. pure copper in thirty minutes. See BRASS-FURNACE; PORTABLE FURNACES.

Gas-house Coke.—This class of coke is invariably unfit for cupola purposes, because it has not sufficient cohesiveness to sustain the weight of the charges above, and therefore crumbles, allowing much of the combustion to take place before it reaches the melting-point of the cupola, at which point it is always desirable to have the fuel compact and in good form to meet the full force of the blast. See COKE; COMBUSTION.

Gas-pipe Vents are a safe and simple means of leading away the gases from vents where there is any possibility of molten metal forcing its way therein. If iron block-prints are used on the cores, as in steamway cores of cylinders, the ends may be threaded to screw into vent-holes that have been previously tapped in the iron print; if the print is sand, then taper the pipe about one inch, so that it may enter snugly. Venting that ordinarily would be intricate and untrustworthy is by this means made absolutely sure. See VENTING.

Gate.—That part of a system of runners which is in direct contact with the casting. In a plain mould, consisting of a cope and nowel, containing two or more castings which must be filled at one operation and without a *runner-basin,* the metal would enter from the ladle by the *sprue* into and down the *down-gate* into the *main runner,* and from thence into the castings through *ingates* or *sprays* connecting with the *main runner.* See BASIN; DOWN-GATE; RUNNER; SKIM-GATE.

Gate-pin.—An upright runner (round, square, or flat) which is rammed up vertically in the cope, and forms the connection betwixt the orifice for pouring into, and the system of gates below. The gate-pin is not unfrequently termed a *runner-stick.* See DOWN-GATE; GATE.

Gate-rake.—A strong, four-pronged steel fork for lifting the gates and medium heavy scrap out of the sand in the scrap-pile. The prongs are wide apart to allow all sand to fall through, and for this reason are preferable to an ordinary shovel for such use.

Gate-spool.—An inverted cone, usually made of wood, and turned smooth, with a handle projecting from its base. It is used for pressing back the sand and making smooth the upper edges of a sprue-runner, forming a funnel-shaped and cleanly formed entrance for the metal. A runner manipulated thus is called a *sprue.* See GATE.

Gathering Metal is a term used to indicate the collecting of a large quantity of metal for the purpose of pouring a heavy casting. If three or four ladles are used for casting a piece 20 tons, the metal is said to be gathered in that number of vessels. If a dam is constructed in which to run from cupolas, pour from ladles, or both means combined, all the metal required: it is then gathered in the dam. It is common in some places to supplement the regular melting in the air or reverberatory furnace by simultaneous melting in the cupola, transferring the metal from the cupola to the bed of the air-furnace as fast as it melts. This is accomplished by means of an inclined runner or spout placed so that the metal will enter the air-furnace at the side and directly over the reservoir. In the latter instance the metal is gathered into the air-furnace, which, if suitably constructed, is assuredly the very best arrangement for collecting metal in large quantities, as by this means the metal is maintained at a suitable temperature and is thoroughly mixed—something which cannot be satisfactorily done by either of the above described methods. See DAM.

Gauge, or **Gage,** is an instrument for measuring with. It may be adjustable, like the caliper, or a fixed and standard measure, as a gauge-stick for loam-work, and may be employed for testing inside or outside surfaces.

Also, an instrument for measuring any special force or dimension, as a pressure or blast gauge for cupolas and blast-furnaces. See CALIPER; BLAST-GAUGE; PRESSURE-GAUGE; GAUGE-STICK.

Gauge-stick.—A fixed measure employed by a loam-moulder. One edge is straight; its full length represents outside diameter, and notches indicate the core's diameter. A semicircle, cut midway along the straight edge to fit the spindle, enables the moulder to set his sweep-boards, and test the accuracy of his work entirely independent of his rule. It is made handier by reducing its bulk from the middle to the extremities on the back edge. See GAUGE.

Geared Ladle.—A pouring ladle provided with mechanism for tipping, invented by James Nasmyth, England. Makers of geared ladles, now very numerous, mount them with every conceivable variety of suitable gearing, from the simple wheel and pinion, spur or worm, to the more elaborate ones that are double-geared, or with mitre-wheels in addition to the worm-gearing. See LADLE.

Gems, Imitation.—See PASTE GEMS.

German-silver.—An alloy deriving its name from the circumstance of its being first made at Hildesheim, Germany. It is a useful silver-like alloy, composed generally of copper, nickel, and zinc. It resembles the *Tutenag* of the Chinese, and is used principally for table articles, and in electro-plating. Copper 3, zinc 1, and nickel 1 is perhaps the most silver-like alloy. *Tiers-argent,* an alloy of *German* with real silver, has come into use of late. It consists of copper 59.0, nickel 3.4, zinc 9.6, silver 27.6.

This alloy is prepared either by fusing the copper and nickel together in a crucible and introducing heated zinc piece by piece, or by finely dividing the metals, and melting in an air-furnace under a good layer of charcoal. These mixtures should be well stirred to promote a thorough solution of the nickel.

The crystalline structure of German-silver is destroyed by heating to a dull red and allowing to cool slowly; this renders it more suitable for working. The alloy is harder than silver, resembles the latter in color, tarnishes yellow in the air, and melts at a bright heat, losing its zinc by oxidation if exposed to the atmosphere. German-silver is exceedingly brittle at a heat just above a dull red. The ordinary composition for knives and forks is copper 4, nickel 2, zinc 2. That for handles for spoons and forks is copper 5, nickel 2, zinc 2. Metal for rolling is composed generally of copper 3, nickel 1, zinc 1. Candlesticks, bells, spurs, and similar articles that are cast are simply the German silver alloyed with from 2 to 3 per cent of lead.

When iron is added to the German-silver composition, it is best to use *tin-plate iron*, which must be first melted along with part of the copper. If from 2 to 2½ per cent of iron be added to German-silver, after the manner as above described, the metal will be much whiter, but harder also, and more brittle.

Park's German-silver contains: copper 91.0, nickel 45.5, zinc 21.0, iron 45.6. An English patent has: copper 5, nickel 4, zinc, tin, lead, and antimony 1 of each. A very malleable German-silver is made from: copper 5, nickel and zinc 7 each. Very many silver imitations are described in their proper order throughout this work. See PACKFONG; PARISIAN WHITE METAL; GERMAN TUTANIA; TOMBAC; BRITANNIA METAL; WHITE ALLOYS.

German Tutania.—A beautiful white alloy for table-ware, etc. Its composition is: copper 1, antimony 4, tin 48. See GERMAN-SILVER; WHITE ALLOYS.

German White Copper.—Copper 88, nickel 8.75. See WHITE ALLOYS.

Gig.—A light, portable centre for sweeping small moulds and cores, etc., in either loam, sand, composition, or plaster. See SPINDLE.

Gilding.—The three methods of gilding are: mechanical, chemical, and encaustic. Picture-frames, etc., are first oiled and then coated with whiting and glue, after which the gold size is applied to such parts as do not require burnishing; those which do are simply sized with the clear animal size. The gold-leaf is then applied with a brush. Electro-gilding is generally practised for metals. Water-gilding is simply applying a gold amalgam paste to the metal, and afterwards applying heat, which volatilizes the mercury, leaving the gold. The amalgam is made by placing grain or leaf gold 1 in a clean iron ladle, add mercury 8, and apply a gentle heat until the gold is dissolved, stir well with a clean iron rod, and run it on a clean slab. This, when cold, is the amalgam, ready for use.

The cleaned metal to be gilded is first rubbed over with a solution of nitrate of mercury, and at once covered with a thin coat of the amalgam. Heat is then applied to volatilize the mercury, and the gold adheres. Cheaper gilding may be made by increasing the quantity of mercury in the amalgam.

Steel may be gilded by dipping the polished article into the ethereal solution of gold; on withdrawing, the ether evaporates, leaving the gold. A cloth dipped in the solution and wiped over the article answers the purpose. See STAINS FOR METALS; TINNING; ZINC COATING.

Globe.—A sphere, a ball. See SPHERE; BALL.

Glucinum.—A metal resembling aluminum, prepared after the same manner. It is a rare metal, and was discovered by Wohler, 1828. See ALUMINUM.

Glue is an impure gelatine, made chiefly from fragments of hides, hoofs, bones, etc. Besides the many uses to which it is put for carpentry, pattern-making, etc., it is capable of furnishing an excellent means for imparting cohesiveness to the several free sands used for cores. When used as a glue water for dampening the sand, the gelatine binds the particles of sand together with a jelly-like substance, which, when the water has evaporated during the drying, leaves the core hard and brittle in proportion to the quantity of glue in the water. By using the smallest quantity necessary to stiffen pure sand, little or no gas is generated by the heat, thus making it possible, in numerous instances where it is difficult to obtain a vent, to use cores that are devoid of vents altogether. When cores of this class have been burnt by the metal there is no difficulty in extracting them from the castings, the glue having burned away, leaving only the incoherent sand. See Free Sand; Core-sand; Flour.

Glue Moulds. — Plaster casts of intricate objects may be obtained by making the mould of glue. Bunches of grapes, etc., for instance, are taken in their natural shape by covering them all over with glue, then cutting through the middle and extracting the grapes, after which the halves are joined together accurately and the cavity filled with plaster. A perfect cast of whatever object has been treated will be discovered after the glue has been melted off with boiling water. See Elastic Moulds.

Gluten is vegetable fibrin. If wheat flour is made into a dough and kneaded on a sieve under a stream of water, the starch is carried away, leaving a gray, tough, and elastic substance having the appearance of animal skin, and which when dried has a glue-like aspect; hence the name. See Starch.

Glycerine is a colorless, inodorous fluid, of a sweet taste. The usual method of obtaining it on a small scale is from olive-oil. See Oils.

Gold is a metal very widely diffused, occurring principally in grains, but sometimes in larger pieces weighing some pounds; it also occurs in the crystalline form in some instances. Its color is yellow, lustre brilliant; specific gravity 19.258. It is the most malleable of metals, is ductile to a high degree, and as soft as lead when pure. It melts at 2587° F., and is not affected by air or water at any temperature.

The usual solvent for gold is *aqua regia,* a mixture of nitric acid 1, chlorhydric acid 3 to 4. The name of this solvent means royal water, so called from its power of dissolving the king of metals.

Gold, like silver, in a pure state is seldom used in the arts, except perhaps as a solder for vessels of platinum for laboratory uses. Dentist's and gilding gold usually contains about 6 grains of copper to one ounce of gold. Standard gold, copper 1, gold 11, has a density of 17.157, and is harder and more fusible than gold when pure. The French standard is copper 1, gold 9.

Carat is a term used to designate one of the parts or units of a certain number which is taken as the standard of pure gold. In the United States the number is 24; hence pure gold is said to be 24 *carats* fine. If it contain 2 parts alloy, it is then 22 *carats,* etc.

Gold is separated from all its ores, except silver, by amalgamation with mercury. (See AMALGAMATION.) It is obtained from silver by boiling it with nitric acid, which dissolves out the silver, leaving the pure gold. See SEPARATING METALS.

Most metals combine with gold, increasing its hardness but impairing its ductility.

With silver 29.2, gold 70.8, the jeweller's composition called green gold is produced. The maximum degree of hardness with silver is obtained when the silver constitutes one third of the alloy; with copper it is one eighteenth. Twenty per cent of iron with gold produces the jeweller's gray gold, and 75 per cent makes an alloy of silvery whiteness, hard enough for cutting instruments.

Thirteen hundred miles of silver wire may be covered by one ounce of gold, the leaf is reduced to the 290,000th part of an inch, and a leaf of 56 square inches may be beaten out of one grain of this metal. See GILDING; ALLOY; TOMBAC; GOLD ALLOY.

Gold Alloy.—An imitation resembling the pure metal in color and of about the same specific gravity is made by melting together in a crucible, well covered with charcoal-dust, copper 7, platinum 16, zinc 1. Mannheim gold, another beautiful imitation, is made in the same way from copper 16, zinc 4, tin 1. Gold 75, copper 25, and a little silver is a remarkable jewelry composition.

Gold-leaf.—See GOLD.

Gold-solder.—Take gold of the same quality as the article to be soldered, and add $\frac{1}{12}$ of silver and $\frac{1}{24}$ of copper. A larger proportion of silver and copper may be added for articles not so fine. See SOLDERS.

Gong-metal is composed of copper 78 to 80, tin 20 to 22. After casting, the metal is subjected to a process of hammering and annealing. Owing to the brittleness of the mixture, great care and judgment is required to beat it into the flat basin-shaped gong, which, when struck with the mallet, puts the metal into such an extraordinary state of vibration as to produce the piercing sound emitted. Annealing is obtained by heating to a dull red, and suddenly immersing in water. When cold, the hammering can be continued until a point of brittleness is reached, when a repetition of the annealing process is made necessary, and so on until completed. See ALLOYS; BRASS.

Grades of Pig-iron.—Pig-iron produced from the same ores differs in its nature and quality, and must be rated or graded in such a manner as will indicate the special purpose for which each is applicable. Broadly stated, the classifications are commonly understood as gray, mottled, and white—a condition discovered by the fracture; but the gray iron is subjected to still further divisions, termed No.

1, No. 2, No. 3, etc., according as the fracture indicates the various degrees of hardness, commencing at the softest, No. 1, the numbers advancing as the hardness increases up to the point where they cease to be suitable for general foundry purposes, and are classed as *forge-irons,* being fit only for conversion into malleable iron in the puddling-furnace. The lack of fluidity common to the latter grades is a quality which makes them highly desirable for the puddling process, as in melting they pass, just before fusion is complete, into a pasty mass favorable for decarburization much easier and with less loss than could be possible if the pig-iron were gray and more fluid. See MALLEABLE IRON.

Grain-tin.—See TIN.

Granite is a widely known igneous rock, composed of quartz, feldspar, and mica, united in a confused crystallization. Feldspar predominates, and quartz is greater than mica. It is so called because of its granular structure. The decomposition of the feldspar of some kinds of granites produces the kaolin used for porcelain, and for many purposes in metallurgy. When granite decomposes and becomes mixed with organic matter it makes good soil. See KAOLIN; MICA; FELDSPAR; ROCK; EARTHS.

Granulated Zinc.—See ZINC, TO PURIFY.

Grapes, A Plaster Cast of.—See GLUE MOULDS.

Graphite.—The nature of graphite, sometimes called plumbago or black lead, is not generally understood. Eminent writers on friction have declared that graphite is the best natural lubricant known, and scientific and mechanical papers have advocated its use for many purposes. Incompetent, if not unscrupulous, parties have attempted to meet the demand by putting on the market graphite productions that are totally unfit for the uses specified.

Graphite is one of the forms of carbon. It is not affected by heat or cold, or any known chemical. As it comes from the mine, however, it contains from 50 to 80 per cent of silica, sulphur, and other impurities, and the process of completely freeing the graphite from impurities requires very expensive machinery and the most skilful manipulation. Only manufacturers having such facilities can hope to produce an absolutely pure article. The impurities in much of the graphite now in the market take on the appearance of graphite by contact, and such impurities are sometimes undetected even by the expert, unless chemical tests are employed. This is especially true of amorphous graphite, commonly called black lead, which is graphite without any particular form, and usually mixed with clay.

Pure graphite, and even black lead, is useful in many ways; but to be useful in the highest degree the graphite should be carefully selected with a view to the use intended. Graphite suitable for lead-pencils is not the most suitable for lubricating, although it has lubricating qualities. Again, graphite suitable for stove-polish would not answer for crucibles, although it might be equally pure and stand the heat equally well.

Graphite varies greatly in its construction and usefulness, and the best results are only brought about through experience, knowledge, and proper mechanical facilities. See Black Lead; Facing.

Graphite in Pig-iron.—Pig-iron contains from 2 to 6 per cent of carbon, some portion of which is held in chemical combination with the iron, the rest being distributed throughout the mass mechanically. The latter is called graphitic carbon, or graphite. This graphite is seen as scales, which may be detached from the mass when the pig-iron is reduced to powder, and may also be found among gray-iron borings that are subjected to a process of grinding and sifting. If gray iron that has been melted in contact with an excess of carbon is allowed to cool slowly, the carbon crystallizes out and forms graphite; this is commonly called *Kish* in the foundry, and it is always seen to gather when the iron is melted under conditions answering to those described above. See KISH; CARBON.

Gravity.—See SPECIFIC GRAVITY.

Gray Pig-iron is all pig-iron that contains a large proportion of its carbon in a graphitic state. Such irons may be distinguished by their crystalline fracture and dark-gray color. See CAST IRON.

Green-sand is moulding-sand in a moist condition, and suitably mixed to form moulds in which the metal can be poured at once, without subsequent drying. See FACING-SAND; DRY-SAND MOULDING; GREEN-SAND MOULDING; DAMPNESS.

Green-sand Core.—The inner mould, whose outside surface has been fashioned to correspond with the desired form of the inside of a casting, and which has been constructed exclusively from materials favorable to a successful issue without the intermediate process of drying consequent upon cores that are made from dry-sand material. The chief requirements in this mode of core-making are, first, a suitable core-bar, or *arbor* (see ARBOR), to carry the sand; second, a tough, strong sand for the lower hanging surface, the upper surface and the interior of the core being formed with sand as open as may be consistent with safety; and thirdly, an uninterrupted passage for the vents if they are open ones; but in large cores cinders are always preferable. See FACING-SAND; GREEN-SAND MOULDING.

Green-sand Moulding is the art of constructing moulds capable of resisting the destructive influence of molten metal without the subsequent drying incident to loam and dry-sand moulding. More skill is required to mould similar castings in green-sand than by either of the other methods, because the moulds cannot possibly be made as rigid and unyielding; therefore there must be superior ingenuity displayed to overcome these disadvantages. Every process connected with green-sand work must be worked with greatest care, provision for sustaining and anchoring cores and portions of mould must be made independent of the mould proper, and in all cases the efforts of the moulder are directed to a maintenance of all the parts of his mould in their exact position without actual contact, otherwise the incoherent material out of which he must necessarily form the mould will be shattered and the mould destroyed. This is by no means the case in loam and dry-sand moulding: the dried loam or sand is compact and hard, and in most cases capable of sustaining its several parts without fear of damage, in addition to which the dried moulds offer a surface always freed from moisture and gas-creating substances, the eradication of which in green-sand moulds must necessarily take place during the process of filling the mould with metal. See DRY-SAND MOULDING; LOAM-MOULDING.

Greiner Patent Cupola.—This remarkable cupola is thus described by the patentee:

"The novelty of the invention consists in a judicious admission of blast into the upper zones of a cupola, whereby the combustible gases are consumed within the cupola and the heat utilized to preheat the descending charges, thereby effecting a saving in the fuel necessary to melt the iron when it reaches the melting zone. In order to fully explain the principle of its workings, we will suppose a cupola of the ordinary design, with a single row of tuyères or air inlets. The incoming air burns the coke in front of the tuyères to carbonic-acid gas, a combination indicating perfect combustion. As this gas ascends through the incandescent coke above, most of it is converted into carbonic oxide by the absorption of an equivalent of carbon. The result of the combustion is, therefore, a gas mostly composed of carbonic oxide (CO), indicating an imperfect utilization of the fuel, as one pound of carbon burned to carbonic acid (CO_2) will develop 14,500 heat-units; whereas the same amount of carbon burned to carbonic oxide (CO) will only develop 4480 heat-units, or less than one third of the heat developed by perfect combustion.

"To avoid this loss of heat additional tuyères have been placed at a short distance above the lower tuyères to introduce air to consume the carbonic oxide (CO), but such arrangement does not have the desired effect, because the material at that place in the cupola has a very high temperature, consequently the entering air also ignites the coke, so that the action at the lower tuyères is simply repeated, and carbonic oxide (CO) again formed at a short distance above."

This led Mr. Greiner to the following conclusions:

"In every cupola there must be a point above which the descending materials have not yet reached the temperature necessary for the ignition of the solid fuel, while the ascending combustible gas is still warm enough to ignite when brought into contact with air. It is clear that air, if properly admitted above that point, will cause the combustion of the carbonic oxide (CO) without igniting the coke.

"But if all the air necessary for the combustion of the carbonic oxide (CO) be admitted at one place or in one horizontal row of tuyères, the heat developed will very soon raise the temperature so as to set fire to the coke, producing loss of carbon as before. Hence the upper blast must not be introduced on a horizontal plane, but through a number of small tuyères, arranged (either in the form of a spiral or otherwise) so as to embrace the higher zones of the cupola, and must be regulated, both as to pressure and arrangement and dimensions of pipes, according to the capacity of each particular cupola.

"The combustible gases are thus burned without heating the coke to incandescence, and the heat thus developed utilized to preheat the iron and the coke, so that they reach the melting zone at a higher temperature and require less heat to effect the melting." See CUPOLA; COMBUSTION.

Grids is the name sometimes given to core-irons made similar to a grate of cast iron and used for sustaining bodies of sand which extend beyond the edge of a lifting-plate, etc., in green-sand work; also with and without prickers for dry-sand cores. In the former instance they may be made to serve a good purpose. By bolting or clamping the back edge to the lifting-plate the extending mould is as firmly held as if it rested on the plate itself. They also constitute a method of tying green-sand drawbacks, etc., far superior to tie-rods. See TIE-RODS; CORE-IRON; DRAWBACK.

Grooved Drums.—See SPIRAL DRUMS.

Grouting.—The process of pouring a thin mixture of *kaolin* or fire-clay betwixt the cupola shell and the fire-bricks, as well as at the joints of the bricks, during the operation of lining. By building the bricks in as close contact with the shell as possible and filling the remaining spaces with the grout, the brick is permanently fixed, and all possibility of air escaping through the joints of the shell obviated. See CUPOLA; REPAIRING THE CUPOLA.

Gudgeon.—The cast or wrought iron journal-piece inserted in the ends of a core-barrel, forming a horizontal shaft or axle, with collars for turning in V's or semicircles, provided on the upper edge of the trestles which constitutes a part of the core-lathe. See CORE-LATHE; CORE-BARREL.

Guides for Green-sand.—See STAKES; FLASK; PIN AND COTTER.

Guides for Loam-work.—These guides are of necessity somewhat temporary, and require to be well preserved during the time the mould remains separated, otherwise it is difficult to close each piece in its place correctly. If the joints are made by the spindle and sweep, let each outside edge be struck at an angle of 45° with the joining surface, extending a plain face $\frac{3}{4}$ inch in each direction. By this means both edges can be seen and felt, and any discrepancy overcome more easily than when one slides into the other by a shallow taper seating. If iron ring or plates meets loam, then make the loam to correspond, and smooth clayey sand over both, dividing at the joint, and marking a few lines thereon with a thin trowel. Should both joining edges be loam, both notches and lines may be made. See LOAM-MOULDING.

Gum-arabic.—See ARABIC-GUM.

Gum-elastic.—See INDIA-RUBBER.

Gum Resins.—See RESINS.

Gun-founding.—See CANNON; ORDNANCE.

Gun-metal.—A soft gun-metal that will bear drifting is made from: copper 16, tin 1. Harder, for heavy guns: copper 9, tin 1. A small proportion of zinc aids the alloy to mix well, and increases the malleability without materially affecting its hardness. Sterling's gun-metal is copper 50, zinc 25, iron 1 to 8. Rosthorn's is copper 56.33, tin 0.49, zinc 41.29, iron 1.84. See ALLOY; BRASS; BRONZE; TIN; COPPER.

Gutta-percha is very similar in many respects to caoutchouc, being the dried juice of the *Isonandra gutta* tree. When mixed with about one fourth of linseed-oil it makes a good substance for obtaining moulds from undercut patterns. After obtaining the mixture and kneading it into cakes of suitable thickness, soften the surface before the fire and press firmly on the pattern, and, before it becomes cold, remove the mould and set it in cold water at once, otherwise it will shrink out of shape. The gutta-percha may be softened by heat until it is possible to press it into the most intricate recesses, but let the final touches leave the mould about equal in thickness all over, taking it off whilst warm, and plunging into water. See ELASTIC MOULDS; INDIA-RUBBER; PLASTER CASTS.

Gypsum is the sulphate of lime. This salt is found in many parts of the world, forming very extensive rocky beds. When pure and transparent it is known as *selenite,* and in its other varieties as gypsum, alabaster, and plaster of Paris. Powdered gypsum parts with its water of crystallization when subjected to a temperature of 300°. If it be then made into a liquid paste with water, it again combines with it, and at once commences to harden and resume its stony condition. It is entirely owing to this wonderful property that it can be used for obtaining impressions of objects by taking casts whilst in a liquid state. It is mixed with glue and colored for architectural purposes, the objects cast being then called stucco-work. See PLASTER CASTS; PLASTER OF PARIS; STUCCO-WORK.

H.

Hammer.—A tool consisting of an iron head fixed crosswise upon a handle. The hammers in common use are of different kinds: including the heaviest sledge, wielded by both hands, with which a very heavy blow may be given; the hand-hammer, which may be used with one hand; and intermediate sizes and shapes for a variety of uses. The largest hammers are those used in the iron manufactories for forging purposes, being machines moved by steam or some other power, the chief of which will be described under their respective heads. See STEAM-HAMMER; TILT-HAMMER.

Hammer-pick.—A furnace-man's steel tool, having a hammer face and sharpened point at the respective ends of the head. Used for cutting out and trimming the inside of the cupola. See PICK-HAMMER; REPAIRING THE CUPOLA.

Hand-barrow.—A wooden platform provided with lifting-handles at both ends. Such wheelless barrows are extremely useful for carrying light loads, as cores, castings, etc., by two men.

Hand-ladle.—See LADLES.

Hand-screw Clamp.—A pair of jaws regulated by two hand-screws, used principally by wood-workers, but a very handy contrivance for binding work in the foundry, such as core-boxes, strips of pattern, etc.

Hand-truck.—A small vehicle to be propelled by one man. It may be a platform with three or four wheels, with swivel lock on the front for turning easily; or the common warehouse truck, consisting of two long handles held together with cross-ties, terminating with axle and wheels and a purchase-plate.

Handwriting Impressions on Cast Iron.—This is accomplished by the use of a carbon ink, which leaves a substantial and hard body—one that will not be destroyed with molten cast iron.

A Boston gentleman discovered the method, which consists of writing *backwards* upon ordinary paper with prepared ink, and from *right to left,* instead of the usual way. The paper is fastened to the mould surface and the metal poured over. The paper burns away of course, but the carbon ink resists the action of the molten iron and leaves an indented impression of the writing upon it. See Embroidery Impressions in Cast Iron.

Hard Alloy.—It is claimed that if an alloy is made from 4 copper, 7 zinc, and 1 tin, it will resist all attempts at turning; but if petroleum is used freely the alloy will yield at once to the tools. See Brass; Speculum Metal.

Hard Brass.—Copper 100, tin 10, zinc 5. See Brass; Speculum Metal.

Hardening Metals.—The processes for hardening or tempering the several metals are various. Steel is wonderfully affected by heating and then plunging into water, being so susceptible to this process that almost any degree of hardness may be obtained, and it may again be made soft and malleable, as before, by reheating and allowing it to slowly cool.

To harden cast iron, use a liquid made as follows: Soft water 10 gallons, salt 1 peck, oil of vitriol ½ pint, saltpetre

$\frac{1}{2}$ pound, prussiate of potash $\frac{1}{4}$ pound, cyanide of potash $\frac{1}{2}$ pound. Heat the cast iron cherry-red, and dip as usual, repeating the process if wanted harder.

Wrought iron is surface-hardened by heating to a bright red, sprinkling with prussiate of potash, and plunging into cold water when it has cooled to a very dull red. See METALS; TEMPERING.

Hardness of Minerals.—The hardness of minerals, beginning with the hardest, is as follows: Diamond 1, corundum 2, sapphire 3, topaz 4, quartz 5, feldspar 6, scapolite 7, apatite 8, fluor-spar 9, calcareous spar 10, gypsum 11, talc 12. See PRECIOUS STONES.

Hardness of Precious Stones.—See PRECIOUS STONES.

Hard Pig-iron is distinguished by showing at the fracture a dull, grayish-white color, flaky in appearance, with more or less mottle. An extreme degree of hardness exists when the fracture shows a highly crystalline nature, with long, needle-like crystals radiating, and no appearance of graphite. See CAST IRON; GRADING PIG-IRON; SOFT PIG-IRON.

Hard Plaster is made by saturating pieces of freshly calcined plaster with water that holds in solution 12 per cent of alum. After thorough saturation the pieces are lifted from the liquid, dried, and calcined at a red heat; after which they are pulverized and sifted, and the plaster is fit for mixing. This plaster requires only about one half of the water used for the ordinary material, but is much longer in setting. When set, this hard plaster is about 50 per cent stronger than the common, and produces a fine, polished surface. See PLASTER.

Hardware.—A common term for such manufactures as are produced from the useful metals, iron, steel, copper, zinc, tin, brass, and some of the commoner kinds of plated goods. See METALS; BRASS; BRITANNIA METAL.

Hay Rope.—Hay twisted into rope to any desired thickness, and used for wrapping core-barrels before the clay and loam is applied, its purpose being to cover the vent-holes in the barrel, and at the same time serve as a medium for carrying the loam. When the molten metal covers the core, the gases generated in the sand enter the hay rope and pass into the barrel through the vent-holes provided. *Straw,* and *meadow* as well as *prairie* hay, are also employed for making these ropes. See CORE-BARREL; ORDNANCE; HAY-ROPE TWISTER.

Hay-rope Twister.—A machine for spinning hay or straw ropes. Formerly rope-spinning was a tedious operation, consisting of a simple hooked crank which an assistant turned in his hands, gradually walking backward as the hay was paid out by the skilful hands of the operator, who sat behind a loose pile of damp hay or straw, and fed it in just such quantity as would produce the thickness of rope required. The machine hay-rope twisters now becoming general for this purpose are of various designs. The following is a full description of a power twister:

It is constructed of the most approved design, of the best material, and the workmanship is first-class. The bearings of the revolving frame turn upon stout iron standards, which rest on heavy wooden skids, two inches by eight inches. The winding pulley is propelled backward and forward by cog-gearing on a right-and-left screw, which reverses by a spring arrangement at each end of same.

An operator feeds hay into the hollow spindle, which directs the rope on its way to the reel. As the rope is twisted by the revolving frame, it is fed on the spool by the operator pressing his foot gently on the treadle, relieving it as soon as the rope is wound, and spinning and feeding together.

The rope can be made tighter or looser according to the tension placed on it by the operator, care being taken when the hay or straw is weak in quality.

Great skill is acquired by practice, and beginners must not be discouraged by breaking the rope or other mishaps.

The machine should make about two hundred revolutions per minute or faster for small rope, which varies from say one-half inch up to one and one-half inches, depending upon the body of material fed by operator. Each reel will contain about one thousand feet of rope on an average, and from five to ten reels can be spun in a day, according to size of rope, which is a large produce for a smart boy.

This machine must be belted to run from right to left at the feeding end, so as to twist the rope right-handed. In securing the twister to the floor, care must be taken not to bolt it in such a way as to cause the frame to bind in its bearings.

The reels or spools when full should be removed and sent to the foundry, where they are dropped in a frame and unwound directly on the core-barrels. A sufficient length of rope is allowed to remain on the machine to begin another reel with, say, six or eight feet—enough to fasten to the body of the reel.

Dimensions.—Extreme length, 6 ft.; extreme height, 2 ft. 10 in.; extreme width, 2 ft. 6 in.; weight, 750 lbs.; shipping weight, 850 lbs.

Adaptation.—Motion of reel, rignt to left; capacity of reel, about 1000 feet of rope; product, 5 to 10 reels per day, according to size of rope and skill of operator; sizes of rope, $\frac{1}{2}$ in. to $1\frac{1}{2}$ in.

Head.—An extension added tc the top end of a casting when the mould is poured in a vertical position and it is desired to obtain a surface that is free from scum and dirt. The sullage is pushed beyond the limits of the casting, lodging in the "head," leaving the former clean.

Another form of riser is one into which the metal is forced by head pressure after the mould is full, and may, if placed on the top, answer as a dirt receiver, or serve as a means for feeding. See RISER.

Heap-sand.—The common sand on the foundry floor. When a moulder is using a certain quantity of sand every day for filling a set number of flasks with, he usually collects it in a heap close by, and designates it as heap-sand; in contradistinction to the facing-sand or new-sand employed in the immediate vicinity of his pattern. See FLOOR-SAND; OLD-SAND; FACING-SAND.

Hearth is that part of a smelting-furnace where the ore accumulates and is finally separated from the impurities which may be present in the ores. It is situated at the bottom of the furnace, a little above the mouth of the tuyères. The term is also applied to the bottoms of finery, open-hearth, and reverberatory furnaces, where the metal is exposed to the action of fire. See BLAST-FURNACE.

Heart-trowel.—A moulder's tool with a heart-shaped blade. When, instead of a handle, another tool is forged at the opposite end, it is called a *double-end,* and may be used at either end as occasion requires. See MOULDING-TOOLS.

Heat.—We experience the sensation of heat when we approach a warm body. The opposite of heat is cold, which merely implies a greater or less deficiency of heat. The two kinds of heat, which are called free, or sensible, and latent, are represented by fire and ice; the free, as in fire, can be felt, while that in ice is latent and cannot be felt. There is heat in all substances, but in those which are called cold it exists in an inferior degree. Some think that heat is not a material substance, but results from the vibrations of the particles of bodies; others believe it to be an exceedingly subtle substance, whose particles repel each other and thus give it a tendency to diffuse itself while they have a strong affinity for other matter. It would appear that heat is closely connected with light, as the one is generally accompanied by the other. That heat has no weight is proved by weighing a piece of ice, and then melting it, the water produced will weigh the same as the ice. The chief sources of heat are the sun, chemical and mechanical action, and electricity. Many speculations have been indulged in as to what composes the sun, that it should continue to give undiminished heat without exhausting the material by which it is supported. That chemical action is a source of heat, may be demonstrated by combining two or more substances to produce a new substance totally different in its nature from either; an increase of temperature alway accompanies such action, as may be proved by mixing sulphuric acid and water in equal quantities; it forms a new substance and gives off heat. Combustion is a chemical union of the oxygen of the atmosphere with the combustible body, or some of its elements. Animal heat is produced by a similar process: when we breathe air is drawn into the lungs, where it comes in contact with the particles of carbon contained in the blood; there is then a chemical union of the carbon with the oxygen of the air inhaled, and, as in the case of combustion, latent heat is evolved. Friction, percussion, and compression are illustrations, showing that mechanical action is a source of heat; and electricity is conclusively shown to be another source of heat, as the heat produced by its action will melt almost any known substance. See COMBUSTION; TEMPERATURE.

Height of Cupola.—What is commonly understood to be the height of a cupola is the distance from the bottom up to the lower edge of the charging-hole. When it is desired to obtain the best results when melting with hard coal or coke, the height for all cupolas up to fifty inches diameter should be at least five diameters; but when the diameter exceeds fifty inches, the height may be four diameters from the bottom to the lower edge of the charging-hole. See CUPOLA; CHARGING THE COMMON CUPOLA.

Helper is one who assists a mechanic or artist in the regular routine of his work, the more laborious and simple duties being his especial work, for which reason he is usually recognized as an unskilled laborer.

Hematite.—A valuable iron ore, consisting chiefly of peroxide of iron. It occurs in large quantities, its two chief varieties being *red* and *brown* hematite. An earthy kind, called *iron-froth,* consists almost entirely of iron. Brown hematite contains about 14 per cent of water. See RED HEMATITE.

Hemp Rope.—A thin hemp band is sometimes wrapped on core-barrels in place of hay or straw rope when it is desired to obtain a greater thickness of loam than would be possible if either of those materials were employed. See CORE-BARREL; HAY ROPE; ORDNANCE; ROPE.

Herbertz Steam-jet Cupola.—See STEAM-JET CUPOLA.

Hessian Crucible.—A triangular-shaped crucible, made from the best fire-clay and coarse sand. They are a cheap kind, and come in nests of sizes from 2 to 8 inches high. They are usually for experimental purposes, and seldom last but once. See CRUCIBLE.

Hexagon.—A plane figure bounded by six straight lines. When these are equal the hexagon is *regular*.

Hide-faced Hammers.—Hammers provided with faces of hide, suitable for a variety of uses, but especially valuable where light, thin castings are made from iron or brass patterns.

Hinged Flasks are flasks operated by hinges fixed on their sides or ends instead of slides or pins, making it only necessary to elevate one side or end in order to separate the parts. Suitable hinges of a self-adjustable kind, if properly secured in their respective positions, are a positive fit, and never get out of order.

Flasks, paired with hinges, require less space to operate them in, and are valuable in small foundries where it would be impossible to lift large flasks entirely off the joint. Resting in hinges, they may be separated very effectively with half the force required by the common methods. See FLASKS.

Hoisting-block.—See HOISTING-MACHINE.

Hoisting-machine is a convenient hoisting-block, very handy for use in places remote from the crane. The Weston differential pulley-blocks lift from $\frac{1}{8}$ to 10 tons, and with them one man may lift from 1000 to 5000 pounds, according to the kind of block employed. The load is held at any point and cannot run down, thus preventing all danger from accident by that source. See CRANE.

Hole.—A foundry term for a pit or trench dug in the sand floor, in which to mould a casting by the bedding-in process. Such a hole takes the place of cheeks and nowel parts of the flask. See BEDDING IN ; PIT.

Hollow Metal Castings.—Hollow or shell castings, in lead, tin, zinc, and their alloys, are obtained by using a brass mould, which is filled with metal, and, after due time has been allowed for a skin to congeal on the surface, inverted, to allow the molten portion to escape. What remains, forms a crust of metal answering to the form of the mould. See STATUARY-FOUNDING.

Hollow Shot are made similar to other hollow castings, except that the flasks containing the moulds are reversed a few times immediately the gates have set. This forces the fluid iron equally against the sides both in top and bottom parts, prevents flattening of the top side, and thus preserves a true spherical form in the casting. The same with solid shot: the moulds are reversed as soon as possible, which allows the fluid metal to first congeal on the sides and the shrinkage to be made good from the more fluid mass inside the ball, which naturally leaves the centre in a spongy condition, yet is preferable to a flattened upper surface. See SHOT ; PROJECTILES ; FEEDING.

Hollow-ware Moulding is not necessarily different from the moulding of other fine objects so far as the processes are concerned. This class of moulding is especially confined to boilers, pots, pans, kettles, including all those cast vessels for domestic use. Owing to the necessity of having most of these patterns and flasks in sections, considerable ingenuity is exercised in their arrangement, and the patterns, usually of iron or brass, are elegantly fitted together and finished. The iron part-flasks are, in some instances, marvels of ingenuity ; the system of pins, latches, clamps, and runners being well worthy of copying by founders engaged in the production of castings that are similar in design and only differ in name.

Homogeneous.—Of the same kind or nature; having similar parts; or, of elements of the like nature; as, *homogeneous* particles, elements, or principles; homogeneous bodies.

Honeycombing is the peculiar phenomena present in the upper portion of cast-steel ingots and steel castings, as well as those of brass and cast iron. In some instances this is supposed to be due to the liberation of imprisoned gases which, for the lack of pressure, remain within the mass of metal and form the honeycombing structure seen. Many schemes have been tried to prevent this, such as regulating the speed of pouring, temperature of metal for pouring with, covering the top with sand, molten slag, etc.; also by the introduction of some alloy, as aluminum; but none of these seem to be as effective for this purpose as the method pursued by Sir Joseph Whitworth, which consists of submitting the fluid metal to an enormous hydraulic pressure, which is maintained until the ingot has solidified. Some of the aluminum alloys have been credited with the ability to render steel castings perfectly sound, besides making the resultant steel tougher. Some claim that by using this alloy manganese can be discarded and time and fuel saved. See PRESSING FLUID STEEL; INGOTS; BLISTERS; BLOW-HOLES; ALUMINUM; SILICON.

Hood is all that portion of the cupola shell which extends above the charging-hole. It is best to contract the hood in size somewhat, and carry it up sufficiently high to induce a good draught, which not only serves a good purpose in lighting up the first charges of fuel, but is a considerable auxiliary to the blower. See CUPOLA; LIGHTING THE CUPOLA.

Hook.—A forged piece of iron bent into a suitable curve for some purpose of catching, holding, or sustaining; such as the crane-hook, sling-hook, chain-hook, changing-hook, etc. The importance of making all such hooks well and of good material will suggest itself to those who know the risks which are taken daily in the foundry and elsewhere by men who must necessarily pass under and work in close proximity to loads suspended thereon. See CHAIN; CRANES.

Hook-bolt.—A bolt, one end of which is threaded for a nut, the other turned as a hook, and used for various purposes in the foundry, such as binding portions of loam and dry-sand moulds together, anchoring cores in lower moulds, and suspending them in covering-plates and copes. See ANCHOR.

Hoop-binder.—A substitute for the binding-plate in a brick cope, consisting of a length of hoop-iron with which to tie the course of brick. These may be used for ordinary purposes instead of binding-plates by turning a hook on each end of the hoop-iron, the hooks to meet within four inches round the brickwork, to be there tied with a few laps of softened wire, and brought up close by inserting a small pointed bar between the strands of wire and twisting them one on another. Another method is to rivet lugs on the ends and draw them together by means of a bolt. See BINDING-PLATE; COPE.

Horizontal Casting.—When a casting is poured endwise in the pit, it is cast vertically; if the same casting is poured flat on the floor, it is then cast horizontally.

Horn-gate.—See FOUNTAIN-RUNNER.

Horn-quicksilver.—The native subchloride of mercury. It occurs in the mines of Idria in Carniola, and Almaden in Spain. See MERCURY.

Horse.—A common term for the trestle or stands used for blocking moulds in the foundry. See STANDS; TRESTLE.

Horse-manure.—A means for conveying gases from the loam used for building and coating the moulds and cores. The quality of sands and mixtures employed for this purpose is necessarily hard and unyielding, having little porosity, and must therefore be rendered porous by artificial means. Besides imparting porosity, the manure possesses a quality of stickiness which renders the sand or loam more cohesive, and it is for this reason that it is to be preferred to other substances, as coke-dust, sawdust, etc., which are frequently used for this purpose. See LOAM; FACING-SAND; VENTING.

Hose.—A flexible pipe, made of rubber, leather, and various other flexible materials, for conveying fluids, especially water. When of good quality and properly cared for by providing reels to wind them on when not in use, and paying strict attention to the joints, they are a great help in the foundry, saving much time in carrying water to and fro.

Hot and Cold Blast.—When the stream of air forced through a furnace is drawn direct from the atmosphere, it is called cold-blast; when it is heated to 500° before it enters the furnace, it is called hot-blast. The combustible gases which come from the stack are invariably used to heat the air in a kind of oven built near the top of the stack, and surmounted by a chimney which draws off some portion. In this oven a series of pipes are built, around which the fire plays whilst the air is being forced through them before it enters the furnace. A considerable saving of heat is effected by this method, the reduction of the most refractory ores being accomplished in less time and with a less expenditure for fuel than the cold blast. As the melting metal necessarily comes in contact with less fuel, and as a less quantity of air enters the furnace, the chemical reactions are somewhat modified, but there does not seem to be any appreciable difference in the quality of the product. See BLAST-FURNACE; BLAST.

House-bells.—A special mixture for this class of bells is copper 77, tin 21, antimony 2. See BELL-METAL; BRASS.

Hundredweight signifies a weight of 112 lbs. avoirdupois. Twenty of these, or 2240 lbs., make one ton. This weight is expressed by the abbreviation *cwt.* See TON.

Hydraulic Casting-press.—Used for the production of homogeneous steel. See HONEYCOMBING; COMPRESSED CASTINGS.

Hydraulic Crane.—Invented by Sir William Armstrong in 1846, who erected the first in Newcastle-on-Tyne. These cranes have come into very extensive use where water under sufficient pressure is available. But it would seem that the latter condition is now made unnecessary by the invention of the steam hydraulic crane. See CRANES.

Hydraulics.—The science of hydraulics treats of liquids in motion, whether issuing from orifices, or running in pipes or the beds of streams. If an opening be made in the side or bottom of a vessel containing a liquid, as molten metal, etc., the latter will at once be forced through it, as the particles at that point are acted upon by the pressure of those above. The rapidity of a stream flowing out of an orifice depends upon the depth of the latter below the surface of the liquid. A liquid issues from a given orifice with equal velocity as long as the liquid is kept at the same height in the vessel, but if the pressure is diminished by a lack of supply above, the liquid gets lower, with a proportionate diminution in the velocity of the stream. The weight of water or molten metal is as the quantity, but the pressure exerted is as the vertical height. Fluids exert an equal pressure in every direction; hence any vessel containing a fluid sustains a pressure equal to as many times the weight of the column of greatest height of that fluid as the area of the vessel is to the sectional area of the column. See PRESSURE OF MOLTEN METAL; WEIGHTING COPES; HYDROSTATIC BELLOWS.

Hydrocarbon Furnace.—A furnace having special burners suitable for using liquid fuel. The burners consist of an apparatus which allows a forced jet of air and steam to carry with them a certain quantity of petroleum which is distributed into the furnace in the form of spray, and there burns with an intensity proportionate to the amount of fuel supplied.

Hydrogen is the lightest substance known, and possesses nearly all the properties of a non-metal in such perfection, that chemists have long hesitated to class it with the metals, though its chemical relations clearly show it to belong to that class of elements. It combines with nearly every non-metal, but with only two or three of the metals. Hydrogen is colorless, tasteless, and inodorous when quite pure. It is inflammable, and burns with a pale yellowish flame, evolving much heat but very little light. The result of the combustion is water. It has never been liquefied, and is even less soluble in water than oxygen. It is incapable of sustaining life, but contains no poisonous properties. Hydrogen is never found free in nature, but exists abundantly in combination, forming one ninth by weight of water, and a considerable proportion of all organized substances. It is the lightest of all known substances, being 16 times lighter than oxygen and 14½ times lighter than air; its density is placed at 0.0692 referred to that of air as unity, 100 cubic inches weighing about 2.14 grains.

Hydrostatic Balance.—A specific-gravity balance. See SPECIFIC GRAVITY; SPECIFIC-GRAVITY BALANCE.

Hydrostatic Bellows is an apparatus which serves to explain that peculiar property of liquids, including molten iron, in virtue of which they transmit pressure in every direction.

The hydrostatic bellows consists of two boards held together by a band of rubber, which allows a bellows motion to take place when force is applied inside. These form an absolutely tight chamber, to which a small tube is attached by inserting it in the top side. The water is poured down the tube, and as the chamber fills the upper board rises with the pressure. If the surface of the board is fifty times as large as the end of the tube, one pound of water will balance fifty pounds of weight on the board. Because the surface of the cover is fifty times larger than the orifice of the tube, there are fifty times as many particles of water in contact with the board as there are at the end of the tube, and as each particle throughout the whole surface is made to exert the same pressure, one pound of water in the tube should balance fifty pounds on the board.

If the moulder who may be unacquainted with these subjects will carefully examine this apparent paradox, and in his mind substitute for the tube a down-runner leading to a mould below, in which molten metal instead of water is to be poured, he will at once discover that the only difference betwixt the two is the difference in weight of the water and the metal. This will enable him to realize why so small a runner will lift such a great weight. See WEIGHTING COPES; PRESSURE OF MOLTEN METAL.

I.

Igneous Rocks include granitic, trappean, and volcanic series, all of which rocks have been produced by fusion, on the surface, or in the interior, of the earth's crust. See ROCK.

Imitation Gold.—An alloy of baser metals which produces a yellow compound metal resembling gold. See GOLD ALLOY; TOMBAC.

Imitation Silver.—An alloy of metals for manufacturing articles of jewelry, etc., in artificial silver. An alloy having the same specific gravity as silver consists of: copper 11.71, platinum 2.4, silver 3.53.

The following is a beautiful imitation silver that retains its brilliancy: Tin $4\frac{1}{2}$, bismuth $\frac{1}{2}$, antimony $\frac{1}{2}$, lead $\frac{1}{2}$.

Many other alloys of this description are given under their respective heads. See SILVER ALLOYS; MOCK SILVER; GERMAN-SILVER; TOMBAC.

Impact.—An instantaneous blow communicated from a moving body to another body either moving or at rest.

Impressions on Cast Iron.—See EMBROIDERY

Impressions on Cast Iron; Handwriting Impressions in Cast Iron.

Impurities in Cast Iron.—The chief impurities contained in cast iron are manganese, sulphur, phosphorus, and silicon. Manganese tends to the formation of combined carbon, reduces tensile strength, produces brittleness, and makes slag. Except in very strong castings, manganese should not exceed 0.5 per cent of the mixture. Sulphur contributes to retain the carbon in the combined state, and promotes the formation of combined carbon. Foundry irons should not contain more than 0.1 per cent of this element. Phosphorus causes hardness by lowering the separation of graphite, but increases fluidity. From 0.3 to 0.5 per cent of this element is all that should be allowed in foundry mixtures, unless cases where great fluidity, regardless of strength, is the chief desideratum. Silicon increases fluidity, reduces hardness and shrinkage, by changing combined into graphitic carbon. Any addition of silicon after the bulk of the carbon has become graphitic hardens the casting. Cast-iron mixtures may contain from 1.75 to 2.5 per cent of silicon. See Cast Iron; Silicon; Softeners.

Incoherent.—Wanting in coherence or cohesion; unconnected; loose, not joined to each other, as the particles in free sand.

Incombustible.—Cannot be decomposed, burned, or consumed by fire. See Refractory Materials.

India Cast Steel is a species of steel of extraordinary quality, and commonly called *Wootz steel.* It is imported into this country and Europe for the manufacture of fine edge instruments, etc. It is said that the celebrated Damascus blades were made of it. The process of making consists of melting small pieces of wrought iron, mixed with some twigs and dried mould, covered up well with green leaves, and luted. The crucibles are built in the form of a pyramid, inside the furnace, and exposed to a strong heat. The pieces of wootz, about as big as a walnut, are not disturbed until the crucible has cooled. The metal contains traces of silica and alumina, and about the maximum amount of carbon ordinarily found in steel. Wootz has been known throughout the East from remote antiquity. See STEEL.

India-rubber, or *Gum-elastic,* is the dried juice of tropical plants. It has a close resemblance to some of the gum resins, but differs from them in that the latter do not contain caoutchouc. This remarkable gum is supposed to have been discovered by a voyager on the second expedition of Columbus, who saw some natives of Hayti playing games with balls made from elastic gum. The india-rubber industry began in earnest about the beginning of the eighteenth century on a very small scale, but in 1870 there were nearly 200 manufactories in America and Europe, who consumed annually more than ten million pounds of caoutchouc. India-rubber is composed of hydrogen and carbon. Dilute acids or alkalies do not act upon the gum; but it is oxidized and destroyed by concentrated nitric acid, and charred with strong, hot sulphuric acid. It is dissolved, more or less perfectly, in melted naphthaline, benzol, bisulphide of carbon, petroleum, and the oils, both fixed and volatile. It fuses at 250° F. Mr. Goodyear invented the system of vulcanizing this gum by incorporating with it from 2 to 3 per cent of sulphur, which increases its elasticity and prevents it from adhering to the moulds when subjected to pressure. Carbonate of lead and numerous other substances are also added to india-rubber for the manufacture of some special goods. If immersed in fused sulphur at 250° F., india-rubber absorbs 15 per cent of the sulphur and is not materially changed. If, however, it be now subjected for an hour to a temperature of 300° F., combination takes place, and vulcanized caoutchouc is the result. A further increase of temperature changes it to ebonite, or black vulcanite, a substance in great demand for the manufacture of countless articles in every-day use. If the sulphur be first dissolved in oil of turpentine, and this used for dissolving the india-rubber, the mixture remaining (after the turpentine has evaporated) will be india-rubber and sulphur, which substance can be readily pressed into plaster or metal moulds of any desired form, and the articles then vulcanized by subjecting them for an hour to a temperature of 280° F. in a closed iron vessel into which steam at high pressure is admitted. See RESIN.

Indigo-copper.—A native sulphuret of copper, generally found uncrystallized, but sometimes occurring in hexagonal crystals. Its color is indigo-blue; contains copper 66.5, sulphur 33.5; specific gravity 4.6. It is found in the lava of Vesuvius, Bolivia, and Chili. See COPPER.

Infusible.—Cannot be melted, dissolved, or infused. Proof against fusion, as an infusible sand or crucible. See REFRACTORY MATERIALS.

Ingate.—See GATE.

Ingot.—A mass of metal which has been cast in a suitable mould for convenience in subsequent working by the various processes of rolling, hammering, casting, etc.; some consideration is also given to the best forms for shipping, etc. Copper is made into *bricks* and *pigs;* tin into *blocks;* zinc into *cakes.* These are all run into metal moulds which give them their respective shapes. The blocks of commercial gold and silver are called *bars.* Cast iron is run direct from the smelting-furnace into moulds formed in an adjacent sand-bed, the product being *pigs.*

Running or "teeming" steel ingots, produced by melting blister-steel in crucibles, or from steel prepared by melting puddled steel with spiegeleisen or black oxide of manganese, if the ingots are small, is usually done by hand, by simply emptying the contents of the crucible direct into the cast-iron ingot-mould. If one crucible is insufficient to fill the mould the pots are *doubled,* that is, two crucibles are emptied into one larger, so that the one operation suffices; but in larger-sized ingots it is often necessary to employ two streams in order to secure an uninterrupted flow of steel into the mould. Extra-large ingots, made from this class of steel, are often run from one ladle by simply melting all the steel in the several crucibles and emptying their contents therein. The ladle employed for this purpose is clay or brick lined, and provided with a nozzle at the bottom, in which a gannister plug or stopper is fitted. This stopper is connected with a vertical rod attached to the arm for raising and lowering the stopper; the rod itself being inside the ladle, is necessarily coated with about 1½ inches of the gannister composition also. By this means a continuous stream of molten steel is delivered, clear of the mould sides, and without fear of intermission until the space is filled.

This ladle, as just described, is the one used for running the steel ingots produced by the Bessemer process, only in this instance it is suspended on an arm which extends from the head of the hydraulic crane in the centre of the casting-pit. The ingot-moulds, being arranged in order around the outer diameter of this pit, are filled in succession by simply bringing the ladle directly over and allowing them to fill by withdrawing the plug at the bottom. Sometimes these ingots are cast in groups arranged round a central one that is placed higher than the rest, and connected with the latter by means of a system of fire-clay runners which radiate from the central ingot, at the bottom, to as many as may be grouped around it. The steel in this case enters the central ingot at the top, and gradually fills all the rest from the bottom.

Very large ingots, which are sometimes over 20 feet long and may weigh from 14 tons up, are preferably cast from the bottom, and suitable provision is made by forming a fountain-runner within a core made from a gannister and fire-clay mixture, which is set in the prepared bottom of the mould. One end of this runner extends past the ingot-casing, and is connected with a vertical cast-iron and gannister-lined runner-box, which, resting thereon, is made to project somewhat above the top of the ingot-casing. This casing usually consists of two wrought or cast iron half-circles, protected by a fire-brick lining coated with some refractory composition. These halves, when duly prepared, are bolted together, with a loam packing between the joining flanges, and then brought into a vertical position for setting down, on a soft loam packing also, upon the lower portion of mould already in the pit. Ingots of even larger dimensions are often made with a central core. Owing to the intense heat to which these cores are subjected, the ordinary preparations are simply valueless, as they are sure to be melted. To overcome this difficulty, the cores are made in one or more lengths, as desired, by ramming composition sand of a very refractory nature around an ordinary cage core-iron, the cast rings of which are not permitted to approach the surface by at least two inches. By this means a core is obtained containing the smallest amount of iron possible in its construction; in fact it is, literally, a sand-core almost free from substances which would be likely to melt. All such ingots are invariably run at the bottom. See PRESSING FLUID STEEL; REEKING INGOT-MOULDS; RUNNING STEEL INGOTS.

Ingot-mould.—The metal, sand, or fire-brick moulds in which metals are cast to form ingots suitable for manufacturing and commercial purposes. The brass-founder's ingot-moulds are of cast iron, about two feet long and wide enough to form three tapered ingots 7 by 2 inches, or of a size suitable for stowing in the crucible for remelting. The webs which divide such an ingot-mould into three are notched at the top, midway; this allows of each mould being filled without removing the crucible from that in which the metal is poured. See INGOT; BRASS SCRAPS; BRASS.

Insect Casts in Metal.—To produce a perfect cast of an insect, animal, or vegetable in metal, it is only necessary to obtain a box large enough to hold whatever it is desired to produce, with a little space to spare. After suspending the object with strings in a suitable position, attach the vents and pouring-gate, and fill the space with a composition made from plaster of Paris 2 parts, and finely ground brick-dust or talc 1 part. The operation must be carefully performed. The whole is then gently dried, and afterwards made red-hot so as to reduce to fine ashes whatever was placed therein. The vents, being placed at all the extremities, are of assistance in blowing the ashes out at the running-gate, and these in conjunction with the holes made by the strings will permit all gas to escape when the metal is poured in at the gate.

A good alloy for small objects cast after this manner is tin 6, lead 3, bismuth 2.

Intaglio.—A kind of engraving distinguished from *cameo* by having the engraved figures sunk into the substance instead of being raised in relief. Seals and other similar articles are engraved thus. See RILIEVO.

Iridium.—A white brittle metal, which may be fused by means of a powerful oxyhydrogen blast-furnace. In its isolated form it is unacted upon by any acid or by aqua regia, but as an alloy it is dissolved in the latter fluid. Its specific gravity is 21.15. An alloy of iridium and osmium is very hard, and is used for pointing gold pens. See METALS.

Iron.—Of all metals iron is the most important. The pure metal is found only in such rare instances as in the case of meteorites which have fallen from space. In South America and elsewhere isolated masses of soft malleable iron have been found loose upon the surface of the earth, and these too would seem to owe their origin to the same meteoric source. In these specimens of native metallic iron nickel is usually found. The presence of iron in an oxidized condition is universal: rocks and soils are colored by it, plants contain it, as also does the blood of the human body. Pure iron is very soft and tough, has a specific gravity of 7.8, is white, and has a perfect lustre. It may be observed that there always exists a very distinct fibrous texture in good bar-iron after it has been attacked with acid; the perfection of this fibre is what gives it strength. See MALLEABLE IRON; CAST IRON; STRENGTH OF MATERIALS.

Iron Alloys.—Very few of the metals alloy with cast iron in such a manner as to be of any practical value to the founder. True, there is a marked difference in the resultant mixture by the addition of alloys, but it does not affect them favorably as a rule. By the addition of a quarter of one per cent of copper, well stirred into the molten iron, a perceptible increase of density may be noticed, and the strength is increased somewhat. Again, if from 10 to 15 per cent of wrought scraps can be successfully mixed with the cast iron after the latter has been melted the same improvements are apparent. Much is claimed for the aluminum fluxes now offered, but any opinion as to their worth would, at this early stage of their application, be premature. See ALLOYS; ALUMINUM; GOLD.

Iron Carrier, Foundry.—The Hayes patent carrier for molten metal is described as follows: There is a continuous overhead track, which runs from the cupola to the extreme end of the floors and return. The floor may be of any length; there is no carrying of iron by hand. On this track ladles of any capacity from four hundred to one thousand pounds may be carried. From these large ladles the iron is poured into smaller ones, into hand-ladles, or larger ladles with double handles.

A very unique and simple device is used for pouring the iron into the hand-ladles, so that the moulder need not hold the weight of the hand-ladle while the iron is being poured from the large ladle into the small one.

The cupola is not stopped up from the time the iron commences to run until all is out. The very unique arrangement of having a catch-ladle which swings into the stream and catches the flowing iron while the exchange of large ladles is being made, saves all the annoyance around the cupola, and catches all the iron.

Moulders never need leave their floors. The iron is brought to them by common laboring men. The apparatus is simple, durable, and so perfectly safe that it frees the foundry from the mishaps that often occur by the old methods of distributing iron.

Iron Furnace.—A furnace in which some operation connected with the manufacture of cast iron, malleable iron, or steel is conducted ; as cupola, smelting, reverberatory furnaces, etc. The several furnaces employed for this purpose will be found described in their regular order.

Iron-lustre.—This lustre is obtained by dissolving zinc in muriatic acid, and mixing the solution with spirit of tar. To be applied on the surface of the iron.

Iron-statue Moulding.—Moulding statuary in iron. This branch of the art is necessarily more difficult than any other of the processes followed for the production of statuary in bronze, because the materials used for moulding with are less rigid, and demand more skill in their manipulation as a consequence. The core is built by the moulder, on which the sculptor carves his model in clay or wax, after which the moulder builds his cope around it in sections ; the latter, when sufficiently hardened, are lifted away, the thickness removed, and the whole mould finished, dried, closed together, and cast like any other ordinary piece of loam-work. See STATUE-FOUNDING.

Iron-wire Cloth.—See WIRE-CLOTH.

Isinglass.—A very pure form of gelatine prepared from the entrails and air-bladders of fish, notably the sturgeon. It is semi-transparent when pure, and this may perhaps account for applying the name to the sheets of mica employed for sight-holes of cupolas, stoves, etc.

Isinglass is an excellent material for making elastic moulds for obtaining plaster casts. See ELASTIC MOULDS.

Isosceles Triangle is a triangle which has two equal sides.

Ivory-imitation.—A good imitation of ivory statuettes may be obtained by casting into *warm* plaster-moulds a mixture composed of finely pulverized egg-shells, isinglass, and alcohol. See PLASTER CASTS.

J.

Jacket-core.—The core which forms the space betwixt inner and outer shells of a jacketed casting, as a jacketed cylinder, etc. Sometimes these shells are joined together by studs at intervals, in which case the core must invariably be made in one piece, and vented at the top through holes purposely made in the casting for this purpose, but which are subsequently plugged. If a convenient branch, etc., offers the opportunity for making adequate vent connections, the labor of plugging is saved.

When the shells are joined by parallel webs the jacket-core is divided into as many segments as there are webs, and each core is vented separately.

In the former case a cage or skeleton core-iron serves to construct the core; the latter needs only a centre web with protruding wings.

For constructing a whole jacket-core the dummy-block is a cheap and effective device ; a narrow core-box is all that is necessary for the web-jacket. See DUMMY-BLOCK ; SKELETON ; CORE-IRON ; VENTING.

Jacketed Cupola.—See WATER-JACKET CUPOLA.

Japanese Bronze-work.—The art of working in bronze is a very old one in Japan. The whole process of casting is done by the artist himself, who forms his moulds from models designed in a mixture of wax and resin which is melted out of the prepared mould previous to the final pouring of the metal. By this means, castings are obtained of every description, from statues of all sizes down to the most intricate and delicate tracery, which is elaborated with scrupulous care, requiring, in some instances, months to prepare the mould.

The Japanese add tin, zinc, lead, and iron to their bell mixtures. Their small bells contain copper 60, tin 24, zinc 9, iron 3. Large bells are composed of copper 60, tin 18, lead 12, zinc 6, iron 3. The mixture is called Kara-Kane. See BRONZES.

Jasper.—Like carnelian, agate, and chalcedony, this mineral is chiefly composed of silex, but it always contains more iron, and hence, instead of being translucent, like them, it is always opaque. Its colors are red, yellow, and brown; specific gravity 2.70. Its composition is silex 75, alumina 0.5, lime 0.02, iron 13. It is infusible. See PRECIOUS STONES.

Jet-cupola.—See STEAM-JET CUPOLA.

Jib-crane.—See CRANES.

Jobbing-moulder.—A moulder whose superior attainments enable him to mould more than one class of castings. Such qualifications are acquired only by perseverance and industrious practice in many foundries, which not only differ in the class of castings produced generally, but differ also in their modes of producing the same casting. Moulders that are engaged exclusively on stove-plate, hollow-ware, snap-work, etc., are naturally unable to do this; hence are distinguished as stove-moulder, hollow-moulder, snap-moulder, etc. See TECHNICAL EDUCATION FOR THE MOULDER.

Jobbing-pipe.—A technical term for all pipes that are irregular in form, including elbows, turns, branch, and numerous others, which must of necessity be moulded by such means as are most convenient for the occasion, without reference to cost, etc. Pipes of this character are usually made in the most approved fashion by skilled moulders who work by the day; while the regular trade straight lengths are made, as a rule, by unskilled labor, in vertical casings that are so elaborately mounted as to preclude any possibility of going astray. See CAST-IRON PIPES; JOBBING-MOULDER.

Joint.—A common name for the point of separation in moulds. When two halves of a core are placed together the joining surfaces form the *joint;* so in flasks cope and drag meet together at the *joint.* See PARTING.

Joint-board.—See MATCH-BOARD; PARTING.

Journal-box Metal.—See ANTI-FRICTION METALS; BABBITT METAL; BRASS.

K.

Kaolin.—A pure white clay resulting from the decomposition of feldspar in granitic rocks. The materials employed by the Chinese for the manufacture of porcelain are known to be *kaolin, petuntze,* or quartz reduced to a fine powder; and the ashes of fern, which contain potassic carbonate.

Kaolin is used extensively for the manufacture of clay crucibles for steel melting, being mixed with equal quantities of Stourbridge clay and some old pot and coke-dust. See CRUCIBLE; FELDSPAR.

Kara-Kane.—The name given by the Japanese to their celebrated bronze mixtures for bells. See JAPANESE BRONZE-WORK.

Keep's Testing-machine.—See TESTING-MACHINES.

Keim's Water-jacketed Cupola.—See WATER-JACKETED CUPOLA.

Kettle.—A vessel of iron or other metal used for the purpose of heating or boiling liquids, or melting metals. The common method of moulding a kettle with the spindle and sweep-board is to first strike a core, answering to the inside, upon a foundation-plate; then strike a sand thickness over it corresponding to the outside, the impression of which is taken in the cope built on a surrounding cope-ring that bears the whole outside structure. After separation, the thickness is removed and moulds finished, when the cope is returned to its place, and, after due preparation, the space is filled with molten metal.

The following table shows the weight of spherically shaped kettles when the depth is equal to half the diameter of core, and one inch thick:

Inside diameter in inches.	36	42	48	54	60	66	72	78	84	90	96	102	108	114	120
Weight in pounds.	590	791	1022	1281	1570	1889	2237	2614	3021	3457	3923	4418	4492	5496	6079

See SPINDLE; SWEEP-BOARD; FOUNDATION-PLATE; COPE-RING; THICKNESS; CASING.

Kiln.—An oven or stove which may be heated for the purpose of drying, hardening, or burning anything. Kilns are used for roasting or calcining iron ores, with the view of expelling water, sulphur, and volatile or other matters which under the influence of heat, or the combined action of heat and atmospheric air, are capable of volatilization, and to free the ore from these constituents and leave it porous; in which condition it is more readily acted upon by the flame and gases of the blast-furnace. See CALCINATION; WEATHERING ORES.

Kish.—When rich gray iron in a state of fusion is permitted to cool very slowly, a graphitic substance, resembling plumbago, gradually separates itself from the molten mass. This substance is called *kish,* and is composed of carbon, sulphur, and manganese in varying proportions. This phenomenon evidences the inability of the metal to hold as much carbon, etc., in solution at a low temperature as at a greater heat. The same metal, if run into moulds at a greater heat, and allowed to solidify rapidly, would retain the most of this carbon either in the graphitic or combined state, or both. See GRAPHITE IN PIG-IRON; CAST IRON.

Krupp's Crucibles for Steel.—See CRUCIBLES.

Kustitien's Tinning Metal.—Malleable iron 1 pound; heat to whiteness; add 5 ounces of antimony, and tin 24 pounds. See TINNING.

L.

Laboratory.—A place where operations and experiments in chemistry, pharmacy, pyrotechny, etc., are performed.

Lac.—See SHELL-LAC.

Lace Impressions on Cast Iron.—See EMBROIDERY IMPRESSIONS ON CAST IRON; HANDWRITING IMPRESSIONS ON CAST IRON.

Lacquering.—Lacquers are varnishes applied upon brass, tin, and other metals to prevent them from tarnishing, and should always be applied soon after the process of bronzing or dipping. Their basis is a solution of seed-lac in alcohol. About 3 ounces of powdered shell-lac are added to a pint of the spirit, and the mixture allowed to digest with a moderate heat. The liquor, after being cleared by settling, is strained and poured off, and is then ready to receive the required coloring substances, the chief of which are annotto, dragon's-blood, gamboge, saffron, and turmeric.

If the brass or other metal to be lacquered be old and dirty, make a strong lye of wood-ashes, which may be strengthened by soap-lees; put in the old brass-work, and the original lacquer and dirt will fall off. It must then be immersed in a mixture of nitric acid and water strong enough to eradicate the dirt; after which, wash in clean water, and it is ready for the lacquer. If the work is new, take off the dust and polish with chamois leather before applying the lacquer. The work to be lacquered must be subjected to a moderate heat; then, holding it in the pincers, apply the preparation with a soft brush, taking pains to cover the whole surface by a gentle pressure of the brush in one direction. The following are some mixtures for lacquers :

Gold Lacquer.—Seed-lac, 3 ounces ; turmeric, 1 ounce ; dragon's-blood, $\frac{1}{4}$ ounce ; alcohol, 1 pint. Digest for a week, frequently shaking ; decant and filter.

Dark Gold Lacquer.—Strongest alcohol, 4 ounces; Spanish annotto, 8 grains ; powdered turmeric, 2 drams; red-sanders, 12 grains. Infuse and add shell-lac, etc., and when dissolved add 30 drops spirits of turpentine.

Brass Lacquer.—Shell-lac, 8 ounces; sandarac, 2 ounces; annotto, 2 ounces; dragon's-blood, $\frac{1}{4}$ ounce; spirits of wine, 1 gallon.

Bronzed Dipped Work.—Alcohol, 12 gallons ; seed-lac, 9 pounds; turmeric, 1 pound to the gallon; Spanish saffron, 4 ounces. If for a light lacquer, the saffron may be omitted.

Tin-plate Lacquer.—Alcohol, 8 ounces; turmeric, 4 drams; hay-saffron, 2 scruples; dragon's-blood, 4 scruples; red-sanders, 1 scruple; shell-lac, 1 ounce; gum-sandarac, 2 drams; gum-mastic, 2 drams; Canada balsam, 2 drams; when dissolved add spirits of turpentine, 80 drops.

Iron Lacquer.—Amber, 12; turpentine, 12; resin, 2; asphaltum, 2; drying oil, 6.

Iron Lacquer.—Asphaltum, 3 pounds; shell-lac, ½ pound; turpentine, 1 gallon.

Red Lacquer.—Spirits of wine, 2 gallons; dragon's-blood, 1 pound; Spanish annotto, 3 pounds; gum-sandarac, 4½ pounds; turpentine, 2 pints. Made as pale brass lacquer.

Pale Brass Lacquer.—Spirits of wine, 2 gallons; Cape aloes, 3 ounces; fine pale shell-lac, 1 pound; gamboge (cut small), 1 ounce. Digest for a week, shake frequently, decant, and filter.

Pale Tin Lacquer.—Strongest alcohol, 4 ounces; powdered turmeric, 2 drams; hay-saffron, 1 scruple; dragon's-blood in powder, 2 scruples; red-sanders, ½ scruple. Infuse this mixture in the cold for 48 hours, pour off the clear and strain the rest; then add powdered shell-lac, ½ ounce; sandarac, 1 dram; mastic, 1 dram; Canada balsam, 1 dram. Dissolve this in the cold by frequent agitation, laying the bottle on its side to present a greater surface to the alcohol. When dissolved, add 40 drops of spirits of turpentine.

Lacquers of Various Tints.—To 32 ounces of spirits of turpentine add 4 ounces of the best gum-gamboge, to the same quantity of spirits of turpentine add 4 ounces of dragon's-blood, and to 8 ounces of the same spirits add 1 ounce of annotto. The three mixtures, made in separate vessels, should be kept warm, and as much as possible in the sun, for three weeks, at the end of which time they will be fit for use; and any desired tints may be obtained by making a composition from them with such proportions of each liquor as the nature of the colors desired will point out.

Ladles.—The business of making foundry ladles has, virtually, been monopolized by the numerous manufacturers of these and other foundry supplies, who are ready to supply every description of ladle at prices astoundingly lower than is possible for private firms to produce them—from a small hand-ladle holding 35 pounds, to the more ponderous ones that are controlled with the greatest ease by improved devices, making it possible to operate with the minimum of help even the largest ones.

The following table gives depth and diameter, inside the lining, of ladles to hold from 50 pounds to 16 tons:

Capacity.	Diameter.	Depth.
16 tons	54 inches.	56 inches.
14 "	52 "	53 "
12 "	49 "	50 "
10 "	46 "	48 "
8 "	43 "	44 "
6 "	39 "	40 "
4 "	34 "	35 "
3 "	31 "	32 "
2 "	27 "	28 "
1 "	22 "	22 "
½ "	17 "	17 "
¼ "	13½ "	13½ "
300 pounds	11½ "	11½ "
200 "	10 "	10½ "
100 "	8 "	8½ "
50 "	6½ "	6½ "
25 "	5 "	5½ "

See Lip.

Lake Ore-iron.—Hydrated peroxide of iron is deposited in large quantities by certain lakes in Sweden and Norway. It is similar in composition to the bog iron-ore found in other parts of Europe. See Bog Iron-ore.

Lamellar.—Consisting of thin or extended plates, layers, or scales; distributed or disposed in thin, filmy processes.

Lampblack consists of a very fine description of infinitely divided charcoal. It is commonly made by heating in an iron vessel vegetable matters rich in carbon, including tar and resins, the vapors of which are burnt in a current of air insufficient for complete combustion; consequently the hydrogen burns away and leaves the carbon behind in a finely divided condition on the walls of the chamber, which are hung with coarse cloths. Lampblack thus obtained invariably contains more or less unburnt resinous or fatty matters. When it is required to obtain a small quantity of very fine lampblack, it may be done by holding a cold plate over a common gas flame until sufficient has been deposited. See Carbon; Charcoal.

Lantern.—A term applied to a temporary drying apparatus for moulds during their course of construction. It is oftentimes called a *lamp* or drying-kettle. See Drying-kettle.

Lapidary.—One who cuts, polishes, or engraves gems or precious stones. See Precious Stones.

Lead.—Ores of lead occur in great abundance in almost all parts of the world. They are generally in veins, sometimes in siliceous rocks, sometimes in calcareous rocks. Abundant Scripture testimony proves the existence of this metal in olden times, and we are informed that the Romans used sheet-lead in the manufacture of water-pipes. The metal is very heavy but soft, is of a bluish-gray color, of great brilliancy. The specific gravity of lead is 11.35, and it melts at 617°. Almost all the lead of commerce is obtained from *galena* (sulphide of lead). It is then pickled, broken, and washed, and afterwards roasted, to eliminate the sulphur. Lead is an important metal in the arts. Rolled into sheets it is used for roofing houses, for cisterns and pipes. It is also of great service in the construction of large chambers for the manufacture of sulphuric acid; its value for making shot is well known.

Lead enters into many very useful alloys, as with *bismuth* for fusible alloys, with *antimony* for type-metal, with *arsenic* for shot, with *tin* for pewter and solders, with *copper* for pot-metal—for which compound it cannot be used more than one half lead, as it separates in cooling. With zinc it will scarcely unite, but their union may be brought about by a small proportion of arsenic. Many of the numerous alloys for mechanical and other purposes are improved by certain proportions of lead, and very few mixtures but may be made more fusible, malleable, and sharper in the cast by a slight addition of this metal; but with gold it forms an alloy of extreme brittleness; $\frac{1}{4}$ of a grain of lead will render an ounce of gold perfectly brittle, although both gold and lead are such soft and ductile metals. The ductility of copper at any temperature is impaired by the use of lead. Alloyed with silver, the metals will separate if slowly cooled from the melting point. It does not appear that cast iron and lead alloys will answer any useful purpose.

Of the compounds of lead other than alloys we have *white-lead* or carbonate of lead, and *red-lead* or red oxide of lead, the latter being much used in the manufacture of flint-glass and porcelain.

The various alloys of which lead forms a component part will be found under the following heads: FUSIBLE ALLOYS; TYPE-METAL; LEAD-SHOT; PEWTER; SOLDER; POT-METAL; BISMUTH; ANTIMONY; ARSENIC; TIN; COPPER; ALLOYS; BRASS; ANTI-FRICTION METALS; WHITE-LEAD; RED-LEAD.

Lead-ladle.—Ladles for melting and pouring lead may be of cast or wrought iron, of any dimension or form best adapted to the purpose for which they are to be used.

Lead-pipe.—See SHEET LEAD.

Lead-shot.—The common method of making small lead-shot is as follows: The melted lead is made to fall through the air from a considerable elevation, and thus leaden rain, as it were, is solidified into leaden hail or shot. The tower in which the manufacture takes place is about 180 feet high, 30 feet diameter at the base, and 15 feet at the top. The melting is conducted at the top in brick furnaces built against the wall, the lead is rained down from a colander, through a central opening into a water-tank below. The size of the shot is regulated by the mesh of the colander, the latter being a hollow hemisphere of sheet iron about 10 inches in diameter. When the shot are taken out of the water they are dried upon metal-plates, that are heated by steam, and the imperfect ones are separated from those that are spherical.

The addition of a slight proportion of arsenic to the lead used for shot helps it to solidify, as well as rendering it more fluid.

The alloy for lead-shot is lead 56, arsenic 1. See LEAD; ARSENIC; HOLLOW-SHOT.

Leaf Gold.—See GOLD.

Level is an instrument used to discover a line parallel to the horizon, and to continue it at pleasure. *Water-level* shows this horizontal line by means of a surface of water or other fluid, found on the principle that water always places itself level or horizontally.

The common mason's level consists of a long parallel straight-edged ruler, in the middle of which is fitted, at right angles, another broader one, at the top of which is suspended a plummet, which, when it hangs over the middle line of the upright piece, shows that the base or horizontal ruler is level. The spirit-level in common use amongst moulders has brass side-views, brass top, and end-plates and corners, protected by $\frac{1}{4}$-inch-square rods extending the entire length of the rosewood staff. The tube, which contains alcohol, is slightly curved, and the straight edge of the instrument is tangent to it. For instructions to level a bed on the foundry floor, see BED.

Lever.—The lever is the simplest of all machines, and is only a straight bar of iron, wood, or other material, supported on and movable round a prop called the *fulcrum*, and having the weight to be moved and the power to move it applied at two other points. The law is that *the power and weight* are in the inverse ratio of their distances from the fulcrum. This is equally true for straight or bent levers, and holds good whatever be the relative positions of the power, weight, and fulcrum ; and as there can be three different arrangements of these, we thus obtain what are called the three kinds of levers. The first kind is where the fulcrum is placed between the power and the weight; levers of the second kind are those in which the weight is betwixt the power and the fulcrum; in levers of the third kind the power is betwixt the weight and the fulcrum. To produce equilibrium in levers of the first kind, the power may, according to the ratio of the lengths of the arm, be either greater or less than the weight: in the second kind it must always be less, and in the third kind always greater.

Levigation.—See TRITURATION.

Lift.—When two parts of a flask are separated the operation is called *lifting*. Should the separation be a clean one, it is termed a *good lift*, and a *bad lift* if much repairing is necessary. When the parting extends much below the joint, it is then a *deep lift*. See GAGGERS; CHOCKS; PARTING.

Lifter.—See CLEANER.

Lifting-tongs.—A form of tongs with which to lift a crucible out of the furnace. They should always be strong, and of various sizes, so that each crucible has its own tongs which grips it closely all round. For large crucibles it is preferable to clasp them above and below with tongs that have double prongs, and an eye should be forged on the end of one leg. By this means a small crane may be employed for hoisting out the crucible when full of metal,—a readier and much safer method than struggling to withdraw it by hand. See CRUCIBLE.

Lighting the Cupola.—Success in cupola-melting depends, to some extent, upon the manner of starting the fire. Carelessness in this particular may result in there being more or less of the fuel in a semi-cold condition lying upon the bottom when the molten iron begins to fall from above. This naturally dulls the iron at the beginning, and may exert a bad effect upon the heat all through. It should be the aim of the cupola-man to have a clear, bright fire upon the bed before the blast is admitted, so that hot fluid metal will show at the first tap. In order to accomplish this, some attention should be paid to the kind of wood used for kindling with, as well as to the manner of distributing it at the bottom of the cupola; short pieces are the best, as they can be arranged with a view to preserving the sand bottom intact; and, whilst it is absolutely necessary to preserve a good free passage for air, yet it is well to prevent, as much as possible, any of the coal or coke from falling to the bottom before it has become thoroughly ignited. If old wood is used, let it be freed from every particle of sand, otherwise a slaggy bottom is the result from the start. Nails, spikes, and other malleable-iron fastenings, usually so plentiful in old foundry chips and lumber, should be carefully extracted before such wood is used for kindling with, as if left in any considerable quantity the nature of the iron is changed for a length of time proportionate to the amount of wrought iron introduced. Dirty kindling-wood and rusty nails have much to answer for at some foundries. Intelligent operation will soon discover just how much wood is needed to thoroughly ignite the coal or coke, so that *only* enough is used; any addition to this is wilful waste. For igniting coal, more wood will be required than for coke, and a little more time must be allowed for kindling a coal-stock. Whilst it is very important that the bed fuel be thoroughly ignited before the charging begins, it is not by any means a wise method to permit the stock to become white-hot before introducing the first charge of iron; when once it is sure that the fire has spread evenly all through the fuel, and is about to strike through the top, the iron may then be charged. By this means the heat, which in the former case escapes uninterrupted up the stack, is utilized for raising the temperature of the iron charged before it has reached the melting-point, the result being quicker melting and hotter metal. See CUPOLA; HOOD; CHARGING THE COMMON CUPOLA.

Lime.—Lime is found in every part of the known world, the purest kinds being limestone, marble, and chalk. None of these substances however are lime, but are capable of becoming so by burning in a white heat. Pure lime may also be obtained by dissolving oyster-shells in muriatic acid. See LIMESTONE; MARBLE; CHALK; LIME-KILN; FLUX; OYSTER-SHELLS.

Lime-kiln.—An oven or a pit, built of brick, with an interior lining of fire-brick. *Intermittent* kilns are such as have the fuel on the bottom and the stone above it, making it necessary to withdraw every charge. *Running kilns* are usually in the form of an inverted cone, and are charged with alternate layers of fuel and stone, so that the lime is withdrawn at the bottom as it is burned, fresh fuel and stone being constantly served at the top.

The process of burning expels the water and carbonic-acid gas from the stone, which falls to pieces on exposure to the air after removal from the kiln, and crumbles into a white flaky powder which is called quicklime, or slaked lime, and is possessed of highly caustic properties. See LIMESTONE; LIME.

Limestone.—The name given to all rocks which are composed to a great extent of carbonate of lime. The chief varieties of limestone are chalk; oolite, compact limestone of the hard, smooth, fine-grained rock, of a bluish-gray color; crystalline limestone; and statuary marble. Magnesian limestone or dolomite is a rock in which carbonate of magnesia is mixed with carbonate of lime. See DOLOMITE.

Limestone-flux. — When the blast-furnace is in operation it is regularly fed with definite proportions of fuel, ore, and broken limestone. The latter is added as a flux to render the iron more fusible, and, by combining with the impurities in the ore, prevent the formation of compounds containing iron, thus effecting a saving of mêtal. See Cast Iron; Flux; Slag; Ore.

Lining Ladles.—The process of daubing loam or ramming sand on the inner surface to protect them from the action of the molten metal.

All ladles above 8 tons capacity should have a fire-brick lining all through; below this, if the ladle bottom is perforated to let out the steam, a fire-sand bottom, rammed over one inch in depth of fine cinders, will serve, one inch of daubing being sufficient for the sides. See Daubing; Ingots; Ladles.

Lining-metal for Journal-boxes.—See Anti-friction Metals.

Lining of the Cupola.—The inner structure of fire-bricks built within the shell of a cupola to protect it from the intense heat during the process of melting. See Cupola; Repairing the Cupola; Daubing; Fire-brick; Grouting.

Lip is that part of a ladle-shell over which the metal falls as the process of pouring takes place. To regulate the stream of molten metal, and maintain it unbroken, is of great importance when numbers of various-sized basins must be served from one ladle; a little experimenting will soon discover which form is the most suitable. See Ladles.

Liquid.—See Fluid.

Liquid Bronze.—See Stains for Metals.

Liquid Fuel.—Liquid fuel, as petroleum, is used in a furnace specially constructed for the purpose. The oil is forced into the fire-box along with air or steam. Some have an injection placed above the fire-door, through which the liquid hydrocarbon is introduced. A cock regulates the supply, and at the mouth of the orifice superheated steam is associated with the petroleum at a temperature of 600° F. The hot ashes on the grate-bars receive the combined spray, and ignition takes place. See FUEL; PETROLEUM.

Litharge is the fused oxide of lead. See RED-LEAD.

Lixiviation.—The process of extracting alkaline salts from ashes by pouring water on them.

Loadstone, or natural magnet, is a species of iron ore found in many parts of the earth. Its property of attracting small pieces of iron was known to the Greeks at an early date, and the Chinese have been acquainted with its wonderful directive power from very remote ages. When this wonderful ore has been carefully examined, it is found that some points possess greater magnetic force than others. The attractive points are the poles of the magnet, which, if rubbed in a particular manner on a hardened steel bar, its characteristic properties will be communicated to the bar, which will then attract filings like itself; particularly is this the case with the two ends of the bar. The bar is then said to be magnetized. For general purposes these bars are bent in the form of a horseshoe, which admits of the two poles being brought into contact with the object to be lifted. See MAGNET.

Loam.—Foundry loam is a mixture of sand with clay and some form of venting medium.

Refractory fire-sands suitable for loam are of themselves too friable to form a compact, hard body. Clay is therefore added to impart adhesiveness, with some accompanying substance, as manure, etc., to counteract its imporous quality, and leave the mixture when dry a hard, unyielding substance, that is permeated with countless small holes through which the surface gas finds its way to the exterior.

The proportion of clay employed must be regulated by the class of castings the loam is for.

The following mixtures are for ordinary use in almost any foundry, and any sands which approximate in their nature to the general run of Jersey, fire, and moulding sands will answer. If the castings are unusually light, as thin plate castings in loam, the clay-water should be proportionately thinner.

Hand-made Loam for Loam-moulds and Core-barrels.—Fire-sand, 5 ; moulding-sand, 2 ; horse-manure, 1½. Mix with thick clay-water.

Mill-made Loam for Loam-moulds and Core-barrels.—Fire-sand, 7 ; moulding-sand, 2 ; horse-manure, 2. Mix with thick clay-water, and grind no longer than is necessary to mix the ingredients intimately together. See HORSE-MANURE ; VENTING ; FACING-SAND; LOAM-MILL.

Loam-board is a technical term for any *strickle, strike, sweep,* or *templet,* so called, that may be employed for forming some part of a mould in loam; whether it be drawn along by the hands of a moulder horizontally, as for a pipe, attached to a centre-spindle to form circular moulds vertically, or be secured fast whilst the mould or core rotates past it, as for cores, both horizontal and vertical.

Such boards should be bevelled on the edge, using the sharp edge for roughing up and the opposite way for skinning. See SWEEP-BOARD ; ROUGHING-UP ; STRICKLE ; LOAM.

Loam-bricks are made in cast-iron moulds. The moulds being set on a smooth plate in the oven are filled with stiff loam and allowed to remain until dry. They are then useful for fashioning into cores with the saw and file, or may be used for building in parts where, on account of their rigidity, the ordinary bricks would interfere with the free contraction of the casting. The loam-bricks, being less rigid, yield readily to the pressure. See Loam.

Loam-cake.—Flat cores, made by simply spreading loam of a stiff nature on a plate in the oven. They may be made any thickness desired, and strengthened by thrusting within the mass a few iron rods. These cakes make excellent covering cores. See Loam.

Loam-mill is any contrivance for mixing well together the ingredients of which loam is composed. The object is not so much to *grind* to a fine consistency as it is to thoroughly *mix* the clay and manure with the sand, so that every portion of the loam may be alike open in its nature. If the loam is ground too much by very heavy rollers, the clay becomes too intimately incorporated with the overground sand, the grains of which have been crushed into fine powder, resulting in a pasty mass which, when it yields its water, shrinks on the surface of the mould, leaving cavities and cracks which are difficult to correct, and always leave a map-like appearance on the casting. By retaining as much as possible the original coarseness of the ingredients the shrinkage spoken of is distributed equally throughout the surface, and is not noticed at all. Another evil which attends the use of all over-ground loam is, that, being less porous, the gases generated by the molten metal have greater difficulty in escaping in a legitimate manner, and hence force their way into the mould, creating great commotion, and sometimes carrying off portions of the mould surface, making scabs. See LOAM; VENTING.

Loam-moulding.—Loam-moulding differs from *sand-moulding* in that the moulds proper are not contained in flasks, or *bedded in* the floor, but are constructed in sections composed of rings, plates, and brickwork. Another chief difference is that sand-moulds are simply impressions of a model that is furnished by the pattern-maker, whilst loam-moulds are in some measure the handiwork of the moulder himself, unaided by the pattern-maker in many instances.

There are instances where of necessity the operations necessary for the successful construction of a high-class loam-mould must include the three chief systems combined, viz., pattern, strickle, and spindle, with ample opportunity throughout the task for supplementing these systems by a nicety of touch which may be acquired only by constant practice and close application by the most intelligent moulders. See TOUCH; GREEN-SAND MOULDING; DRY-SAND MOULDING.

Loam-patterns.—Numerous patterns may be readily made from loam and much pattern lumber saved thereby; many, also, may be made quicker by this means, saving both time and lumber.

Straight pieces of shafting, pipes, etc., may be struck on a barrel to the diameter required, after which a little water blacking will separate the thickness, which may be struck thereon after drying the core. Or should such a pattern be required more than once, the outside diameter can be struck at once, dried, coated with tar, and dried again. Such a substitute for the wood pattern acts very well in an emergency.

If the pipe is a common socket, the bead and socket ends can be formed at once; but in the event of flanges they must be placed after the model is dry, as would be the case also if it were desired to affix a branch thereon.

Bends of any description may be made from loam with either iron or wood templets and a former, each half being first struck on a core-iron to the core size, then dried, flanges fixed, and the thickness struck; first interposing a thin coat of water-blacking to separate the thickness from the core after the mould impression has been taken.

The bottom half of such a pattern needs a few brads driven into the body, the heads of which, protruding somewhat into the thickness, would prevent the thickness from falling off whilst it was doing duty for a pattern. A barrel core is thicknessed by wrapping a hay-rope on the core, and finishing off with clay and loam in the ordinary manner. Those unaccustomed to this method of producing a pattern will see by the above examples what the possibilities are when the emergency presents itself. See Former; Templet; Core-barrel; Thickness; Loam.

Lode.—The term used for an ore-producing vein. Ore occurs in either beds or mineral veins; in the latter the veins are invariably found to have one of two or three principal directions, being either nearly parallel to the axis of elevation of the district, at right angles to that direction, or at an angle of 45° with it. The first are *right-running lodes;* the second, *cross-courses;* and the third, *contra-lodes,* or counters. See Ore; Veins.

Log.—A term of wide application in the foundry, meaning any piece of blocking-timber used for shoring purposes or as a bearing for flasks, etc. See Trestle.

Loosening-bar, or rapping-bar, is usually a round, pointed bar for jarring patterns previous to lifting off the cope or drawing out a pattern. In the first instance the jarring effects a separation of the sand from the pattern before the parts are separated with the view of preventing a *bad lift;* in the latter case the pattern is *loosened* and made to *draw* easier. Rapping-plates are, or should be, inserted in the pattern to receive the point of the bar, which is then struck in opposite directions with a hammer or sledge. See Rapping-plate; Lift.

Low Moor Iron.—This iron is manufactured under exceptional conditions, as both ore and fuel employed for making the pig iron used in their forges are of special quality, and are both obtained within their own premises. The ore is a brown ironstone, containing after calcination 42 per cent of metal, and is found in the coal-measures of the neighborhood. Even the limestone used for flux comes from the same county—Yorkshire, England. See Ores.

Lug (or snug, in some localities) is an extension-piece cast on loam-plates for the purpose of handling and lifting by whatever method is in vogue. Some have staples of wrought iron cast in them to receive a hook, others again have simply a hole in the lug for that object but unless required for some special reason, a plain lug is amply sufficient when chains or slings are used for lifting with. See Snug; Pin and Cotter.

Lustre is the brightness on the outer surface of a mineral, or in the interior when newly broken, as in pig iron, etc. When it can be seen plain at a distance, it is then termed *splendent;* if weak, *shining;* when the lustre is to be seen only at arm's length, *glistening;* and *glimmering* when it must be held close to see the shining points. When the surface is without lustre it is termed *dull.*

Lustre on Iron.—See Iron-lustre.

M.

Mackenzie Blower.—The fan-blades in this blower are supported by a shaft, and caused to revolve by the revolutions of a cylinder contained in the shell. The fan-blades are loosely joined to the shaft and arranged so that they adapt themselves to a continuous alteration of the angle as they pass through the cylinder. Half-rolls in the cylinder act as guides for the fan-blades, allowing them to work smoothly in and out as the cylinder revolves. At each revolution the entire space back of the cylinder between two blades is filled and emptied three times, that being the number of blades contained. See BLOWER.

Mackenzie Cupola.—The Mackenzie cupola has a continuous tuyere, which allows the blast to enter the fuel at all points. Each size is proportioned to melt a given quantity of iron in a certain time. Above one ton per hour melting capacity they are made oval in form. This construction brings the blast to the centre of the furnace with the least possible resistance and, it is claimed, the smallest amount of power, causing a complete diffusion of air and a uniform temperature. The sizes of the cupolas indicate the melting capacity per hour; that is, a No. 1 melts 1 ton per hour; No. 6, 6 tons; and so on with all sizes. See CUPOLA; BLOWER.

Magnesium is a very brilliant metal of almost silvery whiteness. It is more brittle than silver at an ordinary temperature, but becomes malleable at something below a red heat. Its specific gravity is 1.74. It melts at a bright-red heat, and volatilizes at nearly the same temperature as zinc. In dry air its lustre is retained, but a crust of magnesia forms on its surface when subjected to a moist air.

Magnesium in the form of a wire or ribbon takes fire at a red heat, burning with a dazzling bluish-white light. The pure oxide of magnesium (magnesia) is obtained by igniting the carbonate, but this is both a difficult and expensive means of obtaining it, and recourse is had to the impure magnesian limestones found in Thuringia and in some parts of England. It is a white powder, varying in density according to the source from whence it is obtained. It is unalterable by heat, and has never been fused; and on account of its refractoriness is valuable as an ingredient for the manufacture of crucibles for metallurgical purposes. See DOLOMITE.

Magnesian Limestone.—See MAGNESIUM.

Magnet.—There are two kinds of magnets—natural and artificial. The natural magnet is an iron ore which has the property of attracting to itself particles of iron or steel. If suspended, it takes a north and south direction, and it is from this particular *leading* property that it is called *leadstone* or *loadstone*. The magnet (*magnes* in Greek) is supposed to have received its name from Magnesia, in Asia Minor, where it was first discovered. See LOADSTONE.

Magnetite is a magnetic iron ore, or oxidulated iron. It is one of the richest and most important ores of iron, and produces the finest brands of steel. It is found in almost all parts of the world, and occurs crystallized in iron in black octahedrons and dodecahedrons; also massive, as well as in the form of sand. See ORES.

Malachite.—A mineral, the green carbonate of copper ; also called *velvet copper ore*. It is much admired as an ornamental stone for inlaying purposes. There are two varieties, the fibrous and the compact. Constituents: copper 58, carbonic acid 18.0, oxygen 12.5, water 11.5. See COPPER; MINERALS; METALS.

Malleability.—A property possessed by metals which renders them capable of being beaten out with a hammer or pressed into plates between rollers. Gold surpasses all metals in malleability, being capable of reduction into films not exceeding the 200,000th of an inch in thickness, whilst iron has been rolled into sheets less than the 2500th of an inch in thickness. The malleability of metals is here given in their respective order of value, beginning with the highest: Gold, silver, copper, tin, cadmium, platinum, lead, zinc, iron, nickel, palladium. See DUCTILITY; METALS; STRENGTH OF MATERIALS.

Malleable Bronze.—Hard bronze may be made malleable by the addition of from ½ to 2 per cent mercury, which may be combined with either of the metals composing the mixture before the bronze is finally made. It can be put into the melted copper at the same time the tin is added, or can be used as an amalgam with the tin. See BRONZE; ALLOYS; BRASS.

Malleable Cast Iron is made by a process of decarburizing the articles made from cast or pig iron in the annealing furnace, where they are subjected to an oxidizing atmosphere somewhat below the fusing-point. The furnaces employed for this purpose consist of iron plates to enclose the necessary space, which serve also as guides for the doors, which are raised perpendicularly, being balanced by a weight at the back of the furnace. The inside of the furnace consists of fire-space and the oven proper, an arch extending over both, the fire-space being separated from the oven by a bridge wall extending nearly to the arch, leaving only a narrow space through which the flame is forced by the blast, completely filling the oven. The gases escape through small outlets in the corners to the flues below, which are fitted with a damper operating from the front. The castings to be rendered malleable are placed in cast iron covered boxes or saggers, along with oxide of iron, and subjected to a red heat in these furnaces for from two to six days, according to the magnitude of the castings. They are then allowed to cool slowly. See DECARBONIZE.

Malleable Iron.—By depriving cast iron of a portion of its carbon it may be converted into malleable or wrought iron, becoming ductile and tenacious, and capable of being hammered or rolled into thin sheets or drawn into fine wire. Malleable or wrought iron has a fibrous texture, but if it is subjected to repeated jarring or blows it becomes again brittle, and can only be restored by heating and reworking. The ordinary processes of converting cast iron into malleable are: refining, puddling, shingling, hammering, and rolling. The refining-furnace consists of a flat hearth covered with sand, around which are metal troughs through which a constant stream of water is kept running, to prevent the sides from melting; tuyeres set in the direction of the hearth connect with the blowing-engine. The cast iron is melted with coke on the hearth, and a blast of air which blows directly over it causes the carbon of the iron to unite with the oxygen of the incoming air and pass away as carbonic-oxide gas. Oxygen also unites with the silicon present to form silica, and with the iron to form the oxide. A slag of silicate of iron is also produced by the silica of the sand uniting with the oxide of iron. When the molten mass has been sufficiently refined it is run out on cast-iron plates, which are kept cool by streams of water. This process only partially decarbonizes the iron; it is then broken into pieces and passed to the puddling-furnace, where it is again melted and brought up to a high temperature, when it is subjected to the action of a current of air, by which means the carbon burns to carbonic acid, a portion of the iron is oxidized, and this oxide unites with the silicon in the iron and forms a fusible slag. The workmen by means of long bars keep up a constant stirring or puddling of the mass, so that the whole may be exposed to the air, and to intimately mix the oxide with the metal. After a time the iron loses its fluidity, blue flames appear on the surface, it becomes pasty, and finally falls to pieces. The fire is now quickened, and the loose masses unite. They are then gathered by the puddler into balls, which are at once conveyed to the squeezer, or shingling hammer, where the slag is pressed out and the metal formed into a bloom, which is at once passed through the roughing-rolls, and finally the finishing-rolls, which in some instances completes the operation. The quality of the iron is improved by taking the bars from the roughing-rolls and cutting them into lengths, to be reheated in piles or fagots, and then rolled or hammered out together. See PUDDLED STEEL.

Mallet.—A wooden hammer for service in the foundry, where the marks produced by the smaller iron-faced hammer is objectionable. Besides the ordinary wood mallets, with heads 3½ inches long, 2 inches diameter at the ends, there are now made for the trade raw-hide mallets from 1 inch to 2¾ inches diameter at the head; they are made entirely of hide, except the handle, and are especially valuable where light thin castings are made, as they are not as likely to damage the patterns.

Manganese is one of the heavy metals, of which iron may be taken as the representative. Its color is grayish white, of high metallic brilliancy, it takes a fine polish, is non-magnetic, fuses at a white heat only, and is so hard that steel and glass may be scratched by it. As spiegeleisen, or white iron, it contains 8 to 15 per cent of manganese. Ferro-manganese, another regular article of commerce, contains from 25 to 75 per cent of manganese. These alloys of manganese, with carbon and iron, along with certain small proportions of other elements, constituting either spiegeleisen or ferro-manganese, according to the percentage of manganese contained in the alloy, are indispensable for the manufacture of steel by the Siemens, the Bessemer, or the crucible modes of procedure.

Manganese combines with carbon and silica, forming unimportant compounds. One of its principal uses is chemical, under the form of an oxide; it is employed in this state for decomposing hydrochloric acid, in the manufacture of chlorine, as a cheap source of oxygen, and as coloring material in the manufacture of glass and enamels. See SPIEGELEISEN; FERRO-MANGANESE; STEEL.

Manganese-bronze.—This bronze, manufactured by P. M. Parsons, England, for every purpose for which gun-metal has heretofore been employed, and for which object it constitutes an eminently superior alloy, is made by adding from 1 to 2 per cent manganese to the common bronzes of copper, tin, and zinc.

It is largely used for propeller-blades, sheathing, bearings, piston-rings, etc., and is said to be 60 per cent stronger than gun-metal, and will wear three times as long. See BRONZE; BRASS.

Manganese-copper is used as a strengthener to bronze and brass. The density, ductility, and tensile strength of the metal is increased, as it prevents the formation of copper and tin oxides. The alloy is made from copper 70, manganese 30, of which composition sufficient must be used to bring the mixture up to the required degree of hardness. A very hard bronze is made by using from 3 to 6 per cent. A suitable mixture for bearings would be copper 80, tin 6½, zinc 4½, manganese-copper 9.

A hardness resembling steel is produced by increased quantities of cupro-manganese, or manganese-copper. See COPPER; BRONZE; BRASS.

Manheim Gold.—A brass imitation of gold, composed of copper 16, zinc 4, and tin 1. To insure close resemblance to gold, the crucible must be clean, metals pure, and it is best to melt under powdered charcoal in a covered crucible. See GOLD; TOMBAC.

Manure.—See LOAM; HORSE-MANURE.

Marble is a rock belonging to the varieties of carbonate of lime which have a granular and crystalline texture. It is composed of carbonate of lime, either almost pure when the color is white, or combined with oxide of iron or other impurities which give various colors to it. The far-famed quarries of Carrara, Italy, have supplied this beautiful material for statuary purposes from time immemorial. The pure white marble is quarried also in Vermont, but it is not held in as high estimation as that from Italy. Of variegated marble there are many sorts found in this country, but generally not fit for sculpture. See LIMESTONE.

Marble-chips.—The chips from a marble-yard are the very best material to use as a limestone-flux in cupolas, being comparatively free from the deleterious substances usually found in the commoner kinds of limestone. See FLUX; LIMESTONE-FLUX.

Marsh-gas, usually called fire-damp by miners, is often abundantly disengaged in coal-mines from apertures or "blowers," which emit for a length of time a copious stream or jet of gas, probably existing in a state of compression pent up in the coal. When the mud at the bottom of pools in which water-plants grow is stirred it suffers bubbles of gas to escape, which if collected are found to be a mixture of marsh-gas and carbonic anhydride; and it is thought by some that these two gases represent the principal forms in which the hydrogen and the oxygen respectively were separated from wood during the process of its conversion into coal. See AIR; VENTING.

Martin Steel is made in the reverberatory furnace by adding malleable iron to the molten pig iron after the latter has been melted. See STEEL.

Match-board.—Same as match-plate, except that it is made of wood instead of metal. See MATCH-PLATE; MATCH-PART.

Match-part, sometimes called a "sand odd-part" by the moulder. This is a device for economizing time in making partings when a large number of castings are required to be made in the same kind of flasks. One method of procedure is as follows: Procure a well-made "roll-over" board, and arrange the pattern or patterns suitably for gating, etc., and wherever portions of the pattern must of necessity project upwards into the cope, set them just in that position on the board by cutting out the wood at the points of projection, taking care that the parts of the board adjacent to the patterns shall leave the parting all ready made around them when the nowel has been rammed and rolled over. Another ready way of accomplishing this is to extemporize a match-part by forming the same in sand, hard rammed into an odd flask of equal dimensions with the ones to be used; this may be coated with tar and dried, and will be found very serviceable. A decided improvement on the last may be obtained by first making the parting in the usual manner and covering the same with oil, and a good sprinkling of parting-sand; after which set thereon a wood frame (no deeper than is absolutely necessary), having a bottom nailed on, with a few nails driven here and there clear of the parting. A hole in the centre will permit the space to be filled with plaster, which, running all over the surface and around the nails, will, when set, be found a perfect impression of the joint required. The nails will prevent it from dropping out. See MATCH-PLATE; ROLL-OVER BOARD.

Match-plate.—A plate provided with pin-holes corresponding to pins and holes of the top and bottom flasks between which it is placed, to be rammed on both sides before it is removed, and thus save the labor of making a joint or parting. Should the patterns present one plain side, allowing all the mould to be contained in the nowel, all such may be secured to the lower side of the plate; but in the event of there being a portion in each flask, then the patterns must be cut and each part secured to the match-plate exactly opposite to each other on either side of the match-plate. See MATCH-PART; SAND ODD-PART.

Maul.—A heavy wooden sledge-hammer, useful in the foundry for many purposes for which iron ones are objectionable. They are especially effective for settling down iron copes on a sand-joint, bedding-in large patterns, or any purpose where a steel-faced hammer would be likely to break or mar the surface struck.

Meadow-ore.—Conchoidal bog-iron ore. See BOG-IRON ORE.

Measurement of Castings.—See WEIGHTS OF CASTINGS.

Medals.—If it is desired to obtain a convex and a concave plaster-mould from a medal, press tin-foil close into every part of the surface and pour on the requisite thickness of plaster, after which, when it has hardened, take off the medal and oil the tin-foil surface, over which the plaster is again poured. When the latter thickness of plaster has hardened, they may be separated and the foil taken off.

Should the medal have under-cut parts which interfere with a direct separation, then use glue instead of plaster, and the moulds may be forcibly withdrawn without materially damaging them. Any other flat object may be treated as above described. See GLUE-MOULDS.

Melting a Small Quantity of Iron. — See FONDERIE À CALABASSE.

Melting-furnace.—The cupola and reverberatory are the iron-foundry melting-furnaces; the crucible air-furnace, forced-draught, and reverberatory are the brass-founders' and steel-melters'. A reverberatory furnace is employed by glass-makers for calcining the materials, and crucible or "glass furnaces" to melt the glass. The application of the Siemens regenerative process is becoming general for all these purposes, excepting for iron-foundries, and a considerable saving in fuel is effected wherever this system obtains. See FURNACES.

Melting-point.—The exact amount of heat at which metals and other substances become fused and lose their identity. (See FUSIBILITY.) The following gives the melting-points of the simple metals mentioned, but the melting-points of alloys are invariably below those of the simple metals composing them. (See FUSIBLE ALLOYS.) Cast iron melts at 3477 degrees; wrought iron, 3981; steel, 2501; gold, 2587; silver, 1250; copper, 2550; tin, 420; zinc, 741; brass, 1897; lead, 617; aluminum, and 700 degrees.

Mending-up.—The art of repairing broken surfaces in the mould which may have been caused by accident, carelessness, or faulty models or patterns. This phase of the moulder's art calls for the nicest manipulation, with delicate fashioning-tools made for the purpose. See FINISHING.

Mercury or Quicksilver.—A metal always fluid in our climate, but solidified by intense cold into a malleable metal resembling silver. It is found native as well as combined with sulphur, when it is called *cinnabar*. But cinnabar is easily reduced at a red heat to the metallic state by the action of iron or lime, or atmospheric oxygen; the sulphur being extracted, when iron is used, as sulphide of iron; when lime is used, as sulphide and sulphate of calcium; and as sulphurous-acid gas when oxygen is used. The alchemists of old did not believe mercury to be a true metal, because they were unaware of its susceptibility to freezing into a compact solid.

With the exception of iron and platinum, mercury will readily unite with all metals into an amalgam. (See AMALGAM; AMALGAMATION.) Liquid amalgams of the precious metals are largely used for gilding and silvering objects which have been made in baser metals. The amalgam is spread over the object with brushes, after which the mercury is driven off by the application of heat, leaving a film of the nobler metal firmly adhering to the object treated.

Mercury has a great affinity for all other metals that are soluble in mercury; for if an object be dipped into it there is great difficulty in rubbing off the mercury, which immediately adheres to it. If mercury is rubbed over tin-foil, it unites in one mass and forms an amalgam, as is the case with mercury and lead. When lead and bismuth are mixed with mercury, the amalgam will be equally fluid with the mercury itself. This important metal is used for barometers, thermometers, silvering looking-glasses, and for many other useful purposes, including the making of vermilion. It is largely employed in separating the precious metals from extraneous matter.

Mercury is the heaviest of all metals except gold and platinum; consequently silver, iron, lead, etc., float upon it as wood does upon water. The production of mercury (1882) in Austria was 542 tons; Italy, 55 tons; Spain, 929 tons; United States (principally Almaden, Cal.), 2054 tons. See TIN; AMALGAM; FLUID ALLOY; METALS.

Metallurgy.—In a limited sense metallurgy includes only the operations attendant on the separation of metals from their ores; but it really comprehends the whole art of working metals, from the mining of the ore to the production of the manufactured article. See METALS; MINERALS; ORES; REDUCTION OF METALS.

Metals.—There are three states in which metals occur in nature. First, some of them, as gold, silver, platinum, and mercury, are frequently found uncombined. These are said to occur in their native state. Second, many are obtained alloyed with each other, as gold and silver with mercury; but invariably they are found in combination with the metalloids, for which they have a strong attraction; these constitute the third state, and are known as metallic ores. The metals are conductors of electricity and heat, but differ in this respect. Some metals are so volatile that they may be distilled from their compounds. Mercury boils at 662°; lead is volatilized to some extent, and in a slight degree copper also, in the smelting-furnaces; and gold will dissipate in vapor in the focus of a powerful burning-glass. With regard to their fusibility metals show a marked difference. Mercury remains fluid at 39°; sodium and potassium fuse below the boiling-point of water; silver and gold melt at a red heat, iron at a white heat; and platinum only yields to the action of the oxyhydrogen blowpipe. There are great differences with respect to specific gravity of metals. While platinum is twenty-two times heavier than water, lithium is only about half as heavy as that liquid. The lightest metals have the strongest affinity for oxygen. Some of the metals are neither malleable nor ductile, yet others again have those properties to a remarkable extent. Gold may be hammered to the 200,000th of an inch in thickness, and wire has been drawn from platinum to the 30,000th of an inch in diameter. The metals exhibit wide differences in hardness. Steel may be tempered to scratch glass, while potassium is as soft as wax. To pulverize gold or copper great force is required; yet others again, notably antimony and bismuth, may be reduced to powder in a mortar.

The following table gives the relative properties of various metals, their names being arranged in a descending series:

Power to conduct Electricity.	Brittleness.	Malleability.	Tenacity.	Ductility.	Power to conduct Heat.
Silver	Antimony	Gold	Iron	Gold	Silver
Copper	Arsenic	Silver	Copper	Silver	Copper
Gold	Bismuth	Copper	Platinum	Platinum	Gold
Zinc	Cerium	Tin	Silver	Iron	Tin
Iron	Chromium	Cadmium	Gold	Copper	Iron
Tin	Cobalt	Platinum	Zinc	Zinc	Lead
Lead	Columbium	Lead	Tin	Tin	Bismuth
Antimony	Manganese	Zinc	Lead	Lead	
Bismuth	Titanium	Iron		Nickel	
	Tungsten	Nickel		Cadmium	

Meteoric Iron.—Iron mixed with nickel, as found in meteoric stones or aërolites. See METEORIC STONES; IRON; NICKEL.

Meteoric Steel.—Steel resembling the famed Damascus steel is made by melting in a plumbago crucible, well covered with charcoal, silver 4, nickel 16, zinc 80, and pouring the alloy into water, which renders it friable. It may then be readily crushed to powder, and added to steel as follows: Blister-steel, 28 pounds; chromate of iron, 8 ounces; quicklime, 2 ounces; porcelain clay, 3 ounces; meteor-powder, 10 ounces; melted in the regular way, cast into an ingot, drawn into bars, and in every respect treated like any other cast steel.

If the surface is washed with dilute nitric acid (acid 1, water 19), the wavy surface common to Damascus steel will be more pronounced. See STEEL; DAMASCUS STEEL.

Meteoric Stones.—Usually called aërolites, fire-balls, or shooting-stars, which occasionally fall from the atmosphere. When taken up soon after their fall they are found to be hot; and, no matter where they descend, they are all similar in composition, being composed of silica, magnesia, sulphur, iron in the metallic state, nickel, and some traces of chromium; their specific gravity varies from 3.352 to 4.281, that of water being taken as 1.000 or unity. Their exterior appears as if blackened in a furnace but the interior appears of a grayish white. Their size varies from a few ounces up, one in the Museum of Natural Sciences, Philadelphia, weighing 800 pounds. See METEORIC IRON.

Metre.—A measure of length equal to 39.370 English inches, or 39.368 American inches, the standard of linear measure, intended to be the ten-millionth part of the distance from the Equator to the North Pole, as ascertained by actual measurement of an arc of the meridian. See METRIC SYSTEM.

Metric System.—The metric system of weights and measures was first adopted in France, and by Act of Congress was authorized to be used in this country 1866. It is a decimal system, and the units of length, superficies, solidity, and weight are all correlated, two data only being used—the *metre,* and the weight of a cube of water the side of which is the hundredth part of a metre. Upon the metre are based the following primary units: the square metre, the arc, the cubic metre or stere, the litre, and the gram. The square metre is the unit of measure for small surfaces. The arc is the unit of land measure, and is a square whose side is 10 metres in 1, or 100 square metres. The cubic metre or stere is the unit of volume, and is a cube whose edge is one metre in 1. The litre is the unit of capacity; this is the capacity of a cube whose edge is $\frac{1}{10}$ of a metre in 1. The gram is the unit of weight, and is the weight of distilled water contained in a cube whose edge is the $\frac{1}{100}$ part of a metre.

From these primary units the higher and lower orders of units are derived decimally. See METRE.

Mica.—A mineral of a somewhat metallic lustre, that will permit of being split in thin plates, which can be substituted for glass in ship's lanterns, etc.; also for mounting transparencies in stoves. It is a widely diffused and plentiful mineral, entering largely into the composition of granite, mica-slate, etc. It consists essentially of silicate of alumina, with which are combined small portions of silicates of potash, soda, oxide of iron, oxide of manganese, etc. See GRANITE.

Mill-cinder.—The slag produced at the reheating and puddling furnaces. This slag, after several days' roasting, becomes highly refractory, and is known as *bulldog,* making an excellent substance for the bottoms of puddling-furnaces. These rich slags are sometimes mixed with the ores in the blast-furnace, and the iron thus produced is then denominated *cinder-pig;* but, owing to the large percentage of phosphorus usually present in pig iron made by this method, it is very inferior in quality. These slags are frequently called tap and forge cinder. See SLAG.

Milled Lead.—Sheet lead made in the rolling-mill by passing the metal through the rolls. See SHEET LEAD.

Mill-furnace.—A furnace employed to reheat the puddled bar after it has become too cold to pass through the rolls to a finish.

Mill-rolls.—See ROLLS.

Mineral Cotton.—If a jet of steam is forced through liquid slag, the latter is changed into a mass of fine white threads, which when gathered together appear like cotton wool. It is sometimes called *mineral wool.* If an extra strong current of moist air be blown into a cupola that is slagging freely, this phenomenon is likely to occur.

Mineralogy.—The science which treats of the solid and inanimate materials of which our globe consists, the four classes of which are earthy minerals, composing the greater part of the earth's crust; saline minerals, inflammable minerals, and metallic minerals. See MINERALS; METALS; EARTHS.

Mineral Oils.—See PETROLEUM.

Minerals are all such natural bodies as are destitute of organization, existing either within or on the surface of the earth, and which are neither animal nor vegetable.

The hardness of minerals, beginning with the softest, is as follows: 1. Talc; 2. Gypsum; 3. Calcareous spar; 4. Fluor-spar; 5. Apatite; 6. Feldspar; 7. Quartz; 8. Topaz; 9. Sapphire; 10. Corundum; 11. Diamond. See PRECIOUS STONES; EARTHS; MINERALS.

Mirrors.—For methods pursued in producing glass mirrors, see MERCURY. For metal mirrors, see BRASS MIRRORS.

Mitis Metal.—The name given to an alloy of aluminum with wrought iron. For the production of castings in this metal, the wrought iron is heated until it has become pasty, and then treated to a small quantity of aluminum, which immediately liquefies the iron in a fit condition for pouring into the moulds.

These so-called mitis castings, it is claimed, have all the properties, excepting fibre, that wrought iron possesses, besides being much softer than cast iron. Wrought-iron or mild-steel scrap is usually the basis of this metal; but no matter what the kind of material be, it is preferable that it should not contain more than 0.1 per cent of phosphorus when the best results attainable are desired. About 3½ ounces of aluminum are sufficient for 100 pounds of iron. See ALUMINUM.

Mixing Alloys.—See ALLOY.

Mixing Cast Iron.—The art of mixing certain proportions of different brands of iron to obtain castings of such quality as will best serve the purpose for which they are intended. Without a chemical knowledge of the actual ingredients needed for the production of a certain quality of iron, mixing cast iron must always remain in the realm of conjecture. True, there is much to be said in favor of the superior facilities for subsequent testing; but this gives no substantial data, and must always be repeated on every change of the materials employed. Late developments relating to the power of silicon to change the nature of cast iron has opened a way for a more intelligent system of mixing. See ANALYSIS; TESTING-MACHINE; SILICON; SOFTENERS; GRADES OF PIG IRON.

Mock Gold.—See GOLD ALLOY; ORMOLU.

Mock Platinum.—A factitious platinum is produced by mixing 5 zinc with 8 brass. For composition of brass, see BRASS.

Mock Silver is a white-metal alloy, ordinarily used by jewellers, etc. If 3.53 of silver be alloyed with 11.71 copper and 2.4 of platinum, the composition will have about the same specific gravity as the pure metal. Packfong, or tutenag, another imitation, is composed of: copper 40.4, zinc 25.4, and nickel 31.6. German tutania: tin 48, antimony 4, copper 1. See SILVER ALLOYS; IMITATION SILVER.

Modelling.—The art of designing or copying works of art in clay, for the purpose of obtaining moulds in which they may be cast in plaster or metal. The fingers, aided by a few implements of metal or wood,—usually both,—are the only tools required for fashioning the clay. Ordinarily, the common potters'-clay will serve this purpose; but for designs which occupy a lengthened period to produce, it is mixed with other ingredients to keep it in a moist condition. The support of a figure in modelling is of great importance, requiring in some instances a skeleton of wood or iron supports on which to work the clay. When the model is complete, a plaster impression of the same is taken in sections, which are then placed together in precisely the same position as they occupied on the model; the space originally occupied by the model is now filled with plaster, and when the cast is well set the mould is carefully taken off, exposing a finished cast of the model. This is a much better plan than that of the ancient sculptors, who simply dried the clay model ; but clay cracks and shrinks in drying, therefore plaster-casts from the models are best. See FOUNDING OF STATUES ; MODELLING-CLAY.

Modellers' Wax.—See WAX.

Modelling-clay.—Common potters'-clay mixed with water will answer for inferior work ; for work of superior quality dry clay may be brought to the right consistency with glycerine; but for models requiring considerable time for their completion, and to avoid the repeated moistening to which they must be subjected, it is best to use a clay composed of: clay 3, sulphur 6, oxide of zinc 1, fatty acids 2, fats 10. First saponify the zinc-white with oleic acid, which then mix with the other fatty acids ; add sulphur in flowers, and the clay in dry powder. See OILS ; ZINC; POTTERY.

Moire Métallique. — A crystalline appearance of great beauty given to tin-plate by brushing over the heated metal a mixture of 2 parts of nitric acid, 2 of hydrochloric acid, and 4 of water. As soon as the crystals appear the plate is quickly washed, dried, and varnished. See TIN.

Molasses. — A brown, viscid, uncrystallized syrup produced in the manufacture of sugar. Owing principally to the gluey nature of this product, it can be made of great use in the foundry. Core-sands void of the quality of adhesiveness may, by being mixed with molasses, be made sufficiently tenacious to admit of their being employed where, if sands containing aluminous substances were used, there would be great difficulty in extracting the core when cast. The molasses, owing to its sticky nature, holds the loose grains of silica together until the molten metal has solidified, during which time all its cohesive qualities have been burned away by the intense heat, leaving the sand free to run out of the cavity at the slightest provocation. Common beach and river sands may be made serviceable by the use of molasses when the cores are for light castings; but when it is desired to accomplish similar results in heavy castings, the more refractory silica sands must be used.

Molasses is now extensively used for mixing with the silica sands, etc., used in steel casting, in order to bring these incoherent materials up to the right consistency for forming the moulds.

Mixed with water until the latter may be pronounced very sweet, it is an excellent restorative for a badly burned mould surface, especially when a little black lead has been stirred in. If the mixture be too thick with molasses, instead of penetrating the burned mould surface, it will lie there and form a hard skin, which, as it dries, separates and curls up, bringing the sand with it, and making matters worse. See Core-sand; Flour; Glue; Steel Castings.

Molecule.—One of the constituent particles of bodies. The molecules of bodies are divided into *integrant* and *constituent,* the integrant having properties similar to the mass, and are consequently simple or compound, as the mass is either one or the other. A mass of pure metal consists of integrant particles, each of which has metallic properties similar to those possessed by the whole mass. Similarly, a mass of alloy consists of integrant particles, each of which is a compound of the different metals forming the alloy. When a compound integrant molecule is decomposed we arrive at the constituent molecules. Therefore oxygen and hydrogen are the constituent molecules of an integrant molecule of water.

Mosaic Gold.—A cheap brass used for making imitation jewelry. It is made by alloying copper with about equal parts of zinc. See Gold Alloy; Ormolu; Tombac.

Mottled Iron.—The variety of pig iron which is evidently between the two extremes of white and gray. The fracture shows a decided mottle, seemingly caused by the distribution of detached portions of white iron throughout a matrix of gray iron. Pig iron is termed high or low mottle, according to the proportion of white iron present in the pig. See Gray Iron; White Iron; Cast Iron.

Moulding.—The art of preparing moulds from plastic materials of such a nature as will successfully resist the intense heat of molten metal,—as loam or sand,—in which may be formed the object to be produced in metal, the process being completed when the metal has been melted, run into the mould, and solidified. True, there are moulds used for special purposes in iron-casting other than those composed of sand; as for instance, rolls, car-wheels, etc., which require to be chilled in parts. This is accomplished by providing smooth cast-iron surfaces for the metal to lie against. Again, castings in zinc, lead, tin, or alloys made from these metals are frequently cast in moulds composed entirely of either brass or iron; by this means the castings are not only a true duplicate of each other, but are made much cheaper.

For flexible moulds, see GLUE-MOULDS and ELASTIC MOULDS; also, "The Iron Founder" and "The Iron Founder Supplement," in which works the whole art of moulding is comprehensively set forth.

Moulding in Dry Sand.—See DRY-SAND MOULDING.

Moulding in Loam.—See LOAM-MOULDING.

Moulding-machines.—These machines, in infinite variety, are now recognized everywhere as competent to produce castings of limited variety, in a far superior manner than is possible by the old methods. Besides the numerous excellent gear-moulding machines of Scott, Whittaker, Buckley & Taylor, and Simpson,—which, with a small portion of the pattern corresponding to the gear to be moulded, are all able to produce gears from 9 inches diameter up, either spur, bevel, mitre, mortise, or worm, plain or shrouded,—we have numbers of machines for the production of general work of all descriptions. Some of these machines are still worked with hand-levers, but these are being rapidly superseded by steam, hydraulic, and pneumatic contrivances, which, with their several automatic arrangements, demonstrate the capacity of their builders to overcome difficulties which until very lately seemed beyond the bounds of possibility.

The "Tabor" moulding-machine may be used with either steam, water, or compressed air; but steam is preferable in most cases, because it can be easily obtained without the use of special auxiliary machinery of any kind. The rammer system of this machine gives greater pressure at parts which would otherwise be too soft.

The "Yielding Platen" moulding-machine is provided on the top with a rubber bag containing water or compressed air, and the bottom of the machine is caused to rise by compressed air, thus forcing the flask with its sand against the rubber bag, which, they claim, presses the sand in a manner impossible by any other known method.

The "Teetor" moulding-machine provides means for holding the flask securely and turning it over; also for jarring the pattern and holding the same perfectly level, to allow a clean separation of the mould therefrom.

Moulding-sand.—See Facing-sand.

Moulding-tools.—Broadly speaking, moulding-tools consist of every foundry equipment necessary to make moulds with, including shovel, brushes, riddles, clamps, wedges, parallels, level, compass, vent-rods, gaggers, rammers, etc.; but the more artistic class, used for finishing the moulds with, are the ones usually recognized as moulding-tools. A full description of these, with instructions for using them, will be found at their respective places throughout this work.

Moulds for Steel.—See Steel Castings; Ingot-moulds.

Moulds, Open-sand.—See Open-sand Moulding.

Moulds, Pressure in.—See Pressure in Moulds.

Mousing-hook.—A hook with some contrivance for preventing the hook, ring, or link resting therein from slipping out.

Muck-bar.—When the iron has been balled in the puddling-furnace, forced through the squeezer, and passed once through the roughing-rolls, it is termed *muck-bar*, and is ready for being cut into pieces for piling, reheating, and rolling again. See ROLLING-MILL.

Muffle.—An arched vessel with a flat bottom, made of refractory materials, in which to place cupels and tests in the operations of assaying, to preserve them from coming in direct contact with the fuel. One end is open, and slits on the side allow a draught of air through it. The substances operated upon are by this means effectually shielded from the impurities of the fuel. See ASSAY.

Muntz-metal.—An alloy of copper and zinc used for the sheathing of ships, composed of copper 60, zinc 40. This alloy admits of hot rolling. See BRASS; COPPER; SHEATHING-METAL.

Mushet Cast Steel is made by melting malleable scrap-iron with charcoal and oxide of manganese in crucibles directly, independent of blister-steel. See STEEL.

Mushet's Crucibles.—See CRUCIBLES.

Music-metal.—Tin 65.8, antimony 8, copper 26, iron 3.2. The common alloy is tin 80, copper 20. See BRASS; COPPER; ALLOYS.

N.

Nails.—Formerly all nails were made by hand or forged on the anvil, and large quantities are still produced in this manner in England and other parts of Europe. Nail-making by machinery was originated in Massachusetts in 1810. At present we have machine wrought-nails, cut-nails, and cast-nails. The machine cut-nails are simply wedge-like in breadth, equal in thickness—head and body—to the sheet iron from which they are cut, and these are always to be preferred for strengthening and securing the sand surfaces of moulds, rather than those which have had heads forged on them. The length of iron machine cut-nails and the number contained in a pound will be found in the following table:

Size.	Length in inches.	No. in a pound.	Size.	Length in inches.	No. in a pound.	Size.	Length in inches.	No. in a pound.
3-Penny.	1¼	420	6-Penny.	2	175	12-Penny.	3¼	52
4 "	1½	270	8 "	2½	100	20 "	3½	28
5 "	1¾	220	10 "	3	65	30 "	4	24
						40 "	4¼	20

Naphtha.—This word is derived from the Persian (to exude), and was originally applied to an inflammable liquid hydro-carbon which exudes from the soil in certain parts of Persia. The term is, however, now used to designate a similar and almost identical fluid that issues from the ground in many parts of the world, and is known as petroleum, rock-oil, etc., but the term is also applied to other liquids which resemble true naphtha in little else than in their volatility and inflammability, as methylic alcohol or wood-spirit, etc. See PETROLEUM.

Native Iron.—Native iron is of rare occurrence; it almost always forms part of meteoric stones. When found it is malleable, and may be worked like manufactured iron. See METEORIC IRON.

Natural Gas.—Gas-springs or gas-wells through which issue combustible gases from the earth are to be found in various parts of the world. It was by this means that the holy fires of Baku, on the Caspian, and the sacred fires of the Greeks were supplied with fuel. It is supposed to be the same as the *fire-damp* of coal-mines, which is liberated by the pick of the miner. In all cases these combustible gases consist to a large extent of *marsh-gas*, also called light carburetted hydrogen. (See MARSH-GAS.) In many cities throughout the States, notably Pittsburg, the gas is used altogether as a steam-producer; for heating metals,—iron, steel, brass, etc.,—in the diverse branches of their utilization, except for smelting ore, in which coke continues still to be employed. Natural gas has an intense heating-power, is free from substances deleterious to metals, is cheap and easily handled, and leaves no ashes. One thousand cubic feet of gas is equivalent in heating-power to 56 pounds of coal, which represents a saving of 20 per cent at first cost, besides the labor of handling and transportation. See FUEL.

New Red-sandstone.—The name given to a group of sandstones, generally of a red color, occurring between the carboniferous rocks and the lias, which name is given them in contradiction to the old red-sandstone group, which lies below the coal-measures and has a similar mineral structure. See OLD RED SANDSTONE; FACING-SAND; BLACK SAND.

New Sand.—Fresh sand from the quarries and pits, furnished to the foundries for moulding purposes. See BLACK SAND; FACING-SAND; OLD SAND.

Newton's Fusible Metal.—Bismuth 8, lead 5, tin 3. This alloy melts at 212°. See FUSIBLE ALLOYS.

Nickel.—A white metal which, when pure, is both ductile and malleable. Its color is intermediate between that of silver and tin, and is not altered by the air. It is nearly as hard as iron. Its specific gravity is 8.27, and when forged 8.66. The species of nickel ores are its alloy with arsenic and a little sulphur and its oxide; the first is the most abundant, and the one from which nickel is usually extracted. It is known to mineralogists by the German name of *kupfernickel*, or *false copper*, from its color and appearance. Nickel only occurs in the native state in meteoric stones.

Nickel fuses at 2800° F. Its ores are found in the United States and in Germany, Sweden, and Hungary. The effect of the magnet upon pure nickel is very little inferior to that which it exerts on iron, but this entirely ceases when the metal is heated to 350° F.

The chief use of nickel has been in the composition of various alloys, especially German-silver, all of which are duly noticed in their respective order. It is, however, being gradually introduced as an alloy with steel for ship's armor, etc. See GERMAN-SILVER.

Nickel-plating.—The art of nickel electro-plating was invented by Böttcher about 1848, and had developed into an important industry. The best kind of solution to use is one of the double sulphate of nickel and ammonia, which should be saturated at 25°, and used in conjunction with a plate of nickel as positive electrode. See PLATING.

Niello-engraving.—A kind of engraving of considerable antiquity. It was very much practised in the middle ages. The art consisted in drawing a design with a *stylus* or needle on gold and silver plates, and then cutting it with a graver. These incised lines were then filled with a composition of copper 1, bismuth 1, lead 1, and silver 9, the compound being of a bluish color when a little sulphur is added. The metal is called Niello-silver, or Tula.

Nitre, or Saltpetre, as it is commonly called, occurs as a native product in the earth in many parts of the world, and is separated therefrom by leaching the soil and allowing the nitre to crystallize. It is artificially formed by heaping up organic matter with lime, ashes, and soil, and keeping the mass moistened with urine for a lengthened period, when the heap is lixiviated and the salt crystallized out. Nitre dissolves in about three times its weight of cold and one third its weight of boiling water. Paper dipped in this solution and dried forms what is known as touch-paper. Nitre has a cooling, saline taste, and strong antiseptic powers. Owing to the latter quality it is extensively used in packing meat. It is chiefly consumed, however, in the manufacture of gunpowder ; the large amount of oxygen it contains, and the feeble affinity by which it is held, adapting it for sudden and rapid combustion.

Nitric Acid.—The two principal constituent parts of our atmosphere—oxygen and nitrogen gases—when in certain proportions are capable under particular circumstances of combining chemically into one of the most powerful acids—the nitric. For all practical purposes, nitric acid is obtained from nitrate of potash, from which it is expelled by sulphuric acid.

The nitric acid is of considerable use in the arts. It is employed for etching on copper ; as a solvent of tin to form with that metal a mordant for some of the finest dyes; in metallurgy and assaying, in various chemical processes, on account of the facility with which it parts with oxygen and dissolves metals. For the purposes of the arts it is commonly used in a diluted state and adulterated with sulphuric and muriatic acids, by the name of *aquafortis*. Two kinds are made: one called *double aquafortis,* which is one half the strength of nitric acid; the other simply aquafortis, which is half the strength of the double. A compound made by mixing two parts of the nitric acid with one of muriatic, known formerly by the name of *aqua regia,* and now by that of *nitro-muriatic acid,* has the property of dissolving gold and platina. On mixing the two acids heat is given out, an effervescence takes place, and the mixture acquires an orange color. See Aqua Regia; Atmosphere.

Nitrogen.—A gas discovered by Rutherford in 1772. It is extensively diffused in nature, forming about four fifths of the atmosphere, in which it plays the important part of diluting the oxygen and adapting it to the conditions of life. It is an important element of the vegetable kingdom, entering in considerable quantity into many of its compounds. It is supplied to plants by ammonia and nitric acid. Our food is largely composed of nitrogen, and it forms 16 per cent of the tissues of the animal body. Nitrogen is not found in any of the mineral formations of the earth's crust, except in some varieties of coal. See Atmosphere; Oxygen; Ammonia.

Nosing.—The projecting moulding on the edge of a stair tread, which stands immediately in front at the top edge of the riser.

Nowel.—The bottom flask in a set composed of cope and nowel. See Flasks.

Numbering Pig Iron.—The numbers given to pig iron, as No. 1, No. 2, No. 3, etc., is simply a commercial classification in order to distinguish the various qualities as delivered from the blast-furnaces, indicating to the purchaser the grade or quality of each brand and the purposes for which they are best adapted. No. 1 invariably shows the largest crystals, is soft and bright, and adapted for light castings; No. 2, of the same brand, will be recognized as lighter in color, with smaller crystals, suitable for general work, machinery, etc.; while again, of the same brand we may have a more dense iron, with indications of mottle, which is denominated No. 3; and so on to white iron, a higher number still. See CAST IRON, WHITE IRON, GRAY IRON, MOTTLED IRON.

Number of Nails in a Pound.—See NAILS.

Nurnberg Gold.—A mock gold, exactly like Manheim. See MANHEIM GOLD.

Nuts in Loam-plates.—When it is desired to connect one or more plates (with the intervening bricks), in loam-moulding, where staples for hook-bolts would be objectionable, a reliable substitute for the latter will be found by casting threaded nuts at parts of the plate convenient for inserting iron bolts with threads on both ends. The nuts can be made immovable in the plate by filing a slight V at the corners for the molten iron to fill when the plates are cast. See BINDING-PLATES.

O.

Oils and Fats.—Fats are merely solid or semi-fluid oils. The fixed oils and fats form a well-defined group of organic compounds, which are abundantly obtained from the animal and vegetable kingdoms. They are not so heavy as water, their specific gravity ranging from 0.91 to 0.94. They differ very much in their degrees of solidity, and do not consist of any single substance in a state of purity, being principally mixtures in varying proportions of four different but closely-allied bodies, viz.: stearine (or suet); palmitine (so called from olive-oil, being very abundant in the latter); margarine (from a pearl, owing to its pearly lustre); and oleine. The three first are solid at common temperatures, while the fourth remains liquid. Fat is softer and its melting-point lower in proportion to the quantity of oleine it contains.

Fats are all soluble in ether, oil of turpentine, benzol, and to a certain extent in alcohol, but not in water. The most solid fat sare readily reducible, and become reduced to a fluid or oily state at a temperature lower than that of the boiling-point of water. When the fats or oils are boiled with an alkali they undergo the remarkable change called saponification. The fat by this process is decomposed into a fatty acid and glycerine, the acid combining with the alkali to form soap, and the glycerine passes into solution.

Chevreul discovered that the fats and oils consisted of several proximate principles, known as *stearine, margarine,* and *oleine,* which are each capable of being separated into an acid and a base, the base being the same in all, and known as glycerine.

Oleine is that portion of oil which, as before said, causes its fluidity. Stearine gives to certain fats and oils the opposite quality of solidity, as in candles, etc. Margarine resembles stearine in its property of hardness; it exists in human fat, butter, olive-oil, etc.

The fixed oils are of two classes—the drying oils, or those which harden on exposure to the air; and the unctuous oils, or those which remain soft and greasy under the same exposure. The hardening of the oils is due to the absorption of oxygen.

The most important of the drying oils is linseed, which is obtained by subjecting flaxseeds to pressure. Next in importance as a drying oil for paints is hemp-seed, poppy, and walnut. The most important non-drying oils are olive-oil, almond-oil, and colza-oil, which are extensively used in making soap, candles, and illuminating oils. Castor-oil is a connecting link to these two classes of oils, being gradually hardened by long exposure to the atmosphere.

The drying property of oils is much increased by heating them with about .05 of their weight of litharge, which becomes dissolved by the oil. Linseed-oil thus treated is known as boiled oil. See LITHARGE.

Oil-stone.—See WHETSTONE.

Old Red-sandstone.—This group of sandstone lies below the carboniferous strata, and was called "old" to distinguish it from a series of similar strata which occur above the coal-measures. See NEW RED-SANDSTONE.

Old Sand.—See BLACK SAND; NEW SAND; FACING-SAND.

Oleine.—See OILS.

Olive Bronze Dip for Brass.—Nitric acid 3 ounces, muriatic acid 2 ounces; add titanium or palladium. When the metal is dissolved add two gallons of pure soft water to each pint of the solution. See STAINS FOR METALS.

Onyx.—A chalcedony, with alternate layers of white, black, and brown. It is found in Saxony, Arabia, and Ireland, and is used largely for cameos. See PRECIOUS STONES.

Oolite.—A variety of limestone, so called from its being composed of small rounded grains resembling the roe of a fish, cemented together by a calcareous formation. See LIMESTONE.

Opal.—A species of the quartz family of minerals, from which it differs in containing 5 to 13 per cent of water. It is a precious stone, consisting principally of silica with some alumina. When first dug from the earth it is soft, but it hardens and diminishes in bulk by exposure to the air. The specific gravity varies from 1.9 to 2.5. Subspecies of this gem are called the semi and the wood opal. It is translucent, usually blue or yellowish white, and exhibits a beautiful play of brilliant colors owing to minute fissures which refract the light. Found in Hungary, Queenstown, and the United States. See MINERALS; PRECIOUS STONES.

Open-hearth Cast Steel.—This steel is produced on a large scale and is so called to distinguish it from steel made by the Bessemer process, by puddling, or from blister-steel melted in the crucible.

Heath, in 1845, patented his invention of producing cast steel by dissolving malleable scrap in molten cast iron by a process independent of crucibles, by melting pig iron in a cupola, and running this into the bed of a steel-making furnace, into the upper part of which the malleable iron was introduced in bars, that they might be heated by the waste heat and gradually pushed forward so as to dissolve in the molten pig, with the formation of steel. Siemens said this method would have been successful had the regenerative principle been known to Heath, whereby he could have obtained the requisite intensity of heat and absence of cutting draught essential to the proper combination together, by fusion, of the wrought and carbonized iron without oxidation. Substantially, with the addition of the use of a regenerative furnace and improved working details, it is one of the forms of steel-making now known as the Siemens or Siemens-Martin processes. By employing the open-hearth and steel-melting regenerative furnace in the processes of steel-making, the highest possible temperatures are attainable, and the evil effects of a cutting flame and strong draught are obviated.

The Siemens or ore process of producing steel consists in melting hematite or other pig iron free from sulphur and phosphorus, and then adding in small quantities at a time an equally pure ore until a sample, taken out from time to time, does not harden on plunging into water while red-hot. To the fused iron spiegeleisen, etc., is then added. Another method consists of a combination of the Martin and the ore process; the pig and scrap, etc., being fused together, and the decarbonization being then effected, not through oxidation by the gases alone, but by that together with ore added to the mass. The Pernot furnace for steel-making is simply a Siemens-Martin furnace with a rotating bed, the hearth being a saucer-shaped cavity supported by an iron frame, mounted on a nearly vertical axis, and running on wheels upon a rail or guide, supported on a stout bogie. The bed is rotated by means of gear-wheels. The charges of pig iron and scrap are well heated before being placed on the hearth, which, when it is made to revolve at from 2 to 4 revolutions per minute, causes the different pieces to keep constantly changing their position; and this, coupled with the fact that one half of the bed is being alternately brought under the full action of the flame as the charge slips down at each revolution, brings about a very rapid fusion of the mass. See REGENERATIVE FURNACE.

Open-sand Moulding.—The process of moulding castings that have one plain side, in the sand floor of the foundry. Even for such castings it is usual to cover them with a cope, which, when secured, permits of pressure being applied to force the metal close to the upper surface, so that the casting has nearly the same appearance all over; but when the metal is poured into an open mould it must assume a horizontal position of its own accord. If, when the open mould has been cast, fine dry sand is scattered evenly over the surface of molten iron to the depth of one-fourth of an inch, it will shield the metal from the action of the atmosphere and thus prevent the formation of blisters, which almost always rise when the surface is left unprotected. When the mass has solidified more sand may be added with the shovel, in such quantity and location as will favor equal cooling of the whole. See Bed.

Ordnance signifies, in its most comprehensive sense, every kind of artillery, including guns, mortars, howitzers, etc. Many of the early pieces of ordnance were made of hooped bars. The mortar, which was introduced about the commencement of the fourteenth century, was the first European firearm. About the beginning of the fifteenth century bronze cannon were cast, and it is probable that cast-iron cannon of small calibre were made during the sixteenth century. However, there is positive evidence of iron cannon being cast about 1740 by English workmen, who were afterwards taken across the Channel to teach Frenchmen the art.

Cannon-founding has therefore been practised nearly five hundred years; but it would appear, from the wonderful specimens in steel and wrought iron lately produced by Armstrong, Whitworth, Krupp, and some others, that the art of casting ordnance was doomed to decay, as even the monster 300-pounder rifled Parrott and the 15-inch 450-pounder Rodman appear almost insignificant when compared with the more modern steel monsters constructed by the above-named inventors.

Bronze and cast-iron cannon are cast in loam or sand in moulds prepared in the customary manner. They are cast vertically, with an addition to the length to make up for shrinkage, and also to carry off the sullage. It was formerly the practice to cast them hollow; since then, however, solid ones have occasionally been preferred. But the results were not satisfactory, and the Rodman principle has been extensively adopted, the idea being to cool the metal in layers from the inside outwards, thus modifying the initial strain upon the gun, and producing the best results that may be expected from cast iron for ordnance purposes. The method is to flow cold water through the core-barrel during the process of casting and for a stated time afterwards, according to the thickness of the casting. The manner of constructing the mould is as follows: The mould is a dry-sand one, contained in circular sectional casings of length sufficient for the casting with its sinking head. The chief feature is the core-barrel, which consists of a sound, water-tight cast pipe or barrel, with flutes on its exterior surface along its whole length, to permit the gas to escape upwards from behind the hemp and loam with which the barrel is coated. After the mould has been closed together the barrel is attached to a spider or tripod, the legs of which rest upon the top flange of the casing; adjustable screws at the ends of each leg admit of a ready adjustment of the core after it has been suspended and lowered into its place in the mould. The water for cooling is led to the bottom of the core-barrel by a pipe which stands central in the space; it then ascends through the annular space between the pipe and the barrel, and flows off by a suitable arrangement at the top. For a 15-inch gun treated this way the barrel may be withdrawn in about twenty hours, after which a continuous flow of cold air is forced through the bore until the casting is cool enough to be removed, which in this case is about nine or ten days. See SPIDER; CORE-BARREL; DRY-SAND MOULDING.

Oreide.—An alloy supposed to be of French origin; it is used as a substitute for "ormolu" in the manufacture of cheap jewelry, excelling the latter alloy very much in its gold-like character. First, melt copper 100, then add and stir well in magnesia 6, sal-ammoniac 3.6, quicklime 9.12, tartar of commerce 9, and zinc or tin 17, in the order as given. This must be kept fusing about three quarters of an hour before it is used.

Copper 80, zinc 13.5, nickel 6.5 is recommended as equal to the former as an oreide mixture. See ORMOLU; MOSAIC GOLD; MOCK GOLD; GOLD; TOMBAC.

Ores are the mineral bodies from which metals are extracted, the latter being found therein sometimes in a metallic state, and so nearly pure as to be called *native metals.* But it is generally in a state of ore that metal occurs, that is, in combination with its mineralizing substance.

When metals combine in the metallic state they are termed *alloys;* combined with acids, they form carbonates, bromides, phosphates, chlorides, etc., and are then designated *metallic salts.* With sulphur they form sulphurets and sulphides; and, again, combined with oxygen they form the numerous oxides.

The soil and rocks consist of metallic oxides, but the chief metals are not so widely disseminated. They are found in various places and at different depths below the surface, in the form of seams, beds, or mineral veins, and sometimes as lodes (See LODE). The treatment of ores for obtaining the metal is mechanical and chemical, the more valuable ores requiring considerable care in their management; but the operations vary considerably, according to the kind of ore under treatment.

The ores of lead and tin when brought to the surface are at once sorted, and the purest lumps set aside for treatment in the smelting-furnace; what is left, after being subjected to a crushing or hammering process, is again sorted. What remains is then crushed in revolving cylinders and passes through sieves, the finer residue being agitated in water by a process termed *jigging*. The crushing is completed in the *stamping-mill*, where the ore is repeatedly pounded and washed, and the powdered ores settle in layers, according to their specific gravity.

The chemical treatment of ores is invariably twofold—*roasting* or *calcining*, and *reducing*. (See CALCINATION.) If they contain volatile products, as sulphur and arsenic, which may be removed by oxidation or heat, they are first roasted. This is accomplished in a kind of reverberatory furnace, where the fuel is served at one end and the flame and heated gases are reverberated or thrown down from the arched roof of the furnace upon the ore, which is distributed over its bed. In this way ores are oxidized. Should the ore contain sulphur, it is burned off and passes away as sulphurous acid, while arsenic escapes in the form of arsenious acid. Sometimes lead is at once procured by the operation of roasting, or it is changed to the state of oxide, which necessitates another process to set it free.

Reduction of ores means the chemical process of deoxidation, or smelting. It is effected by heating them to a high temperature in contact with substances which take the oxygen from the metal by superior affinity. Carbon is the chief among deoxidizing agents, and removes the oxygen in the form of carbonic oxide and carbonic acid. For the removal of the numerous earthy impurities, substances are employed which are called *fluxes*; these readily combine with them in a molten condition and flow off as a slag. See CAST IRON; REDUCTION OF ORES.

Organ-pipes are usually made from a composition of tin 9, lead 1, subject to slight variations. See ALLOYS; WHITE ALLOYS; TIN; LEAD.

Ormolu.—A variety of brass having a near resemblance to gold, containing from 25 to 50 of zinc to 50 of copper, according to the tint desired. To successfully fuse this alloy, let the zinc be added to the fused copper at the lowest temperature possible, gradually introducing the zinc until the whole amount has been added. In many cases it is used for the ornamentation of furniture. A gold lacquer is sometimes used to heighten the color of the alloy, but the native color of the metal may be preserved if properly brought out by means of sulphuric acid, then washing in water, and applying a liquor varnish to keep it from tarnishing. See BRASS; DIPPING; STAINS FOR METALS; OREIDE.

Ormolu Dipping Acid for Sheet Brass.—Sulphuric acid 2 gallons, nitric acid 1 pint, muriatic acid 1 pint, water 1 pint, nitre 12 pounds. Put in the muriatic acid last, a little at a time, and stir with a stick. For cast brass: Sulphuric acid 1 quart, nitre 1 quart, water 1 quart; a little muriatic acid may be added or omitted. See DIPPING.

Ormolued Brass Dipping Acid.—Sulphuric acid 1 gallon, nitric acid 1 gallon. This is a quick bright dipping acid for brass-work that has been already ormolued. See DIPPING.

Osmium.—This metal was discovered by Tennant in 1803. It belongs to the class usually termed "noble," and occurs in association with platinum in the form of an alloy with iridium. It is the least fusible of all the metals, as the oxyhydrogen jet will volatilize, but not fuse it. This metal, like iridium, is extensively employed for tipping gold pens. See METALS.

Ounce.—A division of the pound weight in English.

In Troy weight it means the twelfth part of a pound, and weighs 480 grains. In avoirdupois weight the ounce is the sixteenth part of a pound, and equal to 437½ grains Troy.

Ovens for Drying Moulds and Cores.—Much subsequent annoyance and loss is saved by exercising forethought with regard to location, size, and style of oven when it has been decided to build a new or make extensive alterations in an old foundry. Some moulds, owing to their magnitude and form, must necessarily be built in the casting-pit and dried there. The pit becomes, in such cases, a drying stove or oven by simply closing the mouth and building open fires at convenient places on the bottom if wood or bituminous coal is used for fuel; if anthracite coal must be the fuel, then recourse must be had to extemporized exterior fireplaces, with suitable arrangements for creating a draught. It is, however, possible, in some instances, to build large moulds in sections, and by this means convey all the parts to the oven to be dried—a very superior way when it can be done. Temporary contrivances for drying small cores are to be met with in almost every foundry, from the rim and bottom-plate of the heating stove to the more elaborate device consisting of wrought- or cast-iron sides bolted together, inside of which are slides to rest shelves upon, the top having a hole with raised edge to receive a stove-pipe. The hinged door may be the full size of the oven, so as to expose all parts of the oven at once. An ordinary fire-pot, with provision for draught underneath, can be set down in the floor and this oven set over it, or the plates may be long enough to permit the fireplace to be enclosed within the structure, and thus make the oven a portable one.

Millet's patent core-oven for small cores is a brick structure with an iron front, to which is attached the necessary hinges for swinging the perforated shelves in and out.

Each of the shelves works independently, and, by means of a duplicate door on the back, the oven is closed, thus retaining the heat in the oven while the cores are being loaded or unloaded. It will be seen that no heat escapes. Cores may be handled with dispatch, as all operations are conducted outside, so that both fuel and time are economized. Other excellent ovens for small cores may be obtained from the supply dealers at a very low cost, which when placed down on the floor and a pipe connection made are at once ready for use.

Steam-heated ovens are now very numerous. They consist of steam-piping laid direct from the boiler to the oven, where a valve controls the amount of steam allowed to enter a system of coils, which latter constitute the core shelves as well, being set somewhat slanting for drainage. Sixty pounds steam-pressure in the coils give a temperature in the oven of 250°, which is sufficient to dry ordinary cores without the possibility of burning them; an increased pressure will, of course, give greater heat. Ventilation is perhaps best secured by a somewhat loose-fitting door and an outlet at the bottom of the wall. The ordinary ovens for drying large moulds and cores are, as a rule, very defective, lacking in suitable rack and carriage accommodation,—two very important features, well worthy of more than ordinary consideration. To save the annoyance and loss attendant on moving heavy loads in and out of the oven, they may very readily be constructed of two main walls of masonry, having hinge fixings built in them on the top and ends, to which plate-iron doors may be accurately hinged. When the moulds are ready for the oven, the covers are thrown back and the end or ends opened, so that a free passage is made for loading direct from the crane to the oven, and thus obviating the jarring of the moulds which usually attends transit on carriages. Closing over the top covers and shutting in the ends converts this into an admirable oven at once, which, when the moulds are dry, may be opened again and become, as it were, part of the foundry floor, on which the moulds may rest safely until required for closing and casting. For description and details of special large oven constructed by the author, see "The Iron Founder," p. 52. See also DAMPER; ROTARY OVENS.

Overhead Cranes.—See CRANES; IRON-CARRIER.

Oxalic Acid.—This substance exists as binoxalate of potash in common sorrel and the rhubarb plant, which accounts for the acid taste common to those vegetables. As oxalate of soda it is found in the barilla plant, and as oxalate of lime in lichens. It is commonly prepared by the oxidation of sugar or starch with nitric acid : 1 part of sugar is dissolved in 8 parts of nitric acid and gently heated, when intense action ensues, with a copious disengagement of nitrous-acid fumes. The crystals obtained are sour and poisonous, resembling Epsom salts, for which they are often mistaken. Chalk or magnesia suspended in water acts as an antidote in cases of poisoning. This acid is extensively used in calico-printing, and is also employed as a test for the presence of lime. It also removes ink and iron stains from cloth by forming a soluble oxalate of iron, but the fabric suffers injury if the acid be not washed off immediately.

Oxidation.—The process or converting metals or other substances into oxides, by combining with them a certain portion of oxygen. It differs from acidification in the addition of oxygen not being sufficient to form an acid with the substance oxidized. See OXIDES; OXYGEN.

Oxide, Carbonic.—When a mixture of purified charcoal and oxide of iron or zinc is exposed to a strong heat in an iron retort, the metallic oxide is gradually reduced, and during the reduction a great quantity of gas is evolved. This gas is a mixture of carbonic-acid gas and another gas, which burns with a blue flame and is called carbonic oxide. See GAS; OXYGEN.

Oxides.—Substances combined with oxygen without being in a state of acid. The metallic oxides are the most important, and occur naturally as abundant and valuable ores. See METALS; ORES; REDUCTION OF ORES; OXYGEN.

Oxidized Metal is silver or other metal subjected to a process of dipping into a boiling solution of hyposulphite of soda or ammonium sulphide, continuing the process until the required degree of discoloration has taken place. It may then be varnished with non-transparent varnish consisting of alcohol 18, red arsenic 3, castor-oil 1. See DIPPING; LACQUERING; STAINING METALS.

Oxygen.—This gas was obtained by Dr. Priestley in 1774 from red oxide of mercury exposed to a burning lens, and again in the following year by the Swedish chemist Scheele. With regard to the importance of this great discovery Prof. Liebig observes: "Since the discovery of oxygen the civilized world has undergone a revolution in manners and customs. The knowledge of the composition of the atmosphere, of the solid crust of the earth, of water, and of their influence upon the life of plants and animals, was linked with that discovery. The successful pursuit of innumerable trades and manufactures, the profitable separation of metals from their ores, also stand in the closest connection therewith. It may well be said that the material prosperity of empires has increased manifold since the time oxygen became known, and the fortune of every individual has been augmented in proportion." Eight ninths of water consist of oxygen; it forms one fifth of air and about one half of silica, chalk, and alumina, which three constitute the chief substances of the earth's surface. It is absolutely essential for the support of animal life. In mechanical combination with nitrogen it forms the atmosphere surrounding the globe, and is given off by all growing plants when under the influence of sunlight. Its chemical affinities for other elementary substances are very powerful, combining with all except *fluorine*. Owing to the intensity with which many of these combinations takes place, this gas has the power of supporting combustion in an eminent degree. It is tasteless, colorless, inodorous, and has hitherto resisted all attempts to liquify it. Combustion is nothing more than a chemical union of the oxygen of the air with the combustible body or some of its elements. We make the fire hotter by bringing more air in contact with the fuel. See COMBUSTION; FLAME, etc.

Oxyhydrogen Blowpipe.—An apparatus for burning oxygen and hydrogen together to produce very high temperature. Now extensively used for melting platinum and other metals. The oxygen and hydrogen pass through separate tubes and mix at the mouth of the jet, producing the most intense heat known.

Oyster-shells.—The carbonate of lime being the prevalent component of the oyster-shell, it has on that account been substituted for limestone as a flux in the cupola at many foundries. But shells are not as effective for this purpose as good limestone, owing to the adhering impurities, which invariably contain some phosphorus. See SHELLS; LIMESTONE FLUX; FLUX; PHOSPHORUS.

P.

Packfong.—An alloy much used by the Chinese, and by them called "white copper," consists of copper 40.4, nickel 31.6, zinc 25.4, iron 2.6. See GERMAN-SILVER; WHITE ALLOYS.

Packing Sand.—The process of forcing sand into the flasks or around patterns bedded in the floor is sometimes termed packing. See RAMMING.

Palladium.—This metal closely resembles platinum in color and appearance; it is also very malleable and ductile. It is not so dense as platinum, being only 11.8, and it is more easily oxidized than that metal, but cannot be melted at ordinary temperatures. Palladium readily alloys with other metals. When alloyed with silver it is very suitable for the graduations on mathematical instruments, etc. It is used also as a galvanizing agent for protecting other metals when amalgamated with mercury, the iron or other articles being cleansed previously as for zinking. See METALS; ZINKING.

Pan, or Kettle, is usually a wide, shallow, round or spherical-shaped vessel, of cast-iron or other metal, employed in the manufacture of sugar, salt chemicals, soap, tin-plate, and in the various processes connected with metallurgy. For sugar-refining there are evaporating-pans, vacuum-pans, condensing-kettles, vats, coolers, etc. Salt-pans are usually very wide and shallow, and are set in rows over a furnace. The brine is pumped into them, the heat evaporates the water, and the salt precipitates. The chemical works employ large numbers of pans of different shapes, heavy and light, such as the flat furnace-pans, 8 to 10 feet across, which are sometimes over 6 inches thick at the crown; lighter ones, as crystallizing cones, etc., are used in large numbers. Pans for soap-making are termed "boilers," and consist of a deep, circular, tapered pan with a spherical bottom. Brackets cast on the sides serve to set the pan on standards over the fire. Pans used for tin-plate are of cast iron. They are set in a row, and are named, respectively, the tin-pot, wash-pot, grease-pot, pan, and list-pot. Pans for metallurgical purposes are termed *amalgamators*, being usually an open, flat-bottomed, pan in which the pulverized ore and mercury are ground together between slabs of stone or metal. (See AMALGAMATION.) Owing to the great demand for castings of this class, much ingenuity has been practised for moulding them readily, resulting in well-established methods of production, which far excel the ordinary systems of moulding. See KETTLE; CASING.

Paper-moulding consists of grinding old paper along with other materials into a pulp, which by the aid of presses and other machinery is moulded into the required form, dried, and then subjected to the processes of sizing, decorating, etc. It is used extensively in the production of architectural ornaments, etc., being less brittle than plaster for that purpose. By mixing white of egg, sulphate of iron, glue, or quicklime, etc., with the pulp it is partly made waterproof, and to make it almost fireproof it only requires a further admixture of borax and sulphate of soda. Another method of producing articles in paper is to glue sheets of paper together and then subject the whole to powerful pressure in dies accurately fashioned to the form of article to be made. This operation is performed when the sheets are moist, which admits of the requisite curvature and flexure without damage to the article, which when dry becomes as hard as board, and is then ready to be operated upon by the japanners, inlayers, and other artists in ornamentation.

Paper-parting.—Ordinary moulding-sand will not adhere to paper that is free from substances of a gummy or gluey nature, no matter how hard it has been rammed thereon. For this reason it makes an excellent substitute for parting-sand at parts of a joint where it is difficult to apply the sand in either a wet or dry condition. See PARTING; JOINT; PARTING-SAND.

Paper Sheathing for Studs.—It is sometimes convenient to use a plain stem chaplet at parts of a casting where there is not sufficient body of metal to partially fuse, and thus fasten it. In such a case the surrounding cast iron is chilled, and it is with great difficulty that a thread can be made by which to insert a plug. If, before the chaplet is inserted in the mould, a thick layer of paper be glued thereon and an extra coat of silver-lead applied, the hole will be clean and the metal soft for tapping.

Paraffine is a product of the distillation of wood (especially beech-wood), coal, and petroleum. It is a white, hard, inodorous, tasteless, crystalline solid, resembling spermaceti. It melts at 111°, and is formed into candles, which burn with a very bright flame. It is a pure hydrocarbon. Paraffine-oil is the term given to the thin oily matter given off during the process of distillation. See PETROLEUM.

Parallel Straight-edges are two straight strips of wood or metal, of equal widths along their length. By setting them edge up, some distance apart, on a pattern or mould, and allowing the eye to range along the upper edges of both, any deviation from a true and even surface is soon discovered, the eye being very quick to detect any discrepancy. See LEVEL; BED.

Paris Gold.—A cheap imitation of the pure metal. See OREIDE; TOMBAC.

Parisian White Metal is composed of copper 69.8, zinc 5.5, cadmium 4.7, nickel 19.8. See WHITE ALLOYS.

Part.—A foundry term, used to signify any one of the sections composing a set of flasks; as top-part, middle-part, bottom-part, etc. See FLASKS.

Particle.—A minute part of matter, an assemblage of general atoms, of which natural bodies are composed, as a *particle* of sand, etc.

Parting.—The joint or point of separation in moulds composed of two or more sections. A suitably prepared surface at some portion of a mould that will permit one part to be separated from another without fracturing the sand structure. For a separation of plain moulds contained in a cope and nowel, the sand-joint is made smooth and sprinkled all over with dry parting-sand, which prevents any portion of the sand rammed over it in the cope from adhering thereto. But should any portion of such joint assume a vertical or other form than the horizontal, the parting-sand must be moistened before it will adhere to the joint surface; especially is this the case with drawbacks, which separate in a vertical position. In either of the latter-mentioned cases paper may be substituted for the moistened parting-sand. See DRAWBACKS; PAPER-PARTING; PARTING-SAND.

Parting-sand is sand specially adapted to the prevention of joint, or separating surfaces amalgamating when they have been rammed against each other. Beach and river sands are eminently adapted for this purpose, as all clayey compounds have, by the action of the water, been washed out. New fine free sand, well burnt to eliminate every trace of clay, is adapted for use as a parting-sand; and it may be said that the beach and river sands have their parting qualities enhanced by burning, the burnt cores from the castings being always preferred to the new sands. See PARTING; JOINT; etc.

Paste.—Foundry-paste is simply flour mixed with water to a consistency suitable for the joining together of dry-sand cores and moulds that are made in sections. It may also be used in the coring of moulds when it is desirable to effectually prevent the escape of metal at the points of junction, its spreading quality permitting the soft, yielding mass to be forced into every crevice, where, if the mould be hot enough, it dries into a hard impenetrable mass. There is much danger, however, in using too much paste, especially in cold moulds. When the molten metal enters the mould the wet surfaces are at once converted into steam, which, if not all ejected during the process of casting, seldom fails in producing blow-holes at some part or other. See SIZE; BLISTER; BLOW-HOLES.

Paste Gems are a glass imitation of precious stones, made from a combination of silica, potash, borax, red oxide of lead, with some arsenic. This is fused gently in Hessian crucibles, in the furnace, for about twenty-four hours, and it then becomes a base for the manufacture of all the spurious gems. For the ruby, 72 parts of oxide of manganese are mixed with 2880 parts of the paste; emerald—green oxide of copper 42, and oxide of chrome 2, to paste 4608 parts—sapphire: oxide of cobalt 68, to paste 4608 parts; fused for thirty hours. Amethyst—oxide of manganese

36, oxide of cobalt 24, purple of cassius 1, to paste 4608. The tints of the real stone are so exactly imitated in many of these imitations as to deceive any but the best judges. See Precious Stones.

Patent Fluxes.—In addition to the limestone, fluorspar, and other fluxes, used in the cupola, blast-furnaces, puddling-furnace, smelting and refining, steel, and copper and brass works, there are numerous other compounds, etc., which are protected by letters-patent, by the use of which it is claimed that steel can be welded to steel or iron, with the best results; preventing the metal from burning by flowing easily, and enveloping it so as to exclude the air. For cupola-melting it is claimed they will save fuel, improve iron, make clean cupolas, and other improvements too numerous to mention.

Mr. Kirk, author of "Founding of Metals," is the inventor of a flux for the cupola, and in presenting his compound says as follows: "It will make hard iron soft, will reduce the percentage of iron lost in melting, will cleanse iron of impurities, will flux the cupola, and make a brittle slag. In introducing this compound as a cupola-flux, we introduce an entirely different theory of fluxing from that used in a blast-furnace, or that formerly used in the cupola, for we propose to flux the iron entirely with the gases generated by the compound, and not with the slag formed by it. The chemicals which we use in the compound are very rich in carbon, and when distributed over the fuel and heated by it they generate a very strong carbonic gas in the cupola, and this gas is absorbed by the iron from the time it begins to heat until it is drawn out of the cupola; so that we have a great deal more time to operate upon it than any of the mineral fluxes do, yet we do not have time enough to change an iron from one extreme to the other, and can only improve it to a certain extent at one melting; but by continued re-melting with the compound we can change the hardest of iron to the softest. If any founder doubts this theory of fluxing and improving iron by the gases, he has only to throw sufficient brimstone into his cupola on the fuel to form a sulphuric gas in the cupola, and he will find his iron to be as hard as glass; and if iron can be hardened by one gas, it can be softened by another." See FLUX; CUPOLA; SLAG.

Pattern.—In moulding, the pattern is a counterpart of the casting required, from which the moulder obtains an impression in sand or other plastic substance. This impression obtained, it remains to fill the space, previously occupied by the pattern, with molten metal, which when solidified is a true representation in metal of the pattern supplied, less the shrinkage. Patterns are sometimes called models, from the fact that the modeller furnishes patterns for both the brass and iron foundries made from plaster or stucco. Wood patterns made by the pattern-maker are by far the most numerous, including as they must patterns for nearly every cast piece used in producing the multitudinous examples of structural, machine, and engine work. Very much of moulding is now accomplished without a full pattern, when a good understanding is maintained between the moulder and the pattern-maker. By a judicious arrangement of strickles, making-up pieces, and sweeps, castings are very often made almost exclusive of a pattern altogether; but this only occurs when the ability of both artisans is above the average. Machines for moulding gears have reduced pattern-making for wheels to a fraction of what it formerly was, and numerous other castings may, by the aid of a segment and perhaps some core-boxes, be made by them as readily. Besides patterns in iron and brass, numerous others are the production of the modeller, made in stucco or plaster, and not a few are, with the aid of template and sweeps, made in loam by the moulder himself. See LOAM-PATTERNS; BACKING-OUT; SPINDLE.

Pattern Varnish.—Usually wood patterns are made from white straight-grained pine, which, while it is an excellent material for working and keeping its shape, is very soft and porous. If such patterns are moulded from without any subsequent treatment, the pores soon fill with sand-dust, which adheres firmly to the moulding-sand and leaves a scarred surface on the mould. To prevent this the patterns should receive a good coat of varnish made from one pound of shellac digested in one gallon of alcohol with as much lamp-black as will color it. After this has thoroughly dried, rub off with fine sand-paper and apply another coat of the varnish slightly diluted with alcohol. See VARNISH.

Pea-ore.—A form of compact brown iron ore, consisting of round, smooth grains varying in size from a mustard-seed to a pea. See ORES.

Pease-meal.—Cheap grades of this valuable food finds its way into the foundry, where it is used as a substitute for flour. See FLOUR.

Peat is one of the most important productions of alluvial ground, composing the soil of swamps, and consisting of the twigs, leaves, and roots of trees mixed with grass, plants, weeds, earth, etc., that have long lain in water, and thereby become decomposed into a blackish-brown mass that may be cut with the spade and dried for fuel. The better qualities contain about 40 per cent of carbon. In Ireland it is known as turf, where it is dug up, dried, and used for fuel. See FUEL.

Peck.—A dry measure of capacity, and equivalent to two imperial gallons, or 554.548 cubic inches. The fourth part of a bushel.

Peening.—The term applied to straightening crooked castings by hammering the concave side immediately opposite to the block or anvil upon which the convex side is resting. A spherical hammer-head is the best ordinarily for this purpose, and the blows should be regulated so that the concave side may be sufficiently expanded with the minimum amount of hammering, always commencing at the centre of the bend and working out gradually in every direction. The hammer used for this purpose is termed the "peening" hammer. See STRAIGHTENING CASTINGS.

Pegging-rammer is sometimes termed the peening-rammer, and consists of an oblong piece of cast or wrought iron of different lengths and widths, and varying from one quarter to one inch in thickness, secured to the end of a piece of tubing or bar iron, with which to force or "ram" the soft open sand of the last filling firmly down upon the preceding course. See BUTT-RAMMER; RAMMING.

Percentage of Fuel Used for Melting Cast Iron in the Cupola.—See RATIO OF FUEL TO IRON.

Petroleum.—Previous to the discovery of the value of petroleum as an illuminating agent, the only artificial light for domestic and other similar uses was the tallow-candle and dirty oil-lamp; but when whale and other animal oils became too costly, resort was had to natural tar and bituminous slate in order to obtain illuminating-oils, and lamp-oils were for a long time prepared from wood, resin, and other substances. The manufacture of coal-oil was introduced into this country about 1853, being confined to districts where bituminous coal could be mined at a cheap rate.

When the value of coal-oil had become recognized, rock-oil or petroleum began to claim attention as a ready means of supplying these oils cheaply, as it was found to be analogous in its properties to that distilled from soft coal. It is probable that the petroleum now found in the earth is the product of original decomposition, and of subsequent distillation. Petroleum is, however, rarely found in contact with bituminous strata of any kind, being usually found in fissures of sand rocks, which fissures serve two purposes—one, to give space for the formation and expansion of the hydrocarbon vapor; the other, to furnish receptacles for the condensed oils. To obtain this oil, one of these fissures must be pierced by a well, when in some instances the oil is forced with such velocity as to produce a jet one hundred feet high. This oil is found in great quantities on the shores of the Caspian Sea; at Burmah, in the East Indies; and in Pennsylvania, Canada, and many other parts of the American continent. Fine specimens of naphtha are found in several parts of Italy. The purer kinds of rock-oil, which are almost colorless and very thin, are NAPHTHA, while the more viscid and darker liquids are PETROLEUM. The variations of color and consistence in rock-oils is owing to the pitchy and fatty substances being more dissolved in those oils that are most fluid. The word *petroleum* (rock-oil) is used to designate the forms of bitumen that are of an oily consistence, the bitumen passing by insensible gradations into the volatile naphtha on the one hand, and semi-fluid mineral tars on the other. Among its distillates are carbon-oil, paraffine, naphtha, gasoline, and benzine. Besides its use for illuminating purposes, it is now recognized as a fuel on both steamships and locomotives, as well as for ordinary domestic and manufacturing purposes. The products of petroleum that have proved most valuable in medicine are the filtered-paraffine residues, as cosmoline, vaseline, etc., widely used, plain and medicated, as ointments. See BITUMEN.

Petroleum-furnace.—A furnace in which petroleum alone, or mixed with air or steam, is used exclusively for fuel. See LIQUID FUEL; PETROLEUM.

Pewter.—A useful alloy of tin and lead. The common or ley-pewter is 4 tin and 1 lead; plate-pewter, 100 tin, 8 antimony, and 2 each of bismuth and copper; trifle-pewter, 83 tin and 17 antimony. The best pewter is composed of 100 parts tin and 17 antimony. A very hard pewter is 192 tin, 16 antimony, and 4 copper. Tin-and-temper pewter is the best, and is made as follows: Let a "temper" be made from 2 parts tin and 1 part copper, and to every pig of tin weighing about 375 pounds add from 1 to 7 pounds of the temper. See PEWTERER'S TEMPER; TIN; ANTIMONY.

Pewterer's Solders.—These are of three kinds: the hard and soft pale, and the middling. Hard pale is made from 2 tin and 1 lead; for the soft pale an addition of 1 bismuth is made; and for the middling pale an equal mixture of both. See SOLDERING; SOLDERS.

Pewterer's Temper.—Tin 2 and copper 1, fused together, make the alloy above named. This temper, mixed in certain proportions with pig tin, produces the pewter named "tin-and-temper." See PEWTER; TIN.

Phosphor-bronze.—This bronze, according to the purposes for which it is intended, contains from 3 to 15 parts tin to 100 copper, with an addition of from $\frac{1}{4}$ to $2\frac{1}{2}$ per cent of phosphorus. This alloy can be remelted any number of times without altering its quality, which is as fine as cast steel, and may be made as hard as that metal or as tough as wrought iron; in fact, it can be made to any degree of hardness, toughness, or elasticity.

It is somewhat difficult to introduce the phosphorus into the crucible, and very much of it is lost in the operation. for which allowance must be made. The action of phosphorus on bronze alloy is to drive out the oxides, and cause the tin to adopt a crystalline structure, which gives the alloy a higher degree of homogeneousness than in common bronze. Another important feature is that any degree of hardness may be obtained by increasing the quantity of phosphorus, exclusive of any further addition of tin, the latter metal being sure to separate when used in too large proportions. The more advanced method of introducing the phosphorus is by adding phosphor copper, or phosphor tin, specially prepared for the purpose. See PHOSPHOR-COPPER; PHOSPHOR-TIN; BRONZE; COPPER.

Phosphor-copper is made by lining a crucible with a mixture composed of bone-ash, 18, silica 14, and powdered carbon 4, which is made into a daubing or lining by adding glue-water containing 4 parts each of powdered glass and carbonate of soda. Granulated copper is charged after the lining has been thoroughly dried, and covered with some of the lining mixture; after which the lid is luted on and the copper melted, when it will be found to contain about 0.52 per cent of phosphorus. The silicic acid acts on the phosphate, the phosphoric acid is reduced, and taken up as freed by the copper.

Another phosphor copper, containing about 9 per cent of phosphorus, can be produced by first making a phosphorous mass by mixing superphosphate of lime with 20 per cent of charcoal and dehydrating the mixture at a dull-red heat. Six hundred parts of this mass are mixed with 975 of copper turnings and 75 of charcoal, and kept at copper-fusion heat for sixteen hours in a graphite crucible. The phosphor copper is obtained in the form of detached granules, which are picked out, re-fused, and cast into cast-iron ingot-moulds. The introduction of phosphorus into the metal is better effected by means of these rich phosphor coppers than by any of the methods adopted for pushing it under the metal in a crude state. See PHOSPHOR-BRONZE.

Phosphor-tin is a phosphide of tin used as a medium for introducing phosphorus into bronze alloys, and sometimes used in conjunction with phosphor-copper for that purpose. It is made by heating 6 parts of phosphorus with 94 parts of moist tin-sponge prepared from the chloride by reduction with zinc. The sticks of phosphorus are first placed in the crucible and the tin sponge pressed hard down. A gentle heat is sufficient for this operation, which ends when the burning phosphorus ceases to give forth flame, and a coarse, white, crystalline substance has formed, which is the phosphor-tin. See PHOSPHOR-BRONZE.

Phosphorus is one of the non-metallic elements, and is found in nature only in combination—chiefly as the phosphate of lime. It would appear that plants require it, as more or less is found concentrated in their seeds. The bodies of animals contain it in a large degree, being present in the nervous tissues, the urine, the blood, the hair, and in the bones, which contain a large proportion of the phosphate of lime. The earthy phosphates are important, as they aid in giving stiffness and inflexibility to the bony skeleton. Phosphorus was discovered in urine by Brandt of Hamburg, 1669. It is chiefly made from bones ; when pure it appears like bleached wax, and is soft and flexible at common temperatures, melts at 44° and boils at 289°. Phosphorus, in its combining relation, is more closely connected with the metals arsenic and antimony than with any of the members of the sulphur group, in which it is commonly placed. See ARSENIC; ANTIMONY; PHOSPHOR-BRONZE.

Piano-plates.—The importance of that portion of a piano called the iron frame or "plate" possessing in the highest degree all the qualities requisite for a perfect casting may be better understood when it is known that in pianos of the largest size the sum of the tension of the strings, when stretched in attuning, reaches 33 tons. It is therefore natural to suppose that skill of the highest order is brought to bear on their production. The minor manufacturers usually contract with some foundry for their supply of plates, but in most cases the restrictions as to weight and finish are so severe that even ordinary profits are never looked for by the founder. Leading firms have them made in their own foundries, where special mixtures of iron, which have been previously determined and tested, are melted down at once, and poured into as many as seventy moulds simultaneously, in order that all may be alike. The chief feature in moulding these castings is the ramming. See RAMMING.

Picker.—There are various devices for picking out small patterns from the sand, including screws, spikes and spring-lifters, etc., all of which are designated by the general name of picker The best picker for very small bench-work patterns that are made of wood and do not require duplicating is a fine-pointed steel wire. But if a large number require to be made from one pattern, have a small hole bored well in, or through if the pattern is thin, and use the spring-lifter. A metal plate inserted neatly at the orifice of the hole will prolong the usefulness of the pattern indefinitely. See SCREW; SPIKE; SPRING-LIFTER.

Pick-hammer.—A steel hammer with tempered points, for use in discovering scoria and other dirt which may be lodged under the thin skin of castings.

Pickle.—A pickle for removing sand from castings by sprinkling is made from sulphuric acid 1 and water 4. The castings are sprinkled and exposed to the atmosphere when this is used; but if it is desired to make a bath in which to submerge the castings, then 10 of water may be added to 1 of the acid.

For cleansing brass castings the pickle should be made from nitric acid 1 and water 3.

The vessel in which the sulphuric-acid pickle is to remain should be lined with sheet lead; that for the nitric-acid bath should be of earthenware or glass.

Cast-iron work should receive considerable attention after pickling, if it is intended to plate or japan them. The gray accumulation seen on the surface after this process will, if left thereon, be sure to fall off in time, bringing with it whatever has been subsequently applied. Simple water is not sufficient to accomplish a thorough cleansing from this objectionable film; the castings should be first steeped in a strong hot potash or soda bath, after which hot water or steam may be played over them until they are thoroughly clean, when after being heat-dried they are ready for the plating, japanning, or paint. See PLATING; DIPPING; LACQUERING.

Pig-iron.—Iron in the form of an oblong bar, so called from having been run from a central or main channel designated the sow, which connects with the tap-hole of the blast-furnace, and may be directed to any part of the sand floor of the casting-house, the pigs being branches from the same. According to the fracture, pig iron is classified as *gray, mottled,* and *white* iron. See CAST-IRON; GRADES OF PIG-IRON.

Pig-iron Barrow.—A vehicle for hauling pig iron, usually made high in the front to prevent the pigs from slipping forward on the wheel, and with a flat tray for ease in loading and unloading. Barrows for this purpose and for the transfer of heavy castings are now made by specialists having the front, and tray made from bent-iron strips set edgewise and securely fastened together, which presents a platform firm and almost indestructible. These barrows can be furnished by the dealers with either one or two wheels attached.

Pig-iron Breaker.—The common form of breaker for pig-iron is a heavy sledge-hammer. Many forms of power breakers are employed at the blast-furnaces which might with considerable profit be introduced in the foundries, where a large quantity of pig iron must be broken for convenience in charging the cupola.

Pig-iron Scales.—The best form of scale, where large quantities of different brands of pig iron must be handled proportionately, is one of sufficient capacity to weigh a whole charge at once. This scale would require a section of railway corresponding to the system throughout the yard and to the furnaces; the pig-iron truck can be run on the scales, and the several quantities constituting a charge could be placed thereon, and be at once conveyed in bulk up an inclined plane to the cupola scaffold or on the level to the elevator platform.

Pig-iron Tester is a simple form of machine for ascertaining the transverse strength of cast iron, some having an indicator attached by which the elastic limit is measured also. This is an excellent contrivance for obtaining a comparative test of the iron supplied subsequent to charging in the cupola by simply melting a small quantity in the crucible and casting one or more 1-inch-square bars, the strength of which may be discovered by the machine. Density, tendency to chill, and shrinkage may also be observed in the cast bars, and thus by these mechanical means a fair knowledge of the iron may be obtained before taking risks in the cupola. See TESTING-MACHINE.

Piling.—Puddled balls, after being shingled, are called *blooms*, which after passing through the puddle-bar rolls are called *puddle-bar*. For the best iron these bars are cut into short lengths and made into *piles*, to be reheated and again passed through the forge-rolls, after which the iron is again cut, piled, and heated, and then passed through the mill-train, the finishing-rolls being the last rolls in the train. For beams, rails, etc., the piling is arranged to suit the form required, the pile consisting of different grades of iron, according to the desired quality of the finished product. See MALLEABLE IRON.

Pin.—A common name in the foundry for a gate-pin, also a flask-pin. See GATE-PIN; SNUG.

Pin and Cotter.—An arrangement for pinning flasks, consisting of a wrought iron or steel pin, with forged or turned shoulder, to rest in holes provided in the drag, to which it is made fast by a nut which is screwed on the small end of the pin. The cotter-hole is forged in the pin, so that when the cotter is driven home its upper edge touches the upper part of the hole, while the lower one rests on the lug or flange of the cope, and clear of the hole entirely; thus by this means drawing cope and nowel close together and holding them. See SNUG.

Pincers.—An instrument for grasping objects, drawing nails, etc. Two handles work the jaws, which are held in position by a pivot.

Pinch-bar.—A long bar of steel or iron, fashioned at the end, suitable for raising weights or propelling vehicles. See LEVER.

Pinchbeck.—An imitation gold, composed of copper 5, zinc 2. See GOLD; TOMBAC.

Pipe-clay.—A clay of a grayish-white color, greasy to the touch, very plastic, and free from iron and other impurities. Its principal use is for making white pottery and tobacco-pipes. See FELDSPAR; KAOLIN; POTTERY-MOULDING; ETC.

Pipe-moulding.—See CAST-IRON PIPES.

Piston-blowers are machines which force the blast with every alternate motion of the piston. See BLOWER.

Pit is a general foundry term for all holes dug in the floor in which to form moulds in green-sand, or close together and cast such as are formed in dry sand or loam. In the former instance the hole is dug, the pattern inserted, and the sand rammed therein, as described at "Bedding In" (q.v.), while in the latter it may be required only to lower the mould down to a suitable depth for casting (see DRY-SAND MOULDING); or, as in the case of a loam-mould, it may be necessary both for closing, and binding the walls sufficient to resist the pressure of the molten iron within by ramming sand firmly in the space betwixt the pit-sides and the mould. See LOAM-MOULDING; CURB; RAMMING.

Pitch is the black residue remaining after distilling wood-tar. Charcoal is made by covering piles of wood to partially exclude the air; this is fired, and the volatile constituents of the wood gradually distil off, leaving the charcoal. If it is desired to produce tar, the resinous woods are employed, and the pit-bottom is made concave. During combustion, the liquid products are separated, collect at the bottom, and flow out through a trough into a reservoir. They consist of *tar, acetic acid,* and *oil of turpentine.* When the tar is distilled, essence of turpentine is separated, and what remains is pitch. See TAR.

Pit-coal.—The name given to mineral coal to distinguish it from charcoal. See COAL.

Plaster.—Sulphate of lime or plaster of Paris. See GYPSUM.

Plaster-cast.—To take a plaster-cast of any figure, bust, medal, etc., it is only necessary to obtain a mould by pressing some soft substance upon it, which when it has hardened may be filled with plaster; the latter soon hardens, and a representation of the original is obtained. The substances used for forming such moulds are various: for some objects a composition of beeswax, rosin, and pitch may be poured round it; for very small objects, wax alone, or the crumbs of new bread, will answer; but for larger ones it is necessary to provide moulds of the plaster itself, or clay may be substituted. A cast of a person's face is obtained by first securing the hair at the back, inserting paper tubes at the nostrils for breathing, and oiling the face, the person lying on his back. The thin plaster is then carefully spread one-fourth inch thick all over, taken away when set, and used for obtaining a clay model, from which to make a plaster-mould, which serves as the matrix for the final cast, and which must be divided at suitable places for easy withdrawal from the face. See STATUE-FOUNDING.

Plaster Patch-part.—A joint board or match-part prepared in plaster. See MATCH-PART.

Plate.—Foundry plates are of two kinds principally, being for the purpose of carrying or covering moulds. Those used for carrying are usually plain open-sand plates, with handles or lugs made in a form suitable for the lifting tackle used; whilst the covering plates have dabbers or prickers cast on them for sustaining the loam or sand with which they are covered on the mould or face side. See PRICKERS; LOAM-MOULDING; OPEN-SAND MOULDING.

Plate Brass is cast brass for rolling into sheets, and is composed of copper 16, zinc 3. See BRASS.

Plate-moulding is simply dividing the pattern to be moulded exactly at the joint or parting, and placing the halves opposite to each other on an iron plate or a board, which is provided with pin-holes exactly corresponding to the interchangeable flasks to be used. Cope and nowel may then be rammed respectively, cope lifted off, plate taken away, and the cope again pinned to place. If distinct plates are made for each side the operations are facilitated somewhat, as all the nowels can be completed at once and the copes follow in succession: the advantage in the latter method is, that the plate is withdrawn from the mould in both cases, while in the former the cope is lifted off the plate—a bad feature when the patterns are not comparatively plain. When more than one pattern are thus treated, and all run from one common gate, it is customary to call it a *card* of patterns. See MATCH-PLATE.

Platen, in moulding-machines, is the upper diaphragm or plate, against which the flask with its containing sand and pattern is forced by pressure from below. See MOULDING-MACHINES.

Plates of Metal.—For weight of a superficial square foot of different metals, see WEIGHT OF PLATES.

Plate-wheel.—A wheel having the rim and hub connected by a plate instead of arms.

Platform.—The scaffold round the cupola, built for convenience in charging. If possible, they should always be of sufficient area to accommodate the stowing of all the iron, fuel, material for repairs, etc., required for one day's melting at least, for which reason there should be no mistake made as to the strength of such structures. If there be a system of tracks in the yard, an incline from the platform will serve to communicate therewith. See PIG-IRON SCALES; CHARGING-PLATFORM.

Platform-cranes are walking cranes erected on trucks which run on rails or road. See CRANES.

Platform Scale.—A weighing-machine provided with a platform on which to place the object to be weighed. See WEIGHING-SCALES.

Plating.—The coating of one metal with another. This is done in some cases to protect the underlying metal from oxidation; in others, that the properties of two metals, such as strength and lustre, may be combined in one object; but in the majority of cases it is done that some inferior metal may appear like a superior one. Originally, silver-plate was made by wiring thin plates of silver to ingots of German-silver or copper, and submitting to a soldering temperature in a plating-furnace to unite the two surfaces. The ingot was then rolled down to a sheet, in which the relative thickness of the two metals was maintained. This method of plating has now become almost extinct, being superseded by electro-plating and gilding, which covers the object with a film by the aid of electricity. To coat articles with silver, a bath is made of cyanide of silver 1 part, to 2 or 3 parts of cyanide of potassium, dissolved in 150 parts of water. The article to be plated is made the negative pole, and a piece of silver hung in the bath forms the positive pole. Articles are gilded by employing a solution of the double cyanide of gold and potassium, and suspending plates of gold in the solution. A proper coating takes from three to six hours, but any thickness may be given by continuing the operation. From ½ to 1 ounce of silver suffices for one square foot of plating. Other metals besides copper, silver, and gold can be electrically deposited from their solutions, as, for instance, the coating of iron with zinc, a solution of the sulphate of zinc being employed for that purpose. The deposition of nickel from the sulphate of nickel and ammonium is deposited as a very thin but extremely hard coating by this process, so that innumerable articles may be protected from tarnishing and corrosion, as nickel will not readily tarnish, even in a very moist atmosphere. See ELECTRO-PLATING; NICKEL-PLATING; GILDING.

Platinum is a rare metal, invariably found native, and usually associated with palladium, iridium, and rhodium. It occurs also alloyed with gold, copper, iron, and lead. Found chiefly in the mines of the Ural Mountains, Brazil, and Mexico. Its color is grayish white, almost like silver in appearance. It is ductile, takes a good polish, and is as malleable as gold or silver. Its most useful qualities, however, are the difficulty of fusion and its absolute resistance to the action of almost all acids; but it may be slowly dissolved by *aqua regia*. It will not oxidize in air at any temperature. Its specific gravity is 21.5. Platinum with steel forms an alloy that is exceedingly hard. See METALS, AQUA REGIA; PLATINUM ALLOYS.

Platinum Alloys.—These alloys are almost non-oxidizable, and may be prepared by the usual methods of melting, without flux. Nickel 100, tin 10, platinum 1—suitable for table-ware. Nickel 100, tin 20, platinum 1, silver 2—a good mixture for bells. Nickel 100, tin 20, platinum 20—optical and similar instruments. Another non-oxidizable alloy of platinum is composed of nickel 60, brass 130, platinum 70. Platinum alloys readily with steel, and produces a very tough and fine-grained product when present to the extent of 1 per cent. See SILVER; SILVER ALLOYS; SILVERING; NICKEL.

Platinum Steel.—See PLATINUM ALLOYS.

Pliers.—A kind of pincers with which to seize, bend, break, or cut small objects.

Plinth.—The square member at the bottom of the base of a column. Also, the projecting band forming the base of a wall, etc. See COLUMN.

Plug.—A conical clay bott, or bod, secured to the end of the bott-stick, with which to plug the tap-hole of the cupola. See BOTT-STICK.

Plumbago.—See BLACK LEAD; GRAPHITE; FACING.

Plumb-bob.—Usually a conically shaped piece of lead or iron, suspended on a cord, with which to obtain a perpendicular to the horizon. See LEVEL.

Plumber's Solder.—Solder for lead is composed of tin 1, lead 1½; flux with tallow or rosin. For tin: tin 1, lead 2; flux with rosin and sweet-oil. A useful solder for general purposes is made from lead 5, tin 3, bismuth 1. See SOLDERING; SOLDERS.

Pneumatic Cranes.—Are being extensively used because of their convenience, especially for moderate duty. The transmission of air under pressure results in none of the annoyances from leakage incident to steam and hydraulic piping, and obviates all trouble in disposing of the exhaust, as this may be allowed to discharge anywhere without inconveniencing any one. See CRANES.

Pneumatic Lifts.—These lifts are now becoming common among blast-furnaces in different parts of the world, as compressed air is readily obtained from the blowing-engines which supply the furnaces. A wrought-iron cylinder, with its top end closed, somewhat longer than the distance to be travelled is suspended in a tank by counter-weights, after the manner of a gasometer. Air at three or four pounds above the atmospheric pressure is forced into the tank through a pipe. The load is lifted to the height required, and as the whole of the working parts are balanced, the amount of power required is only what will be sufficient to elevate the load. The return stroke is obtained by allowing the air to escape through a valve into the atmosphere, the empty wagon being weight sufficient to lower the bell in the tank. The motive power for the Gjers pneumatic lift is obtained from a pair of double-acting air-pumps, the lift being effected by the pressure of the atmosphere acting against a vacuum in a cylinder, the empty wagon being returned by the compression of air on the under side of the piston. See ELEVATOR.

Pocket.—The temporary extension of a flask in one or more direction, to fit it for use on some special casting for which it had not been originally designed.

Polling.—The operation of mixing metal by vigorous stirring with a rod of iron or pole of wood. Wood-polling is more effective especially when the wood is green, as it yields its juices in a gaseous form which causes the metal to bubble freely, and the operation is accelerated wonderfully. See COPPER.

Polishing Substances.—The substances used by the worker in gems and precious stones are principally powdered diamond, sapphire, and ruby; for the several operations in the various metals, powdered corundum, emery, pumice-stone, flint, tripoli, rottenstone, chalk, oxide of tin, oxide of iron, etc., are used by metal-workers. For the first operations in glass-polishing, silex sand and water are used between the rubber and the glass, after which different grades of emery, and finally the putty powders, or oxide of tin. See throughout the work for a description of the substances mentioned.

Porcelain Moulding.—Not many branches of industry are of higher antiquity than that of the potter, as the plasticity of natural clays and their hardening when exposed to heat are properties which were known in the earliest ages. There is a marked difference between true porcelain and earthenware, the body of the former ware being very compact and translucent, and breaking with a conchoidal fracture, which shows there has been partial fusion.

The glaze which is applied to porcelain to produce the smooth surface evidently blends with the substance of which the body is composed. This cannot be said of earthenware, which, when it is broken, shows an open and somewhat earthy fracture, and the glaze can be readily detached. The clay employed in porcelain-making is derived from decomposed feldspar, no other kind being pure enough; this is white, and free from ferric oxide. To diminish the contraction which this substance undergoes in the fire, finely divided silica made from pulverized flints is added, together with a proper proportion of feldspar or other fusible material, also reduced to an impalpable powder. The ware is moulded in plaster-of-Paris matrices, or formed by means of a vertical spindle and table (potters'-wheel), and is partially dried in the air, still more by heat, and then converted into what is termed *biscuit* by exposure to a higher temperature. This porous *biscuit* is in a condition favorable for receiving its *glaze*, which is either ground feldspar, or a mixture of silica, gypsum, and some porcelain clay diffused through water. After dipping in this mixture the water sinks into the ware, leaving an evenly spread surface of the powder; after it has again dried it is fired at an exceedingly high temperature.

The manufacture of porcelain outside of China is of modern origin, but the Chinese have practised the art from the beginning of the seventh century, their work being in some respects unequalled. The materials employed by them are kaolin, or decomposed feldspar; petuntze, or quartz reduced to fine powder; and the ashes of fern, which contain potassic carbonate. See POTTERY-MOULDING.

Porosity.—Pores are small interstices between the particles of matter which compose bodies, and are either empty or filled with some insensible medium. Condensation and rarefaction are only performed by opening and closing the pores. What shape the atoms of different bodies are, we have no means of determining. Pores are often visible to the naked eye, as in sponge and pumice-stone; but in gold and granite they are too minute to be detected. If we place a little water on chalk or cloth it disappears; in a certain sense it penetrates them, but it does not enter into the solid particles; it only passes into the vacant places or pores. A piece of iron is made smaller by hammering. This proves its porosity. Its particles could not be brought into closer contact if there were no interstices between them. Mercury passes through lead, and water may be forced through the pores of gold. So that, though matter is essentially impenetrable, it is also universally porous. See PARTICLE.

Portable Furnaces.—A French portable brass furnace consists of a furnace with a fixed crucible, and arranged so that the castings may be poured direct from the crucible without removing it from the furnace, the two moving simultaneously from the furnace to the moulds, and *vice versa*. The metal may be fused by the use of fuel, the ashes of which can be cleaned out of the furnace before casting, or the latter annoyance may be obviated by connecting with a regenerative or a gas-blast system. That part of the furnace which contains the fixed crucible is set in standards provided with bearings for the trunnions to rest in, and the standards being secured to a suitable truck, the whole is run on the tracks for casting, which operation is readily performed by means of a small hoist attached to one of the standards, which tilts the furnace sufficient to allow the metal to flow from the crucible at its upper edge. See GAS-BLAST FURNACE; BRASS FURNACE.

A very handy and serviceable portable cupola for melting cast iron or other metals may be made and mounted on wheels, for use on special occasions, such as mixing for tests, or taking off a very light heat occasionally. The shell could be of $\frac{1}{16}$ plate, and large enough in diameter to measure about 18 inches diameter when lined with 4-inch bricks. Its height might be 60 inches, with wind-box attached, covering 3 tuyère holes $2\frac{1}{2}$ inches diameter, pierced about 16 inches from the bottom plate. A small fan-blower set back of the cupola could be arranged for running either by hand or power. Made in this manner, the refuse material contained in the cupola, when done melting, would have to be drawn out at the front or spout; but this might be obviated by suspending the cupola on central trunnions, and by this means eject the whole contents at the mouth. The latter method is a great help in cleaning and repairing so small a cupola. With efficient blast and good management such a cupola should melt 1000 pounds per hour. See CUPOLA.

Portable Ovens.—Brass and iron moulders' drying stoves, or portable ovens, are supplied by the dealers at very low prices. They are made in sections, which fit into each other, and are excellent contrivances for drying small cores. See OVENS.

Portland Cement.—So called from its near resemblance to Portland stone in color. It not only possesses the property of setting more quickly, and has greater power of cohesion than the natural cements, but it may be used with a superabundance of water in the form of grout, which they cannot be. This cement is made from Westmacott's patent carbonate in combination with chalk, gray, and all other limes. All the carbonic acid being removed from the lime in its burning, 75 per cent of this acid is restored by its mixture with the prepared patent carbonate.

Pot.—A common name in foundries for the crucible. See CRUCIBLE.

Potash.—This substance exists in plants, combined with other organic acids. The plants being burned destroys the combination, the organic acids being decomposed into carbonic acid and water, and the liberated potash unites with some of the carbonic acid formed by the combustion, thus producing carbonate of potash. This salt is highly alkaline, is used to prepare caustic potash, and for the manufacture of soap, glass, etc. Wood-ashes furnish from 20 to 50 per cent of their weight of carbonate of potash, being obtained from them by leaching and boiling the solution to dryness in iron pots. See ALKALI; ASHES.

Potassium.—Potassium was discovered by Sir Humphry Davy in 1807, together with sodium, barium, strontium, and calcium. Before this time the alkalies and alkaline earths had been considered as simple bodies, and it is to him we owe the discovery of their compound nature. He obtained it in very small quantity by exposing a piece of moistened potassic hydrate to the action of a powerful voltaic battery; the positive pole gave off oxygen, and metallic globules of pure potassium appeared at the negative pole. Potassium is a brilliant white metal with a high degree of lustre; at the common temperature of the air it is soft, and may be easily cut with a knife, but at 32° F. it is brittle and crystalline. It melts completely at 130° F. and distils at a low-red heat. It floats on water, its specific gravity being only 0.865. It oxidizes instantly in the air; takes fire if thrown upon water. Potassium decomposes nearly all compounds containing oxygen if brought in contact with them at high temperatures; hence to preserve it pure it is kept under naphtha, a liquid containing no oxygen. See MÉTALS; ALLOYS.

Potato-flux.—If a raw potato is fastened on the end of a bar and thrust into a ladle of cast iron and held there, the escaping steam will cause a violent ebullition, which thoroughly mixes and cleanses the mass. The dirt rises to the surface, and may be removed with the skimmer. See POLLING.

Pot-metal.—An alloy of lead and copper, and called pot-metal when the alloy consists of these two metals only, exclusive of any other. The object in making pot-metal is to use as much lead as possible, and thus obtain a cheap compound for use on the commonest class of work, such as beer-taps, etc. A mixture of copper 16, lead 2 makes a ductile alloy of a red color. When the mixture consists of copper 16, lead 4, its redness and ductility are very perceptibly decreased. Copper 16 and lead 6 is the real pot-metal, and is commonly termed "dry pot-metal," or *cock alloy*. Beyond this proportion of lead there is danger of the lead separating from the alloy as it cools; but by careful manipulation it is possible to make a compound of copper 16 and lead 8, which is termed "wet pot-metal." The addition of a small proportion of tin to wet pot-metal will prevent the lead from separating, as tin may be mixed in almost any proportion with the alloy; and if the mixture consist of copper 16, lead 7, antimony 1, the same effect is obtained; but it is no longer the true pot-metal when these additions have been made. See COPPER; LEAD; ANTIMONY; TIN.

Pottery-moulding.—Pottery is a term applied to all objects made in clay and baked. The potter's art has been practised by even semi-barbarous races from the remotest period. Vases of baked earthenware were in use at the earliest period of Egyptian civilization, and Babylon and Assyria were noted for their pottery, which was of a red color and more refined shape than that of the Egyptians. The Greeks claimed the invention of the potter's-wheel. Etruscan ware, famous for the bas-relief ornaments moulded—evidently from metal ores on its surface, was in use 500 years B.C., and was the source of Roman pottery. The existence of unglazed earthenware in North America dates from remote times. This ware is of the rudest kind, and bears a striking resemblance to the earliest specimens of Northern Europe. Mexico and Peru were excellent workers in pottery in the earlier ages, to which the moulding, coloring, and ornamentation of preserved specimens bear ample evidence; but they never acquired the art of glazing. The knowledge of glazes was first acquired by the Egyptians and Assyrians, and descended from them to the Persians, Moors, and Arabs, the latter race introducing into Spain the art of making glazed tile about 711 A.D. The first appearance of Italian enamelled faience, the precursor of modern porcelain, dates about 1420, being then used by Lucca della Robbia for subjects in relief. A century later the works of Raphael were copied on plates and other ware, and painted in brilliant colors. Enamelled ware passed into France in 1590 with Catherine de Medici. The celebrated Palissy discovered at Saintes, 1555, the art of enamelling a gray paste, from which he moulded fruit, animals, etc., for decorating dishes. Glazed earthenware delft was first made at Delft about 1360; but none of these wares was equal to the Chinese porcelain, which, brought to Europe by the Arabs in the thirteenth century, became known in Italy 1330, in France 1370, and later in England. Wedgwood, the great English potter, was born at Burslem in Staffordshire 1730.

Pottery and porcelain differ chiefly in this, that the superior quality of the materials used for making the latter gives it the peculiar quality of translucency it possesses. (See PORCELAIN.) Inferior materials used for making pottery, include phosphate of lime, bone-ashes, calcined flint, etc., which are added to the native clays. Besides the common methods of moulding by the wheel and forming with the hand, improved moulding machinery has been introduced, which facilitates operations to a great extent. Large numbers of articles are made in plaster-moulds, which being porous rapidly absorbs the moisture from the creamy clay with which they are filled; a stopper at the bottom of the mould is withdrawn when it is known that a sufficient thickness of the paste has adhered to the mould, and the superfluous paste runs out. If it is found that the article thus produced is not thick enough the operation is repeated. Another method of obtaining the desired form from plaster-moulds is to roll the clay into thin sheets and press it upon the surface with a sponge. See PORCELAIN.

Pound.—The pound is a standard weight, and consists of 16 ounces avoirdupois, or 12 ounces Troy. The avoirdupois pound weighs 7000 Troy grains, and the Troy pound 5760 grains.

Pouring-basin.—A reservoir formed in sand to receive the molten metal from the ladle, from whence it passes to the mould by whatever system of running-gates is suitable. See BASIN; GATES; etc.

Power-hammer is a hammering machine operated by steam, air, or some other mechanical contrivance. See HAMMER.

Prairie Hay.—This hay is now obtained in large quantities and spun into ropes suitable for wrapping on core-barrels. Spools of this ready-made rope containing from 300 to 350 feet may be purchased from any of the dealers in foundry supplies at a very low price. See HAY-ROPE; CORE-BARREL.

Precious Metals.—Gold and silver are denominated precious metals because their peculiar properties pre-eminently fit them for becoming standards of value. Even barbarians are cognizant of their superiority over all other metals. They have a brilliant lustre, are hard, and of high specific gravity, not subject to oxidization, fusible, malleable—the two latter properties permitting them to be cast or stamped with designs; and, besides all these superior qualities, they are found pure. See GOLD; SILVER.

Precious Stones.—The hardness of precious stones, beginning with the hardest, is as follows: 1. Diamond; 2. Ruby; 3. Sapphire; 4. Topaz; 5. Hyacinth; 6. Emerald; 7. Garnet; 8. Amethyst; 9. Agate; 10. Turquoise; 11. Opal.

Precipitation.—When a body dissolved in a fluid, either through the action of the air, or of a gas, or of a chemical agent in solution, is made to separate and fall down in the concrete state, this falling down is called *precipitation*, and the matter thus separated is called a *precipitate*. See SOLUBILITY.

Pressed Fuel.—Many loose substances which otherwise would be wasted are mixed with cements composed of either coal-tar, cow-dung, pitch, clay, or other combinations, to bind them together, after which they are subjected to pressure, and solid fuel is produced from the mass in the form of bricks or balls. Pulverized coal is treated in this way.

Pressing Fluid Steel.—The invention of Sir Joseph Whitworth for the production of sound steel ingots consists in applying pressure, by powerful hydraulic machinery, while the metal is solidifying in the ingot. As from 6 to 20 tons per square inch is the amount of pressure required to produce a sound ingot in this manner, the moulds employed are of special construction. The main cylinder is strengthened by steel bands on the outside, and the inside or iron lining is composed of cast-iron lagging, which receives a coat of very refractory loam. This system of lagging permits the gases to escape freely, as they are forced out by the enormous pressure exerted. See INGOT.

Pressure-blower.—A blowing-engine that gives a positive blast, and measures and forces forward at each revolution a fixed quantity of air, whether the pressure be high or low, or the speed fast or slow. See BLOWER.

Pressure-forging.—Usually a substitution of hydraulic or other machinery for the regular processes of hammering and rolling metals into the required form.

Pressure-gauge.—A pressure-gauge for showing the amount of pressure in the wind-box and pipes of the cupola consists of a glass siphon tube, with equal legs, half filled with mercury; one end is cemented into a pipe which enters the wind-box, the other is open to the atmosphere. If a stop-cock is provided, it may be shut off at pleasure. The wind acting on the mercury in one leg of the gauge presses it down, and it rises correspondingly in the other leg. The difference between the two columns is the height of mercury which corresponds to the excess of the pressure in the wind-box above the pressure of the atmosphere. If eight ounces per inch be allowed for the length of this column, the effective pressure of the blast in ounces per square inch is obtained. Therefore all that is necessary for graduating the tube is to mark it off in one-eighth-inch divisions, and each division would represent one ounce of pressure. See BLAST-GAUGE.

Pressure-moulding.—The several moulding-machines which operate by forcing the sand into the flask betwixt the table and platen may be taken as examples of pressure-moulding, effecting by machine pressure what has hitherto been accomplished by hand-ramming. See MOULDING-MACHINES.

Pressure of Blast.—See BLAST-PRESSURE.

Pressure of Molten Metal.—The conditions of liquid pressure exist in moulds exactly the same as in any other vessel in which liquids may be placed. Solids transmit pressure only in the line in which it is exerted; liquids transmit it in every direction—as may be noticed when in casting the poured metal escapes at every riser, at equal velocities. Molten metal influenced by gravity alone presses in all directions, as will be seen by the following: Let a covered mould be filled with molten metal, and maintain a pressure by a raised runner-basin; if this mould be tapped at the bottom the metal will rush out,—this proves a downward pressure; if it be tapped on the side, the metal rushes out, showing a lateral pressure; and if it be tapped on the top, the metal will escape also, showing an upward pressure. The pressure of molten metal in every direction is proportioned to the depth; hence the necessity of increasing the strength of moulds towards their bases, and additional precautions being taken to hold down the cope when large areas are subjected to a considerable head-pressure. See WEIGHTING COPES; HYDRAULICS; HYDROSTATIC BELLOWS.

Pricker.—A moulder's tool with which to pierce the sand to permit the escape of steam and gas. See VENT-WIRE; VENTING.

Prickers on Plates.—These are frequently called *dabbers* or *prods* by moulders. If the plate to be used for covering a loam-mould is only to form a plain surface, the prickers need only be long enough to carry as much sand as will prevent the heat from damaging the plate when the mould is cast. In the event of projections of loam or sand having to be sustained safely, the prickers are made long enough to reach such projections. The method of forming prickers is by thrusting a pricker-pattern into the sand to the required depth, after the outer edges of the plate have been formed, the bed having been previously prepared to the required density to receive it. See LOAM-MOULDING; PLATE; COVERING-PLATE.

Prince Rupert's Gold.—A kind of pinchbeck; copper 3, zinc 1. See GOLD; TOMBAC.

Prince's-metal.—An alloy for cheap jewelry; copper 18, zinc 7. See GOLD; TOMBAC.

Print.—A boss or hub on a pattern indicating the place for a core of that shape and dimension. See CORE-PRINT.

Printing.—Printing mould surfaces is a process requiring more than ordinary judgment and dexterity on the part of the moulder to do it well. It is usually practised in foundries that make a specialty of fine register and stove-plate work, where the patterns are very thin, with more or less decorative work on their front surfaces. Any attempt to fasten the blacking on these surfaces successfully with the brush or tools is next to impossible, and it is certain that returning the pattern for that purpose is not only productive of better work, but more expeditious also. A heavy lead or charcoal that adheres well to the sand is first dusted over the surface and the dust allowed to subside. In the mean time the moulder has brushed his pattern, and perhaps warmed it a little; a dusting of lighter blacking is applied, and the pattern returned, rapped down, and withdrawn, leaving a thin coat of carbon evenly distributed on every part, and having no other blemishes than are contained in the pattern. See RETURN-FACING.

Prods.—A common name in some parts for the prickers on a loam-plate. See PRICKERS.

Projectiles are such bodies as, being put in a violent motion by any great force, are then cast off or let go from the place where they received their quantity of motion; as a shell or shot from a gun. There are various descriptions of projectiles, spherical and elongated, some being solid, others hollow; also case-shot, etc. See SHOT; SHELL; ORDNANCE.

Propeller.—An instrument placed at the back part of a steam-vessel for the purpose of propelling her through the water. See SCREW-PROPELLER.

Puddled Steel, or Semi-steel, is produced by the decarburization of cast iron in the puddling-furnace. Krupp, of Germany, makes the bulk of his steel by this process, using irons rich in manganese and carbon, which are suited for conversion into steel. The puddling process for steel is very like that for malleable iron, except that the former is conducted at a lower temperature and needs more careful manipulation. There is no previous refinement of the iron to be operated upon when steel is produced by puddling. About 400 pounds are first melted, mixed with silicate of iron (slag), and kept stirred with a rabble. During this operation the carbon contained in the iron is oxidized by the oxygen present in the cinder, producing carbonic oxide, which as it escapes causes the appearance of boiling. When this boiling is general through the mass, the temperature is increased until the appearance of incipient solidification occurs; the temperature is then reduced, and the ordinary process of balling proceeded with. The work in this case demands more than ordinary skill. This steel, after being made into bars, is cut up and remelted in crucibles, in order to produce cast steel. See MALLEABLE IRON; CRUCIBLE STEEL.

Puddle-rolls are the pair of rolls on the left of the train, usually called the *roughing-rolls*. See MALLEABLE IRON; ROLLS; TRAIN.

Puddling.—See MALLEABLE IRON.

Puddling-furnace.—A furnace for separating the carbon and other impurities from cast iron. This furnace is usually of the reverberatory kind, and in the process the fire is not mingled with the metal, as in the case of smelting, the material being melted by causing the flame to impinge upon it on its way from the fireplace at one end to the chimney at the other. See MALLEABLE IRON; REVERBERATORY FURNACE.

Pug-mill.—A mill used by potters and brickmakers to cut up and blend the clay. Pug-mills are of various designs, and some of them are capable of performing several operations successively, as cutting the clay, grinding and tempering it, and finally ejecting a limited quantity into the moulds below.

Pulverized Coal.—See PRESSED FUEL.

Pulverizer.—See SAND-PULVERIZER; ROCK-CRUSHER.

Pumice-stone.—A spongy lava of a very porous nature, and so light that it will float on water. It is found in volcanic districts, being composed chiefly of silica and alumina, with some potash and soda. See POLISHING SUBSTANCES.

Pure Iron is of very rare occurrence, and can be obtained only by purely chemical methods in the laboratory. See NATIVE IRON.

Putty is whiting and linseed-oil kneaded into a thick paste. See WHITING.

Putty-powder.—The peroxide of tin, made by skimming the oxidized surface from melting tin, which when cold is reduced to a fine white powder. The particles being very hard, it is used as a polishing material, and also as a coloring for enamels and glass. See POLISHING SUBSTANCES.

Pyrites.—A native compound of metal with sulphur. See SULPHUR.

Pyrometer.—An instrument for measuring temperatures beyond the ability of mercury to indicate. The older instruments of this class, such as the Wedgwood, Daniell's, etc., have been superseded by others based on the expansion of gases or on the electrical properties of bodies.

Q.

Quadrant is the fourth part of the circumference of a circle; an arc of 90 degrees.

Quart.—The fourth part of a gallon. Two pints make one quart.

Quarter-turn Pipe.—A curved section of piping, the ends of which finish at an angle of 90°.

Quartz.—The purest condition of silicon is that of quartz, in which it forms hexagonal crystals terminated by six-sided summits. It is a very abundant and widely diffused mineral. Quartz rock is mainly composed of it, and it is in this substance that gold is more frequently found than in any other. Quartz is the principal constituent of nearly all granites, as well as the numerous sandstones, limestones, trap-rocks, etc. Sands of both desert and sea-shore, and the common flint, are chiefly composed of it ; and many stones, as the agate, amethyst, carnelian, chalcedony, jasper, rock-crystal, etc., are simply varieties of quartz. It is thought that a great deal of the silica which exists in nature has been originally deposited in the soluble condition. The structure of the chalcedony, etc., proves that they were formed by a solution of silica having penetrated into a cavity in the surrounding rock and there crystallized. See throughout this work for a description of the substances mentioned.

Quartzite.—A sedimentary sandstone which by metamorphic action has been converted into a hard rock possessing a highly refractory nature, for which reason it was formerly employed for constructing blast-furnace hearths, etc. See SAND-STONE.

Queen's Metal.—For teapots, spoons, etc. Tin 100, bismuth 1, antimony 8, copper 4; or, tin 9, bismuth 1, antimony 1, lead 1. See WHITE METALS; BRITANNIA METAL; TOMBAC; GERMAN-SILVER.

Quick-dipping Acid. — Sulphuric acid 1 gallon, nitric acid, 1 gallon. This is for brass which has been ormolued. See DIPPING.

Quicklime.—Limestone or carbonate of lime deprived of its carbonic acid. Unslaked lime. See LIME; LIMESTONE, etc.

Quicksilver.—A name given by the ancients to the metal mercury. See MERCURY.

R.

Racks for Cores.—Brackets projecting from the walls of the foundry oven on which to place the cores during the process of drying. There is nothing more detrimental to the business of core-drying than a scarcity of suitably arranged racks along the walls of the oven; the carriage may also be utilized for this purpose in some instances. When this is practicable, large numbers of cores may be conveniently dried simultaneously with the moulds, etc., with which it may be loaded. See OVEN; CARRIAGE.

Radius.—The radius of a circle is just half its diameter; in other words, it is a straight line drawn from the centre to the circumference. See CIRCLE.

Ramming.—The process of ramming moulds is by no means a simple operation. Inelegant and laborious as it may seem, it is at the ramming stage of the moulder's art that the foundation is laid for the successful achievement of the task he undertakes; and nothing but sound judgment based upon intelligent practice is able to qualify the moulder in this particular department of his trade. See BUTT-RAMMER; PEEN-RAMMER.

Much subsequent repairing and finishing of the mould may be avoided when strict attention is paid to the necessity of ramming each portion of the mould in exact accordance with absolute requirements. For light castings of a duplicate character it is essential that the ramming be systematized in order that each casting shall be a true copy of its fellow in all respects, but particularly so in reference to weight, where due regard must be had to their being as light as possible. This of course can only be accomplished by discovering the point where the hardness of the mould surface interferes with an uninterrupted flow of the molten metal over it. Nearly all classes of light work may be successfully moulded without subsequent venting if due attention be given to the grading and tempering of the sand used, and ramming no harder than is absolutely necessary; careful tramping with the feet being all that is requisite in countless instances. The ignorant moulder pounds away, regardless of the differences consequent on whatever changes may be made in the material he works with. Not so the intelligent one: he is closely observant of all these things, and regulates his ramming accordingly.

The admirable precision and duplication of similar castings produced on the moulding-machines furnish ample evidence of the truth of the aforesaid, as the whole process of moulding by this method consists in placing a measured quantity of sand in the flask every time to be operated upon by the rammer, which with mechanical precision presses it down into the flask and around the pattern with an exactness impossible of attainment by hand-ramming. It is very evident that whatever superiority machine-made castings possess over those made by hand-ramming, it must all inevitably result from the more efficient and exact ramming performed by the machine, as the entire operation consists of introducing an exact quantity of sand into the flask, bringing on the pressure, and withdrawing the pattern,—all of which operations are, in the majority of cases, performed automatically. Subsequent treatment of these moulds is limited to the placing of cores and closing the parts for casting, no hand-finishing whatever being required. See Moulding-machines.

The ramming of *heavy* green-sand work undoubtedly calls for very superior ability, as not only must the mould face be made of the proper nature and density to resist the intense heat of the metal, but every suitable means must be employed to resist the constant pressure exerted whilst it remains in a fluid state. How to meet all these conditions and maintain a mould surface that shall be free from errors likely to produce faults in the resultant casting taxes the moulder severely when the material is not in all respects what it should be, and many are the contrivances invented to counteract or neutralize evils that are known to exist, as well as to provide against possible contingencies.

The nature and quality of sands changing with each locality renders it almost impossible to formulate absolute rules for ramming which shall be equally applicable at all places; it remains, therefore, with the intelligent moulder to observe well the kinds of sand he must work with, and regulate his ramming accordingly, remembering that with the finer grades there is always a possibility of ramming the mass to a consistency that will effectually prevent the escape of gases which form throughout the mould's surface when the metal enters therein; especially is this to be observed when the sand is of a clayey nature. See Green-sand Moulding; Facing-sand; etc.

Ramming dry-sand moulds is not by any means as important as green sand, it only being required in this case to pack the sand firmly and evenly to the mould face, and of sufficient density elsewhere to permit of free handling and resist pressure from within. If the facing-sand be comparatively free from gas-producing substances, and the moulds are thoroughly dried, there is no necessity whatever for venting ordinary dry-sand moulds, there being no steam to lead away, as in the case of green-sand moulds. For this reason unskilled labor may, with some direction, be employed for ramming very many of the moulds made in dry-sand. See DRY-SAND MOULDING; DRY-SAND FACING; etc.

Pit ramming is simply the process of packing the space between the mould and the pit wall with sand to prevent the pressure exerted within the mould from forcing out the walls; in other words, the pit is made to answer the purpose of confining the whole mould, just as a flask does. A knowledge of the laws of pressure in moulds is very helpful to the moulder in this instance, because, knowing that pressure is greatest at the bottom it is at that point where the hardest ramming must occur, and every course of ramming may be made proportionately less dense as the top is reached, and consequently much valuable time saved in the operation. See TRAMPING; PIT; VENTING; BUTT-RAMMER; PEGGING-RAMMER.

Ram's-horn.—A hook used for passing loads from one crane to another. See DOUBLE-HOOK.

Rapping-bar.—A pointed bar of iron with which to jar the pattern in order to make it leave the sand more readily. See LOOSENING-BAR.

Rapping-plate.—An iron plate inserted in a pattern at such places as it may be desired to effect a jarring or loosening of the same. Ordinarily these plates are sunk down even with the surface, and fastened with common wood screws. For light patterns easy to loosen these answer well enough; but in larger ones it becomes necessary to make the plates strong, with more surface, and secure them by bolts to a similar one on the opposite side of the pattern. By this means the nuts will always bring both plates close to the pattern, and thus obviate the unpleasantness which is sure to follow if the common screw-plates are used. Another advantage the bolted plates offer is that the upper plate may have a threaded hole in which to insert an iron screw for drawing out the pattern. These are often called *screw-plates*. They are much better than driving spikes into the pattern. See LOOSENING-BAR.

Rasp.—The rasp differs from the file in that the teeth protrude separately, thus making a surface much more suitable for filing cores than does the chisel-cut teeth of an ordinary file.

Ratio of Fuel to Iron.—Ratio of fuel to iron means the proportion of fuel burned to melt a given quantity of iron, as 1 to 5, or 1 to 12,—indicating that five pounds of iron is melted with an expenditure of one pound of fuel in the first instance, the latter indicating that twelve pounds is the quantity of iron melted with the same amount of fuel. Any attempt to formulate absolute rules to be observed by the cupola-man at all foundries alike must assuredly result in extreme disappointment, as nearly every place has its own special needs and requirements, which can be successfully met only by intelligent observation and persistent effort on the part of the cupola-man or his superiors. For this reason comparisons relating to the economics of melting iron at different foundries are of no real value, disappointment and loss being sure to attend any attempt to appropriate the systems of others, which may in all probability have been founded on experiences diametrically opposite to our own.

Any conceit we may have indulged in because of our ability to melt iron at the ratio of 1 to 10 for the line of castings we produce must be forever dissipated when we discover that the exceedingly low temperature of such iron would render it utterly valueless for the light castings produced by our neighbor, who for this reason must necessarily use more fuel to meet his case successfully. The foundry melting a standard gray pig with first-class scrap should undoubtedly melt its iron down with greater regularity and with much less fuel than where perhaps unwieldy and promiscuous scrap with a slight admixture of pig is the iron charged.

Quality of fuel affects results perhaps more than anything else; if poor, a greater amount must be used to obtain the requisite quantity of carbon. This, of course, increases the bulk between charges and requires extra time for its consumption; while the superfluous, impure substances, as slate, etc., yield a viscous slag, which interferes in no small degree with the regular process of melting, retarding it always. Even when all other things are favorable, the pressure of blast and care bestowed on apparatus will always exert an influence for better or worse proportionate to the amount of intelligence brought to bear upon such important details. Leaky pipes and fitful and uncertain blast mean extra fuel and delay in melting operations.

Construction of the cupola and its location, with reference to adverse wind currents and draught, is sufficient in some instances to mar effectually the best efforts of the cupola-man, interfering, as it does, with the first efforts to ignite the fire, and thus precluding all possibility of an evenly-burned stock—a forerunner sometimes of endless subsequent vexations and delays. The unfairness of comparing the performance of cupolas laboring under these and kindred disadvantages with others of faultless construction and suitable location will be apparent.

The wastefulness attending melting small heats in cupolas designed for more extended operations is made plain by the following: Suppose a 44-inch cupola is employed for a heat of 12,060 pounds, the amount of fuel used, including bed, being 2140 pounds: the ratio would be 1 fuel to 5.63

iron melted. Now increase the heat by six additional charges of iron to 37,440 pounds, maintaining the same ratio of fuel between the charges as before: this gives 4960 pounds total fuel used, and the ratio is now 1 to 7.53. These are only a few of the things to be considered when comparisons are made.

It may be a subject for remark that such a firm is melting iron with a much lower ratio of fuel to iron than another, and much annoyance is caused by this undisputed fact; but all this would perhaps be modified if careful investigation were instituted. Possibly this distinguished firm is melting carefully selected irons of the same mixture every day without deviation all the year round—a state of things eminently conducive to perfect practice; while those with whom they have been compared are, owing to the numerous and sometimes unpleasant changes in the nature and quality of the castings made, compelled to change their mixtures often, and more than once during the same heat sometimes.

Means for rapid transit, or close proximity of the cupola to the moulds which are to be poured, will favor metal of a low temperature being melted, thus allowing a diminished ratio of fuel. But if facilities for conveying are limited and the moulds far removed, it is incumbent that hotter metal be provided to compensate for the extra time occupied in handling. This increased temperature can only be obtained by increasing the ratio of fuel.

The preceding represents in some measure a few of the reasons for the high ratio of fuel to iron as necessitated in foundries which are unfavorably circumstanced as described; still, without doubt, there is considerable waste of fuel almost everywhere, that might be remedied if rigid investigation by qualified practitioners were established. Cupolas now yielding unsatisfactory results at many places might be changed to the best of their kind if those who work them were compelled to learn the importance of placing every charge of fuel and iron in the cupola systematically and precise. This, of course, can only be done by the cupola-man who knows that in order to retain the heat within the cupola and not have it wasted up the stack more than ordinary attention must be paid to a favorable disposition of the materials charged, and, further, that to insure regularity in both speed and fluidity every pound of such material should be carefully weighed. By this means alone can he pursue a course of safe experimental practice, the results of which if carefully noted will furnish him with all the knowledge essential for supplying metal from his cupola at all times the exact temperature demanded, and without fear of disappointment. No reliance can be placed on any method of melting that does not include a correct proportioning of the fuel and iron at every charge.

Besides this, it is incumbent on the cupola-man that he carefully observe the action of his tuyeres, changing the form from time to time, raising or lowering them, increasing or diminishing their number; or, if the tuyeres be continuous, trying the effect of a gradual contraction or expansion from their original width. Expansion of tuyere area with no increase in wind-pressure will soften the blast while contracting them will have the effect of creating a cutting blast if original wind-pressure is maintained. By observing results from these several changes, as well as increasing and decreasing wind-pressure in the blast-pipes, he may arrive at the very best practice possible for the cupola he manages, and the ratio of fuel may be reduced intelligently to the lowest possible rate consistent with the actual requirements of the foundry.

Much, if not all, of the annoyance and loss consequent on melting inferior irons, which include large quantities of the meanest machinery, stove-plate scrap, etc., in cupolas of moderate capacity may be obviated by a persistent adoption of the fluxing method. Usually, when large proportions of such iron are melted in the cupolas above mentioned, the heat is short-lived and unsatisfactory; but if a suitable flux is used, the dirt in the iron intimately associates with it and forms a thin liquid slag, which, by means of a slag-hole placed a short distance below the tuyeres, can be run off at pleasure, and so continue the melting uninterruptedly for an indefinite space of time. See CUPOLA.

Rattler.—A name given in some localities to the tumbling-barrels used for cleaning castings. See TUMBLING-BARRELS.

Rawhide Hammers are light mallets made entirely of hide (except the handle), and are especially valuable where light, thin castings are made. See MALLET.

Rectangle.—A right-angled parallelogram; a four-sided figure having right angles only.

Rectangular Cupola.—This style of cupola is not often met with at this day, the common round or oval one having taken its place almost everywhere. The sides of these cupolas were usually composed of four cast-iron plates which rested vertically on a solid foundation of stone or brick, and were held together by bolts at the corners. The widest plates were about one third longer than the others, and it is one of these wide plates which faces the foundry, being provided with a breast-hole at the bottom, which answers for tap-hole, and furnishes means for raking out when done melting. In order that the greatest quantity of metal possible might be gathered on the bottom before a tap was made, it was customary to pierce each side with several holes about 8 inches apart, one above the other, so that by means of a flexible hose or a sliding pipe the tuyeres might be raised as the metal accumulated, the blast being suspended during the process of raising the pipe and making the lower holes good with suitable plugs. The height of these cupolas was about three times the length of the long side, and the hole was lined with ordinary square fire-brick, the bottom being made with sand as now. See CUPOLA; BREAST-HOLE.

Red Brass.—The common red brass called red tombac, used for cheap jewelry, is composed of copper 11, zinc 1. Red sheet brass is copper 11, zinc 2. A good red brass for turning: copper 24, zinc 5, lead 8. Red brass for fine castings: copper 24, zinc 5, bismuth 1, the latter to be added just before pouring. See TOMBAC.

Red Hematite.—A very important class of iron ores, which vary in color from a deep-bright red to gray. Its streak and powder are a blood-red. Specular iron is a variety of hematite often found in beautifully colored crystals. Clay ironstone consists of hematite mixed with certain proportions of clay and other impurities. The common red chalk is a variety of hematite mixed with clay. It is a valuable iron ore, and yields when pure about 70 per cent of metallic iron. Its powder is used as a coloring material for paints and for polishing metals. The variety called "puddler's-mine," being of a soft, compact nature, is used for making and repairing the bottoms of puddling-furnaces; when used for this purpose it is called "ore" by the puddlers. See ORES; PUDDLING-FURNACE.

Red Lead.—When metallic lead is exposed at a red heat to a current of air, the lead rapidly combines with oxygen, and the oxide so produced fuses. It forms, on cooling, crystalline masses of a greenish-yellow color; this constitutes the *litharge* of commerce. Red lead is produced when the lead is oxidized so that the oxide formed shall not be fused, and when the metal is all converted into the yellow powder, increasing the heat to incipient redness. Oxygen continues to be absorbed until one third of the metal is converted into peroxide; this is the pure red lead. See LEAD; LITHARGE.

Red Ochre.—One of the soft, earthy varieties of red-hematite iron ore. See RED-HEMATITE.

Red-short.—Iron or steel is by the millmen termed red-short when it shows an impaired malleability at a red heat. See COLD-SHORT.

Red Tombac.—See RED BRASS.

Reduction of Metals.—The circumstances under which the metals are found in nature are exceedingly diverse, some being found in a native state or alloyed with other metals, as gold, silver, bismuth, and some others; some combined with arsenic, as cobalt, nickel, etc.; but by far the most abundant forms in which the metals are to be found are combinations with oxygen and sulphur. There are few of the metals that do not exist naturally in the state of oxides, which are either free or else combined with acids, forming salts. The majority of the metals exist also in nature combined with sulphur. The native compounds of the metals are termed *ores*, and the metal is said to be mineralized by the substance to which it is united. The several processes of reduction, or extracting the metal, must of course be regulated by the composition of the ores in which it is contained. When the metal exists only in an oxidized condition, the ore is heated in contact with the fuel, by which carbon is supplied in abundance for its reduction. The carbon combines with the oxygen and the metal is set free. Should the mineralizing substance be anything else than oxygen, carbon, no matter how intense the heat, could produce no effect upon the ore. Native sulphurets, etc., for this reason are not acted upon by carbon; and in order to reduce the metal from its sulphuret, the ores of lead, zinc, copper, etc., are first reduced to powder and heated to redness in a current of air by the oxygen, of which the sulphur is converted into sulphurous and sulphuric acid, while the metal is oxidized. This process is termed *calcination.* A great part of the sulphuric acid formed is carried off with the current of air, and the remaining product is a sulphate of the metal. When the salt so formed is deoxidized by contact with the fuel, the excess of oxide, abandoning its oxygen, yields an equivalent quantity of metal, which, however, would be impure and of inferior quality, having dissolved a portion of the sulphuret reproduced by the reduction of the sulphur from the sulphuric acid. It is therefore necessary to get rid of that residual portion of the sulphuric acid before the deoxidizing process commences, and this is effected by mixing up a quantity of lime with the calcined mass. The lime decomposes the metallic sulphate, combines with the sulphuric acid, and sets the oxide free; and when the deoxidizing flames of the reverberatory furnace pass over the calcined mass, the metallic oxide being reduced yields a pure metal, while the sulphate of lime, by losing its oxygen, is brought to the state of sulphuret of calcium, and remains a slag upon the surface. For the processes by which iron is reduced, see Cast Iron; Calcination; etc.

Reeking Ingot-moulds.—To prevent cast-steel ingots from sticking to the cast-iron moulds, it is customary, at some steel-works, to place the halves of the moulds with their faces down, upon a suitably provided support, which permits the burning coal-tar underneath them to deposit a coating of soot upon their surfaces. The process is termed *reeking*. See INGOT-MOULDS; RUNNING-STEEL INGOTS.

Refining Metals.—The art of purifying a metal from dross, or separating it from metallic alloys. More or less impurities remain after the common methods of reduction have been employed, which can only be eliminated by subsequent refining. Copper, for instance, usually contains small quantities of antimony, iron, tin, etc., after reduction in the reverberatory furnace used for this purpose. By remelting in the refining-furnace and exposing the metal to the oxidizing influence of the air, these foreign metals oxidize and are converted to slag, which is skimmed off as it rises in the crucible. This operation subjects the copper to oxidization also, but the copper oxide is reduced again by adding coal to the surface and stirring the metal with a green-wood pole. The pole emits its gases forcibly, and creates a violent ebullition which exposes every portion to the reducing action of the coal, by which means the oxide of copper is deprived of its oxygen and the copper is made pure. Tin and lead are treated after the same manner ordinarily, but special processes are followed for the separation of silver from the latter metal. Gold is refined by first dissolving the metal in *aqua regia* (see AQUA REGIA), after which the silver, etc., with which it is usually alloyed may be precipitated by chemicals having no action on the solution of gold. Salt of iron is then employed to precipitate the gold in a fine powder, which is then melted and cast, the product being pure gold. Refined silver is obtained by dissolving the metal in nitric acid, and, after filtering the solution, precipitating it with common salt as a chloride of silver, which, after being mixed with sulphuric acid, is acted upon by bars of zinc, by which means chloride of zinc is formed and the silver again resumes the metallic state. See REDUCING METALS; SEPARATING METALS FROM THEIR ALLOYS. For refining iron, see MALLEABLE IRON; FINERY-FURNACE; etc.

Reflecting-glass.—A small mirror confined within a frame, having a small handle. These glasses are supplied by the foundry supply dealers, and are extremely useful for directing light down into the deep cavities of a mould.

Reflector Metal.—Very good reflectors are made by dipping the round end of a glass vessel (which has been previously ground) into an alloy composed of tin 49, lead 19. A thin coating of the alloy, remarkably brilliant in appearance, will adhere to the ground surface. See DIAMOND AND BRILLIANT IMITATIONS.

Refractory Materials.—All such substances as melt only at the highest temperatures that can be produced are classed as refractory. Amongst these are included some natural rocks, as sandstones, quartzites, granites, etc.; but it is not customary to use these alone for metallurgical purposes, on account of their liability to split apart at high temperatures. The principal substances employed, in varying proportions, as mixtures for furnace-linings, crucibles, retorts, fire-bricks, etc., are silica, magnesia, bauxite, steatite, clays, carbon, gannister, coke, etc. Nearly all clays require to be mixed with other materials, to counteract the tendency to shrink and crack. If it were not for these admixtures, the bricks made from some of the clays would soften and melt away when subjected to very high temperatures. A description of the materials mentioned, and numerous other refractory substances, will be found at their respective places.

Regenerative Furnace.—The Siemens regenerative furnace is composed of three divisions, including the *producers,* where the crude gas is generated; the *regenerators,* chambers containing a network of fire-brick passages through which the heated gases and flame may circulate and the heat be stored as they escape from the furnace, to be again mixed with the gases from the producer and the air as they pass through the regenerator to the furnace hearth; and the furnace itself, which is the third division. By this arrangement the outgoing heated volatile products heat the mass of bricks in the chamber, and this again heats the incoming air and gas supplied to the furnace. See SIEMENS-MARTIN STEEL.

Reheating-furnace. — These furnaces, although used for various purposes, are all of the reverberatory type, similar to a puddling-furnace. They are used for heating wrought-iron piles, blooms, billets, etc., and the ingots, slabs, blooms, etc., of steel, to the temperature suitable for hammering or rolling. They are sometimes called *balling-furnaces.* See REVERBERATORY FURNACE.

Relievo, or **Rilievo,** is a term applied to works in sculpture and the fine arts where figures are made to project from the ground or body on which they are formed and to which they remain attached. It is *Basso-rilievo* when the figures project only slightly from the ground, *Mezzo-rilievo* when they stand out half their natural proportions, and *Alto-rilievo,* or high relief, when the figures are so prominent from the ground that merely a small part of them remains attached. See INTAGLIO.

Repairing the Cupola.—The first duty of the cupola-man, after the refuse of the previous day has been carefully picked for whatever iron and unburnt fuel may be found, is to chip out the cinder and scoria from the inside of his cupola and ascertain what damage has been done to the walls. Now, good tools for this operations are an absolute necessity, as the more pounding required for the loosening of this adhering dirt, the more will the brick lining be loosened—a result to be avoided if possible. For this operation the cupola-man should be supplied with an adequate set of steel-pointed chisel-bars, large and small, and these, along with steel pick-hammers of suitable dimensions, should be kept sharp and of proper temper. When tools of this class are supplied there will be no difficulty in chipping out in such a way as to jar the bricks but little, and leave the surface clean and ready for the daubing, and in much less time than it takes to do it in the slipshod way it must inevitably be done where perhaps only a sledge-hammer is used.

The chief object in repairing is to maintain as near as possible the original shape of the cupola. Except at the melting zone, just above the tuyeres, this may be accomplished fairly well; but at that point there will be, owing to the intense heat and force of the blast a decided tendency of the bricks to waste away; and it is just here where the judgment and skill of the cupola-man is put to the test, as by proper management a lining may be preserved almost indefinitely. By careful observation it may be seen which parts are being acted upon the most. Follow up at these parts with thin coats of daubing (see DAUBING), and use no more than will adhere firmly to the wall, without fear of its being prematurely loosened by the intense heat. The bad effects from using too much daubing of any kind may be understood when we consider that most of this drying must take place immediately the heat is intensified by the admission of the blast; the front of the patching dries at once, and the rapidly formed steam should find an outlet at the brickwork behind; failing this it naturally forces off the daubing, which falls over on the stock, the result being that the regular action of the cupola is interfered with to the extent of changing the direction of the blast and preventing the iron as it melts from falling direct to the bottom; by this means some iron finds its way into the tuyeres, some lodges around them and solidifies, ultimately choking the orifice altogether. Thin daubing, *well rubbed on,* will never fall away if made of the correct ingredients. When it has been thought necessary to insert new bricks at parts, as well as to rub on more daubing than usual, light up a little earlier in order to dry it out with a more gentle heat. Better a little extra expense in fuel than run the risk of a bad heat. See DAUBING; CUPOLA.

Reservoir.—Dams constructed for the purpose of gathering a large quantity of metal are sometimes called reservoirs; as also are runner-basins when constructed of extraordinary dimensions to receive the molten metal from very large pouring-ladles. See DAMS; BASIN; GATHERING-METAL.

Resin is a solid, inflammable substance, of vegetable origin, being obtained from various trees by making incisions in their bark and allowing the liquid to exude. This liquid is the essential oil of the plant, and holds the resin in solution. Resins are insoluble in water, but alcohol dissolves them; they are of an inflammable nature, and yield a dense, sooty smoke when burning. *Mastic, sandarac, lac, copal,* etc., are some of the resins from which varnishes are made, all of which are readily dissolved in such solvents as spirits of wine, oil of turpentine, methylated spirit, and wood naphtha. The evaporation of the spirit, after these varnishes have been applied, leaves a hard layer of the resin on the surface of the object treated. The common resin, or *rosin,* of commerce is obtained from the various species of pine. Gum-resins are the solidified milky exudations of plants.

They consist of resin, essential oils, and a gummy substance peculiar to the plant. The ammoniacum, assafœtida, aloes, myrrh, gamboge, etc., belong to this class; they are all soluble in rectified alcohol, and are valuable as medicinal agents principally. Elastic gums, as caoutchouc or india-rubber and gutta-percha, are valuable in the arts and manufactures; the former consists of a thick milky juice of certain trees growing in tropical countries, and is a mixture of several hydrocarbons with turpentine oil. When pure it is nearly white. It will soften in boiling water, but not dissolve; it is also insoluble in alcohol, but readily dissolves in coal naphtha, rectified oil of turpentine, pure ether, chloroform, or carbonic disulphide. Caoutchouc is rendered more permanently elastic by combining with it certain proportions of sulphur. It is then called *vulcanized india-rubber*. See GUTTA-PERCHA; INDIA-RUBBER.

Restoring Burnt Steel.—It is said that burnt steel may be restored by making a powder composed of 8 oz. sal-ammoniac, 3 oz. prussiate of potash, 3 oz. borax, 1½ lbs. resin, 2 oz. blue clay, ½ pint alcohol, and ½ pint of water. These ingredients are to simmer over a fire until dried to a powder; the burnt steel may then be reheated, dipped in the powder, and hammered. See TEMPERING.

Retort.—A vessel employed for the purpose of decomposing bodies by the aid of heat, the process being termed *distillation*. Those used in the chemist's laboratory are a kind of globular bottle, with a long neck bent at an angle of about sixty degrees with the belly of the retort; they are made of glass, porcelain, platinum, earthenware, etc., according to the substances to be acted upon. The spirit-lamp, gas, or sand-bath is usually employed for heating glass retorts, but when higher temperatures are required it is necessary to use those made of platinum or earthenware.

Single retorts for distilling coal-gas are usually made D-shaped, about 21 × 14 inches × 9 feet, closed at one end, and provided with a mouthpiece at the other.

Through retorts are made twice this length, with both ends open, but having mouthpieces which close them during the process of distillation. Formerly these retorts were all made of cast iron, but they are fast being superseded by those made of fire-clay, which admit of higher temperatures and last much longer. The distillation of mercury from cinnabar is conducted in retorts similar to those used for making illuminating-gas. See DISTILLATION; MERCURY; TAR.

Return-facing.—The use of return-facing is confined principally to foundries manufacturing thin, light castings, as stoves, etc.; where, having no coal mixed through the sand, means must be provided, not only to scale the casting clean, but leave the color uniform throughout. To effect this the raw sand surfaces of the moulds are first treated to a dusting of bolted hydraulic cement or German clay (a cheap substitute for heavy carbon-facing) to fill the pores of the sand, then a light dusting of heavy facing, and, lastly, the return-facing in just sufficient quantity to permit the pattern, when returned, to leave its impression sharp and smooth without sticking. The carbonized preparations of return-facings supplied by the dealers are, as a rule, preferable to the light charcoal-facings usually employed for this purpose, as they neither run before the metal nor adhere to the pattern as much as charcoal is liable to. See PRINTING; FACING.

Reverberatory Furnace.—Democritus is supposed to have invented the reverberatory furnace long before the birth of Christ. These furnaces are constructed so that the materials to be treated are operated upon by the heat of the flame without their coming into direct contact with the fuel. The reverberatory furnace is commonly employed for metallurgic purposes, and is especially advantageous for extracting metals from their ores, and for the numerous processes connected with the manufacture of malleable iron, steel, melting cast-iron, brass, etc.

The furnace consists usually of a rectangular fire-brick construction about twelve feet long, six feet wide, and from five to six feet in height, contained within iron plates which are bound together by an arrangement of buckstays and bolts. The fireplace at one end is separated from the bed proper by a fire-bridge, and an arched roof is made to dip towards the chimney at the opposite end of the furnace; by this means the flame is caused to play with considerable force over the fire-bridge and against the roof, to be again reflected or reverberated downwards upon whatever has been placed upon the bed behind the bridge. A charging-hole is provided on the side opposite to the fireplace for fuel, and a larger one for charging the materials to be operated upon is also provided convenient to the bed, some distance from its bottom. The latter hole is opened and closed by a vertically sliding door, the inner side of which is lined with fire-bricks, and is controlled by means of a lever; but the hole at the fireplace is simply stopped with coal. A hole at the bottom of the chimney allows the cinder produced during the puddling process to escape as it flows down from the bed over a bridge built in the flue. Other smaller holes are provided to permit a free use of iron bars for polling, etc., during the operations. Except in a few minor particulars, the air or reverberatory furnace for melting metals answers to the above description. See PUDDLING-FURNACE; MALLEABLE IRON; POLLING.

Reverse-mould is sometimes termed a *dummy-block*, and consists of forming in loam or sand, by means of the spindle-centre or otherwise, any model, the impression of which it is desired to copy in the cope or other containing part of the mould. This means is employed when it is desired to obtain a casting such as a bevel or spur-wheel, etc., without incurring the expense of supplying a whole pattern.

For example, if it was required to mould a bevel-wheel after this manner, the first operation would be to strike a reverse-mould or "dummy" answering to the permanent joint at the points of the teeth, and from thence over the entire back of the wheel exact to the wheel's form and dimensions on that side. This would give a true model of the back, the impression of which being obtained in the cope, it only remains to first destroy the "dummy" and then sweep out the lower surface direct, commencing at the points of the teeth again, as for the cope impression. After the teeth are rammed from the segment supplied, and the arm-cores have been placed, the cope, as previously obtained from the reverse-mould, is returned.

The joint is the original one from which the cope impression was taken; if tops of teeth and arm-cores are made to correspond with the original model obtained, the mould will close as accurately as when a full pattern is employed. A thicknessed pan-core serves as a reverse-mould for the cope. See DUMMY-BLOCK; KETTLE; BACKING-OUT.

Revolving Furnace.—Revolving furnaces consist of horizontal wrought-iron cylinders lined with fire-brick, one end of which communicates with a fireplace and the other to a chimney, which, being revolved on rollers as the flame passes through the interior, permits a thorough mixing of the mass and exposes every portion of the material to the action of the heat. This description of furnace is principally employed for roasting, desulphurizing, and chloridizing ores. The Danks and other furnaces of a rotary kind are used for puddling purposes, and consist of the fixed fire-place and bridge, but, instead of the regular bed, a revolving hearth through which the flames are made to pass to the chimney is used for melting the metal. The molten metal, being spread over the interior by the rotary action of the chamber, is brought in contact with the lining, which, being composed of iron ore, acts in conjunction with the oxygen of the furnace gases to oxidize the carbon and silicon contained in the iron. The spongy mass of malleable iron produced is readily lifted out and conveyed to the squeezers after the movable end has been taken away for this purpose. See PUDDLING-FURNACE; MALLEABLE IRON.

Revolving Oven.—See ROTARY OVEN.

Revolving Sand-screen.—See RIDDLES.

Rhodium is one of the rare metals of the platinum group. Excepting iridium, it is the most infusible metal, very hard and brittle, and of a whitish color. When this metal is alloyed with copper, bismuth, or platinum, it may be dissolved with them in aqua regia, but it is insoluble in acids when pure. Owing to its unalterable nature, rhodium has been extensively used to form the nibs of metallic pens and other similar purposes. See PLATINUM.

Rice-glue Statuary.—Statuary composed of rice-glue or paste is a very common production of the Japanese, who mix the flour with cold water and then boil to the consistency of paste, adding whatever color is desired. This paste, when stiffened by a further addition of flour to the consistency of clay, is then modelled and allowed to dry, when it assumes the appearance of marble, and will take a beautiful polish. See STATUARY-FOUNDING; MODELLING; PLASTER-CASTS.

Riddles.—There is no tool that a moulder uses more constantly than a riddle, and it behooves the proprietor to buy the very best riddle that he can find. The reason is obvious. A cheap riddle is put together in the quickest manner possible, the wood used in the rim is of the commonest kind, and much too light for the purpose. The wire is bought by the pound, therefore the lighter wire is put in the riddle to lessen the cost; the wire for, say, a No. 6 extra-heavy riddle is used for a No. 4 cheap riddle, etc.; then the cloth is cut so sparingly that it does not wrap upon the rim far enough to hold for any length of time. Nine times out of ten one or the other (cloth or rim) gives way before the light wire wears out.

The brass riddle is undoubtedly the best for use on the foundry-floor: it never rusts; the wires are always clean of sand, allowing the use of the full mesh. A steel-wire riddle will rust; and the galvanized riddle having wires of a rough surface, the sand will cling to them, filling up the meshes, thereby taking longer time to riddle the sand.

For iron, coal, or cinder riddles the heavy crimped iron-wire riddle is the best. Those made especially for sifting iron out of sand and other similar uses should be made one-inch mesh, from good strong iron wire. Parting-sand riddles or sieves, any diameter, with or without cross-bars, can be obtained from the dealers, and special sizes of heavy steel sand-screens may be had from the same parties, as well as an endless variety of power and portable sand-sifting machines. The revolving riddle or screen is a remarkable improvement on existing methods for sifting and mixing sand. See SAND-SCREEN.

Rigging.—"Rigging" and "tackle" are synonymous terms in the foundry, meaning the furnishings or apparatus provided for the construction of moulds. Foundation-plate, rings, plates, beams, slings, bolts, etc., constitute a large proportion of the rigging for loam-work; while the flasks, cheeks, drawback-plates, clamps, bolts, beams, etc., represent the rigging almost always required for any important mould in green or dry sand.

Ring.—A word of general application to all circular contrivances for moulding purposes, but invariably recognized as meaning the cast-iron ring which encircles the seating of a loam-mould, upon which ring the cope is built, and by means of which it is passed to the oven and from thence back to the pit for final closing over the mould. See COPE-RING; COPE; LOAM-MOULDING; BUILDING-RING.

Ring-bolt.—See EYE-BOLT.

Riser.—A gate set on the top or leading from the side of a casting, either to indicate when the mould is filled with metal or to be used as a means for introducing fresh supplies of hot fluid metal to make good the deficiency caused by shrinkage. In the latter instance the riser is often called a cut-off or flow-gate; in the former the terms "rising-head" or "feeding-head" are commonly used. See CUT-OFF; FLOW-GATE; FEEDING-HEAD; FEEDING-ROD.

Rising-head.—See RISER.

Roasting Ores.—Ores are roasted in order to separate the volatile bodies from those which are more fixed, and is generally performed in a current of air so as to effect simultaneous oxidation. See ORES; WEATHERING ORES.

Rock.—A stony substance which forms a great part of the earth's crust, sometimes loose and friable-like sand, and again compact, like granite and limestone. Rocks are classified as primitive, rocks of transition, stratified, alluvial depositions, and volcanic, and modifications resulting from the conditions to which they have been exposed.

Rock-crusher.—A mill for breaking and crushing rocks; it may also be used for pulverizing quartz, gold or silver ores, plumbago, Portland cement, rosin, foundry facings, etc. Some of the machines used for this purpose will work either wet or dry, and deliver a finished product. Their capacity is 3 to 4 tons per hour on phosphate rock, 1½ to 2 tons per hour on Portland cement, quartz, or ores, depending on hardness of material to be pulverized and fineness of product, and will grind from 30 to 250 mesh with equal facility. See SAND-PULVERIZER.

Rock-crystal.—A common name for the finest and purest quartz or transparent, crystallized silica. The *pebble* lenses for spectacles, etc., are made from rock-crystal. See QUARTZ; SILICA.

Rock-oil.—See PETROLEUM.

Rock-sand.—The name given to all moulding-sands obtained by pulverizing the rock; their value is regulated according to the durability they possess. The new red-sandstone is preferable for this purpose, as its nature is refractory, and it may by artificial means be made to answer nearly every description of mould. See FACING-SAND; CORE-SAND; etc.

Rod-iron.—The common round and square rolled iron, used in the foundry for making feeding-rods, gaggers, lifters, core-irons, mould-stiffeners, etc.

Rolled Glass.—An inferior kind of plate-glass about one inch in thickness is now made for common purposes by first obtaining the requisite quantity of molten glass in a suitable dipper and then emptying it on a casting-table, on the edges of which are the thickness strips, on which the roller travels as it spreads the glass over the surface.

Rolls are cylindrical rollers of steel or cast iron, which when mounted in the housings so that they cannot recede from each other, and provided with suitable gearing for causing them to revolve, are employed for reducing metals to plates, rails, bars, etc. Steel is fast taking the place of cast iron for the manufacture of rolls.

Cast-iron rolls are made to present a hard steely surface by casting the plain body in a smooth cast-iron chill-mould, the ends of the casting being formed in the sand or loam as for soft rolls. Common soft rolls may be swept horizontally, as described in "The Iron Founder," p. 274; also vertically, as an ordinary loam-mould; or they may be moulded from patterns in either of the positions mentioned—the only difference being that the pattern for horizontal moulding must be equally divided lengthwise, whilst the one for vertical would consist of a separate upper and lower neck and body patterns, with drag, check, and cope parts to match. The latter represents the method to be employed for chilled rolls, excepting that instead of the body-pattern and cheek-part, the chill is here substituted, consisting of a smooth cast-iron mould of sufficient thickness to absorb the heat rapidly, and thus produce a hard steely surface by preventing any separation of the chemically combined carbon into graphite at that part.

Whatever mode of moulding is adopted, it is all important that the metal be introduced at the lower neck, away from any direct action on the chill; otherwise the chill may be irretrievably damaged, and, if the stream be caused to flow in a tangential direction, the molten mass within will be made to rotate rapidly, and thus collect all the lighter scum in the centre, which, as the mould is filled, mounts upward, to be finally ejected into the open riser above. See RISER.

Rolling-mill is where the balls from the puddling-furnace, after being operated upon by the squeezer, are, by means of successive *passes* through the various rolls, reduced in bulk, with a corresponding increase in length, until the desired bars or sheets are produced. See MALLEABLE IRON; TRAIN.

Rolling-over.—A term applied to the method of obtaining bottom or lower portions of mould by first ramming the pattern within the drag or nowel part, and then reversing the position of the flask, by means proportionate to its size and weight. Ordinarily the pattern is placed face down on the follow-board or match-plate, over which is set the nowel or drag. The pattern, being first covered with facing-sand, is then subjected to a process of ramming until the flask is filled with sand, when, if the flask be an open one, a board or plate is laid over and clamped firmly to the follow-board, but should there be cross-bars in the flask, the plate is dispensed with. After clamping, the whole is rolled over, and is ready for subsequent operations. See FOLLOW-BOARD; MATCH-PLATE.

Roman Cement.—A beautiful cement, improperly called Roman, is made as follows: Calcine 3 parts of ordinary clay, and mix it with 2 parts lime; grind it to powder, and calcine again.

Root's Positive Blower.—The internal operating parts of this positive blower consist of two revolvers, each of which is operative. Externally the blower consists of the case, four journals and journal-boxes, four cut gears, an oil-tight housing, and two driving-pulleys. This blower operates by a regular displacement of air at each revolution, whether it runs fast or slow. When the air enters the case at the opening for induction, and is closed in by the wings of the revolvers, it is absolutely confined, and positively forced forward until brought to the eduction-pipe, where it must be discharged, or the machine stop, if perfectly tight, as there can be no backward escapement of the air after it once enters the case, the contact being kept up at all times in the centre of the blower between the pistons or revolvers, thus preventing any escape of the air in that direction. See Blower; Blast.

Rope.—Any cord over an inch in diameter is called a *rope.* Ropes are principally made of vegetable fibre, the chief of which is hemp. Coir rope is made from the fibrous husk of the cocoanut; manilla rope from the fibres of a species of banana; in addition to which cotton and

TABLE OF

Dimensions and Weights of Short-linked Chains and Ropes, and Proof of the Chain in Tons. (Haswell.)

Diam. of Chain.	Weight per Fathom.	Proof Strain.	Circum. of Rope.	Weight of Rope per Fathom.	Diam. of Chain.	Weight per Fathom.	Proof Strain.	Circum. of Rope.	Weight of Rope per Fathom.
Inches.	Lbs.	Tons.	Inches.	Lbs.	Inches.	Lbs.	Tons.	Inches.	Lbs.
$\frac{5}{16}$	6	.75	$2\frac{1}{2}$	1.5	$\frac{11}{16}$	28	6.5	7	10.5
$\frac{3}{8}$	8.5	1.5	$3\frac{1}{4}$	2.5	$\frac{3}{4}$	32	7.75	$7\frac{1}{2}$	12
$\frac{7}{16}$	11	2.5	4	3.75	$\frac{13}{16}$	36	9.25	$8\frac{1}{4}$	15
$\frac{1}{2}$	14	3.5	$4\frac{3}{4}$	5	$\frac{7}{8}$	44	10.75	9	17.5
$\frac{9}{16}$	18	4.5	$5\frac{1}{2}$	7	$\frac{15}{16}$	50	12.5	$9\frac{1}{2}$	19.5
$\frac{5}{8}$	24	5.25	$6\frac{1}{4}$	8.7	1	56	14	10	22

Note.—The ropes of the sizes given in the table are considered to be of equal strength with the chains.

other similar substances enter largely into the business of rope-making. Wire rope, both iron and steel, is now extensively employed both on shipboard and on land. The machines invented by Mr. John Good, Brooklyn, N. Y., and others have made it possible to so manufacture ropes that their strength may be measured with the greatest exactness. Large cable-laid ropes consist of three large strands, each made up of three smaller strands. Hawser-laid rope has only three strands, each containing a sufficient number of yarns to make up the required thickness.

Rope-slings.—A very handy and useful substitute for heavy iron slings, when the flasks to be turned over are not too ponderous. Made as a single strand, with eyes at each end, or by splicing both ends of the rope together, they are infinitely superior to chains where large wood flasks are in constant service. The dealers supply these slings, leather-bound at theloops and middle, as desired. See SLINGS.

Rose's Fusible Alloy.—This alloy melts at 201°, and is composed of bismuth 2, lead 1, and tin 1. See FUSIBLE ALLOYS.

Rosin-cores.—When a core contains more or less rosin in its composition it is called a *rosin-core.* Where large numbers of dry-sand column or other cores are in constant requisition, rosin may be readily substituted for flour if a pulverizer is obtained for grinding the cheap grades bought in bulk; besides which it is much cheaper than good foundry flour.

To secure the best results, it is important that the rosin be ground very fine in order that its gumminess may be more generally disseminated throughout the mass, and thus strengthen the green core. It may also be said that, owing to the closer intimacy of the grains of rosin, the sand-grains are spread out and a free passage is made for the gases to travel towards the vents. For small cores made from fine beach or free sand the proportion of rosin may be one to eleven; less when stronger sands are used. Should cores made from this proportion lack stiffness when green, a little molasses or glue-water will serve to increase their tenacity. Large column-cores, round or square, may be made from a mixture composed of 14 each of fire and beach sand, with 6 of moulding-sand and 3 of finely pulverized rosin added. Cores made from these ingredients, if well dried and allowed to cool before removing, are extremely tough and unyielding, and for this reason the system of core-ironing may be of the simplest kind.

The sands composing these mixtures being principally free sand, are at once liberated when the rosin has burned out, making the core-cleaning a matter of the least difficulty imaginable. See FLOUR; MOLASSES; GLUE; CORE-SAND.

Rosse Telescope.—This wonderful telescope was made by the renowned astronomer Lord Rosse (born 1800, died 1867), who devoted a great portion of his life to the improvement of reflecting telescopes, and succeeded in mounting one of 3-feet aperture at his home, Birr Castle, Ireland, in the year 1839. In 1842 the now celebrated six-foot reflector was successfully cast and polished, being finally mounted in 1845. The immense tube which contains it is 54 feet long and 7 feet diameter. The speculum metal employed for casting this reflector consisted of 4 equivalents of copper to 1 of tin, which is equal in weight to the following proportions: Copper 252.8, tin 117.8. This alloy is exceedingly hard and brittle, will take a beautiful white polish, and does not readily tarnish; but, owing to its extreme brittleness, there was much difficulty experienced in obtaining a speculum casting of this magnitude absolutely free from shrinkage cracks, gas-holes, and a decided tendency to warp out of shape. To obviate these difficulties, the cooling of the mass must be controlled and the gas eliminated ; all of which, we are told, was successfully accomplished by Lord Rosse after a somewhat novel fashion. He formed the face side of his mould with hoop-irons, side by side, and edge up. When this iron bed had been thus made, the outside edge was formed with sand, and the casting poured as an open mould. The closely packed hoop-iron bed contained comparatively no gas-producing substances, as sand does, and whatever gas might exude from the metal thereon would be instantly pressed through the countless interstices by the superincumbent pressure of the metal above. See SPECULUM METAL ; TIN.

Rosthorn's Austrian Metal for Cannon.—See GUN-METAL.

Rotary Blower.—A machine provided with rotating pistons or vanes, the motion of which produces an increased current of air. See BLAST; BLOWERS.

Rotary Core-oven.—When properly constructed, this oven consists of a fireplace suitably located for supplying sufficient heat without burning the cores, and the oven structure is limited to the diameter of the rotating shelves, which are affixed to a central shaft, the lower end of which rests in a step, its vertical position being secured by a suitable contrivance at the roof. The latter, like the outer walls, must be no farther from the rotating shelves than is absolutely necessary. By this means quicker drying is obtained than would occur if unnecessary space had to be heated. The shelves may be either plain or grate, and as wide apart as will accommodate the class of cores to be dried. By this admirable contrivance the process of drying cores is materially facilitated, as the core-maker stands at the door, outside and away from the heat and gas, simply rotating the shelves in order to place within or carry away his cores. See OVENS.

Rotary Muddling-furnace.—See REVOLVING FURNACE.

Rotary Squeezer.—A shingling-machine used to consolidate and weld together the puddled balls and expel the cinder therefrom. There are many forms of squeezers, reciprocating as well as rotary. The rotary may be worked either vertically or horizontally. A strong cylindrical casing provided with an opening equal to about one fourth of its circumference forms the outside; the inside consists of a rotating cylinder, placed excentric to the casing, but with parallel faces. Both faces are deeply corrugated, and, as the inner cylinder revolves towards the small aperture, the puddled ball, entering at the widest part, is carried round and subjected to a gradually increased compression until it is forced out at the small end in a suitable shape and condition for passing through the rolls. The process is termed *shingling*. See MALLEABLE IRON.

Rottenstone.—A brownish-gray or reddish-brown mineral, found chiefly in Derbyshire, England. Its composition is alumina 86, silex 4, carbon 10. It is supposed to be decomposed shale. It is easily reduced to powder, and is largely used for polishing metals. See POLISHING SUBSTANCES.

Rouge.—The light-red powder used for polishing speculums, and extensively employed by jewellers for polishing glass and metal work. The protosulphate of iron is calcined until nothing remains but the anhydrous sesquioxide, which is afterwards submitted to fine levigation. See SPECULUM; LEVIGATION.

Roughing-rolls.—See MALLEABLE IRON; TRAIN.

Roughing-up.—A term applied to the first process when covering the bricks of a loam-mould with loam. After the bricks are set three fourths of an inch back from the sweep-board, the coarse, wet loam is rubbed vigorously on the bricks to make it adhere firmly, a little more than enough being spread over. The sharp edge of the sweep-board scrapes off the surplus, leaving a rough face—hence the term. This rough face is afterwards made smooth by the application of fine loam, over which the sweep-board is again drawn in the opposite direction. See BRICKING-UP; LOAM-BOARD; SKINNING-LOAM.

Rubber.—See RESIN; INDIA-RUBBER.

Rubber Patterns are patterns made from India-rubber, and vulcanized. This substance makes elegant and durable patterns for hardware castings, etc., and may be readily attached to either a card or match plate. See INDIA-RUBBER.

Rubidium and **Cæsium.**—These metals were discovered by Bunsen and Kirchoff in 1860 in some spring-water they were analyzing. They are found in other waters, in the ashes of beet-root, in the mineral lepidolite, and are also found associated with potassium. Both these metals are closely analogous to potassium, but are more easily fusible and convertible into vapor, and also have more attraction for oxygen. Rubidium burns on water like potassium, and fires spontaneously in the air. See POTASSIUM.

Rubstone.—A prepared emery block for cleaning and rubbing scales from castings; it is an excellent substitute for casting-brush, and for some purposes superior; this, as well as the vitrified rubstone, is to be obtained from the supply dealers in convenient sizes for hand use. See EMERY.

Ruby.—A precious stone almost equal in value to the diamond. Some regard the ruby as a red variety of the sapphire. There are balas, or rose-red rubies; alamantine, or violet and brown rubies; and oriental rubies from Burmah and Ceylon, which are the finest red. The ruby is a silicate of magnesia and alumina, with lime, manganese, and iron in varying admixtures. See PRECIOUS STONES.

Runner.—A foundry term synonymous with "gate," and of general application to almost every system adopted by moulders for leading the fluid metal into moulds. For instance, the metal enters the mould by the *runner;* a *basin* is termed *runner-basin;* and there is the *drop*-runner, the *side*-runner, the *fountain*-runner, the *spray*-runner, etc. The *channel-basin* for pouring open-sand work, and every variety of pattern for forming *passage-ways* in the sand or loam for the metal to course through —all in their respective localities, are recognized as runners. See GATE; BASIN; DROP-RUNNER, FOUNTAIN-RUNNER, etc.

Runner-box.—The wood or iron casing in which the pouring-basin is formed. See BASIN.

Runner-stick.—A common name, in some districts, for the gate-pin. See GATE-PIN.

Running-steel Ingots.—See INGOTS.

Running-through.—A rather questionable method in some foundries of trying to produce clean sound castings by forcing more or less fluid metal through the mould and out at the riser after the mould is full. If the mould manifests a condition of unrest by voiding air or steam, which should have been carried away in a more legitimate manner by the process of venting, it is well to continue the pouring slowly in order to compensate for what is thrown out at the gates and risers; beyond this it is simply waste, as neither dirt nor gas, remote from the risers, will be favorably affected by such a method, no matter how long the process is continued. The value of running through into built-up risers accrues from the increased pressure exerted on the casting. See CUT-OFF; RISER.

Run-up.—A foundry term, signifying that the mould is full of molten metal. If there should be any lacking, it is then called "short-run." See SHORT-RUN.

Russia Plate-iron.—A remarkably pure iron made in Russia, which, by special processes of refining and annealing, is rendered very tough and flexible. Owing to these excellent qualities, it is capable of being rolled exceedingly thin, and will bear much hammering and bending at a red heat without cracking at the edges.

Rust-joint.—A quick-setting compound is made from pulverized sal-ammoniac 1 lb., flour of sulphur 2 lbs., iron borings 80 lbs.; mix to a paste with water in quantities as required for use. A better cement than the above, but requiring more time to set, is made from sal-ammoniac 2 lbs., sulphur 1 lb., iron filings 206 lbs. See CEMENTS.

Rust, To preserve from.—It is commonly claimed that iron, under ordinary conditions, decomposes water, abstracts the oxygen and combines with it, and thus forms rust; but it is now asserted that the chief agent in this phenomenon is carbonic acid, which, if excluded, neither moist nor dry oxygen can affect the iron to rust it.

Polished steel or iron is prevented from rusting by applying a coat of paraffine, or steeping the object for a few minutes in a solution of sulphate of copper, and then transferring it into a solution of hyposulphite of soda acidulated with hydrochloric acid. The coating obtained will resist the action of either air or water.

Cast iron is best preserved by rubbing with black lead. Polished work may be varnished with wax dissolved in benzine. Clean white wax may be rubbed over polished work when hot, and allowed to remain some time, after which rub over with a piece of serge.

Deep-seated rust may be removed with benzine, or soak the object in kerosene for a day.

Ruthenium.—This is the most refractory of all metals except osmium. It has, however, been fused in the oxyhydrogen flame. Ruthenium is scarcely attacked by nitro-muriatic acid. After fusion it has a density of 11.4. See METALS.

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Safety-lamp.—This is simply an ordinary oil-lamp enclosed in a cage of wire-gauze, which permits the light to pass out, but prevents the exit of flame. This lamp is the invention of Sir Humphry Davy. The explosions of carburetted hydrogen gas in coal-mines, from the unprotected lamps of the miners, caused great destruction of life, and various arrangements had been fruitlessly made to prevent such fearful accidents. This great philosopher found that when a lamp is surrounded with a wire gauze, under $\frac{1}{40}$ of an inch mesh, any explosions taking place from the passage of fire-damp (light carburetted hydrogen) into the lamp are not communicated to the gaseous mixture outside. The space within the gauze often becomes filled with flame, from the burning of the mixed gases which penetrate the network, but the isolation is so complete that the explosive mixture outside is not fired.

The power of wire-gauze to prevent the passage of flame may be usefully applied in the foundry. Let a wire-gauze be placed over the outlet or vent from beneath a hollow core where, when the mould has been cast, just such gases generate; the smoke and unburned gases will pass uninterruptedly through the gauze into the atmosphere, and may be ignited *with safety,* as no flame can possibly reach the dangerous gases below (to cause explosion) as long as the intervening gauze is there to prevent it. See VENTING.

Saggers.—Cast-iron boxes in which articles of cast iron are packed, along with red-hematite ore, or smithy scales, to be converted into malleable cast iron by a process of decarbonization in the annealing-furnace. See MALLEABLE CAST IRON.

Sagging.—If, on account of unequal distribution of the means employed for lifting flasks, etc., in the foundry, some portion of the suspended object should bend out of parallel, this term would, by moulders, be used to indicate that feature. Or, when some mould surface, as a cope-face, etc., betrays a disposition to separate from the main sand structure on account of faulty workmanship, or otherwise, it is then said to sag.

Salamander.—When, through faulty charging, bad fuel, too heavy burdens of refractory ores, or from any fault in the shape of the blast-furnace a scaffold should take place, it sometimes occurs that an accumulation of cinder and cold metal is formed, which proves highly refractory, and extremely difficult to remove. This obstruction is technically termed a *salamander*. In some extreme cases, when all other means used for their removal has been obstinately resisted, dynamite has been successfully employed for that purpose. See SCAFFOLD.

Salt.—Common salt, or the chloride of sodium, is found in many parts of the world in solid beds. Sea-water contains about 4 ounces of salt in every gallon. The springs of New York State furnish an enormous annual supply. Rock-salt is seldom pure enough for use, and where no natural brine-springs exist, an artificial one is formed by sinking a shaft into the rock-salt and introducing water, if necessary. This, when saturated, is pumped up and evaporated more or less rapidly in large iron pans. Besides its use for preserving meats, by absorbing water from the flesh, it is used as a source of sodium in the manufacture of caustic soda, and as a source of chlorine in the production of chlorohydric acid. It fuses at a red heat, and is hence used for glazing stoneware, earthenware, etc. This property renders sea-water unfit for foundry purposes. See SEA-WATER.

Salt-cake is the sulphate of soda as prepared for the manufacture of soap and glass. This compound is of great value as a flux for smelting valuable metals. By using a little on the surface of the metal in the crucible, the scum and dirt readily unite with the salt-cake, and the appearance of the metal is much improved. See FLUX.

Saltpetre.—See NITRE.

Sand.—Fine particles of stone or mineral. The finely granulated particles of siliceous stones constitute the beach and river sand, which, when dry, are without cohesion. The various sands are made through the agency of winds, water, decomposition by chemical action, and other agencies. See FACING-SAND.

Sand-bed.—The sand-bed of a cupola is the sand rammed on the bottom, on which the molten iron rests after it has been melted above and fallen down through the fuel thereon. The old or black sand off the floor, that which has been slightly burned, is the best to use for this purpose; being free from clay, it does not bake hard, and by using it a little drier than ordinary moulding-sand it may be rammed well down to a solid bed without fear of danger from blowing or boiling—a too frequent occurrence when the sand used for this purpose is close and too damp. The thickness of the sand-bed may always be increased when it is desired to reduce the depth from the tuyeres down, but there should never be less than 2½ inches over the bottom plate. A slight down grade towards the tapping-hole is necessary to run all the iron off, but avoid too much slope, as it increases the pressure at the tapping-hole, making it more difficult to insert the bott. See CUPOLA; SPOUT; BREAST-HOLE; BOTT.

Sand-blast.—The process of engraving, cleaning, boring, and cutting glass, metals, and other substances by forcing or blowing sand, emery, powdered quartz, granules of iron, etc., upon the surface by means of steam-pressure or air-blast. Corundum 1½ inches thick has been pierced by a jet issuing at 300 pounds pressure. It is also used for cleaning castings, graining of zinc-plate, cutting letters on stone and glass, frosting silverware, and many other similar purposes.

Sand-dusters.—Flat, round vessels of block-tin, with fine perforations on one of the flat sides. They are used largely among hardware and stove founders for dusting the joints with parting-sand, instead of using the hand for that purpose. See PARTING; PARTING-SAND.

Sand-floor is that part of the foundry floor usually devoted to the production of castings in green sand, many of which are moulded in the sand-floor itself, and termed "sand-floor," to distinguish it from the dry-sand and loam-work floors. See FLOOR-MOULDING; BLACK SAND.

Sand-mould.—A mould constructed in the sand, either in the floor or contained within flasks. In this instance it may be either a dry-sand or green-sand mould, the term "sand-mould" simply distinguishing it from one constructed by the processes of loam-moulding. See LOAM-MOULDING; GREEN-SAND MOULDING; FLOOR-MOULDING; DRY-SAND MOULDING.

Sand Odd-part.—See MATCH-PART.

Sand-pulverizer.—Any machine that will crush lumps and grind the particles of sand together, and thus produce a thorough blending of the materials employed for producing sand and loam mixtures in the foundry. The ordinary loam-mill and crusher may be classed as such; but for the purpose of mixing and sifting the finer grades of sand there are other excellent contrivances, with which, by means of a grinding-plate and vertical yielding bed set in below the hopper, the sand is pulverized and mixed, and finally delivered into a horizontal revolving screen to be sifted. See ROCK-CRUSHER; LOAM-MILL; SAND SCREEN.

Sandstone is a rock composed of siliceous or calcareous grains of sand cemented together by siliceous, calcareous, or ferruginous infiltrations, though the loose sand solidifies by pressure alone. The sand grains are invariably composed of quartz with a slight admixture of other minerals, which gives rise to the variations in color. Some of these sandstones, owing to the highly refractory nature of their composition, are occasionally employed as hearths of blast-furnaces, also for the beds of air-furnaces; but the want of homogeneity in the stone makes them liable to crack, and for this reason other refractory materials are generally preferred. See ROCK-SAND; FACING-SAND.

Sand-washing.—The process of washing sand, in order to free it from deleterious matter, and thus render it more suitable for moulding purposes, may be materially facilitated by rotating a cylindrical wire-sieve within a shallow trough, which receives a constant supply of water at one end and discharges it at the other, along with the soluble matter which has passed through the sieve. See CORE-SAND.

Sand-Screen.—The ordinary sand-screen in the foundry is similar to the one used for coal and for the sand used by builders, etc. The regular sizes used for brickwork and plastering is 3- or 4-mesh, for fine sand 5-mesh, for gravel 2-mesh. These frames measure 6 feet high, 26½ inches in width. The sizes most used are ¼-inch openings for taking out the dust; ⅜-inch for chestnut coal; ½ to ⅝-inch for nut; ⅝ to ¾-inch for stove; ⅞, 1, and 1¼-inch for cleaning soft coal. These screens are made with a heavy hard-wood frame, and of extra heavy crimped wire. The frame is securely fastened together with bolts, and the wires are firmly stapled to the frame, and finished at the top and bottom with sheet iron. The revolving screen consists of a grating of wire cloth secured to a framework of iron, forming a cylindrical riddle or sieve, into which the sand is thrown at one end. A slight incline causes what is too large to run through the meshes to pass out at the other end as the cylinder rotates horizontally on its axis.

Sand Sifters.—The common kinds of sand-sifters are made to operate by either hand or power, and usually consist of a stout oblong frame supported on four legs, inside of which the sieve or riddle is caused to move rapidly back and forth by a mechanical device attached to the end of the frame. Some makers claim six movements of the sieve to each revolution of the driving-wheel or pulley; the object in this being to prevent clogging by imparting a constant jarring motion to the sifter. Other sifters are suspended from beams above, and an oscillating motion imparted to them by a three-toothed cam-pinion, the teeth of which thrust (alternately); pins in the slotted piece attached to the bar which actuates the sifter, and a rapid back-and-forth movement is imparted thereto. See RIDDLE.

Sapphire.—A precious stone, almost equal to the diamond in hardness. It is highly transparent and brilliant, and consists of nearly pure alumina or clay, with a minute portion of iron. White sapphire resembles the diamond. Red sapphire is called the oriental ruby; blue being the common sapphire of the ancients, and yellow the oriental topaz. See PRECIOUS STONES.

Sardonyx.—A very beautiful and rare variety of onyx, composed of alternate layers of sard and white chalcedony, used by the ancients for cameo engravings. See PRECIOUS STONES.

Satin-Spar.—A white fibrous limestone, which exhibits, when polished, a lustre like satin. It is found in England and Scotland. See LIMESTONE.

Saturation.—A liquid is said to be saturated when it has taken up as large a quantity of a solid as it can dissolve, in which case the force of cohesion between the particles of the solid is equalled by the adhesion of the liquid and the solid to each other. Saturation means also the absorption of liquids by solids, the permeation of an element by other elements, etc. See SOLUBILITY.

Scabbed Castings are castings on the surface of which rough and unsightly excrescences are found when the adhering sand has been removed. These imperfections arise from a variety of causes: such as imperfect venting; faults in the ramming; unsuitable material; too much coal; extreme moisture, and numerous other causes, all of which, in the great majority of instances, might be easily avoided if the intelligence of those engaged in their production was equal to the demands made on it. The moulders of to-day are deficient from both an intellectual and artistic point of view, and no substantial improvement in the quality of castings may be anticipated until a more rigorous system of apprenticeship and superior technical training shall have been adopted. This and this only will amplify the minds of our young men and enable them to intelligently trace cause and effect, and thus avoid the errors which, owing to their present ignorance, are now so frequent. See TECHNICAL EDUCATION FOR THE MOULDER; FACING-SAND; VENTING; RAMMING; CUTTING; CURRENT.

Scaffold.—See CHARGING-PLATFORM.

Scaffolding is the formation of highly refractory masses of scoria and iron upon the cupola or blast-furnace walls, which interfere to a remarkable extent with their free working. These obstructions may be caused by the accumulation of refractory slag; from the use of soft fuel that is crushed by the superincumbent charges; uneven distribution of the charges; inferior fuel; too heavy burdens; etc. Most of the conditions enumerated act by obstructing the blast, and thus interfering with a free ascent of the gases; the furnace loses heat, and the slag coagulates and favors the formation of scaffolds. In the ordinary cupola a scaffold may be removed by the introduction of finely divided fuel at the tuyeres, which are directly underneath the offending mass, reducing the blast somewhat until the obstruction begins to yield; and it is sometimes possible to loosen them off by means of a long bar from the charging-hole; but in the case of blast-furnaces more drastic measures must be employed. See CHARGING; RATIO OF FUEL TO IRON; SALAMANDER.

Scaling-furnace, as its name implies, is the furnace in which plates have the scales removed by the application of heat.

Scoria.—The cinder and slag rejected after the reduction of metallic ores, or the superfluous matter of metals in fusion. See SLAG.

Scotch Pig Iron is a brand of iron that in the past has been highly esteemed by founders almost everywhere for its softness and fluidity, as well as for the particular quality of retaining its heat when melted for a much longer time than most other irons. This remarkable iron is made from ores and coal eminently adapted to the production of No. 1 irons. The particular quality of fluidity which it possesses is owing to the presence of a large proportion of phosphorus; but many of these brands are high in both manganese and combined carbon, which renders their use for strong castings that have to be tooled very undesirable. When these irons have been low in the latter-mentioned elements and correspondingly high in silicon and graphitic carbon, they have been unquestionably successful as softeners; but the following comparison of a cheap No. 2 American with a high-grade Scotch iron will show that our domestic brands are far superior as softeners—a fact that is becoming more widely known by foundrymen, as the decreased imports testify. This shows the

	Silicon.	Phosphorus.	Manganese.	Sulphur.	Graphite.	Com. Carbon.
American No. 2.	3.81	.49	.15	.04	3.26	.04
Scotch No. 1.	1.70	1.10	1.83	.01	3.50	.40

softening element, *silicon,* to be much higher in the American brand—while phosphorus, manganese, and combined carbon, all hardening, are almost absent by comparison with the Scotch. See SOFTENERS; SILICON.

Scrap-metal.—Fragments of cast-metal to be remelted, or of malleable iron. The latter, when reworked in the forge by piling, heating, and rolling, is sometimes converted into the strongest iron by reason of the twisted fibre imparted to the forgings. Cast-iron scrap of good quality forms a good corrective in all mixtures when the resultant casting made from the pig iron in stock would be too soft and graphitic. See MIXING CAST IRON; BUGS; SILICON; SOFTENERS.

Screen.—See SAND-SCREEN.

Screw-jack, or jack-screw, is a lifting-machine in which the power consists of a strong screw, which is made to rotate by means of a large nut which rests upon a base or pedestal. It is raised or lowered by turning the nut.

Screw-moulding.—Cast-iron screws for conveyors and elevators are made in greensand by screwing a section of screw through the entire flask; first bedding the shaft with section attached in the lower flask, making joint half-way and ramming thereon the cope, which, when the pattern has been screwed out endwise, may if necessary be separated for finishing.

Screw-plates.—See Rapping-plate.

Screw Propellers.—A screw propeller is a similar construction to the common screw, except that the thread enlarges to a plate as the cylinder diminishes to a spindle. It acts much as a bolt in a fixed nut. When placed under the ship and revolved, the screw advances, pushing the ship, and the water is thrust backwards. John Stevens, of Hoboken, employed a screw propeller in 1804. In 1836 patents were granted to Capt. J. Ericsson, United States of America, and Francis P. Smith, England, which resulted in their final adoption as a regular mode of propulsion for steamships. Propellers are cast from bronze, steel, and cast iron—some whole and others with boss and blades as separate castings. The latter may very readily be all made in greensand. Large numbers of small wheels are made from entire patterns in greensand. An improved method of moulding small wheels in greensand from one blade and an equal section of hub secured to a nowel-frame of wood, cut to the shape of the joint, allows of the pattern being rammed therein, the joint made, and an impression of the upper side being taken in a close-fitting cope, also of wood. This whole process, being performed upon a lifting-plate that stands within the nowel-frame, permits the blade-moulds when placed together to be arranged in their respective positions upon a level bed, and all rammed with a containing flask or curb. The covering-plate, weights, and runners complete the operation. Larger wheels are made in dry-sand from one-blade pattern with hub attached, the latter being made to fit a central spindle that rests on a foundation-plate on which as many nowels are fixed as there are blades to the wheel. The copes, being separate ones, are rammed in succession over the pattern, as the lower surface of the blades are alternately formed in each nowel. When all the blades have been moulded by this means, the whole mould is finished, blackened, and dried for casting. When small and medium-sized wheels are made in loam, the whole of the blades are formed upon one foundation-plate; very large ones have a separate foundation-plate for each blade. An outer swept-bearing, just beyond the brickwork of the blades, serves as a rest for the inclined plane on which the sweep-board, attached to the free arms of the spindle, must be made to travel, and which gives the pitch of the wheel. Bottom and top surfaces of the blade are struck with this board, which is set at right angles with the spindle, a tapered thickness or guide-piece being attached when the blades are made face up. If the blades are to be cast face up, the moulds are carved out of the loam; if face down, then some pattern device is schemed, in order to give the cope impression. The piers or nowels are built of bricks and loam; but the copes are carried off in iron frames, so constructed that a good loam impression of the blade along with that portion of the hub may be lifted away, to be again returned when the whole mould has been dried, and all is ready for binding and ramming together in the pit.

Scruple.—The scruple is the 288th of a troy pound; the 24th of an ounce; the third part of a drachm, and contains 20 troy grains.

Sculpture is an art in which, by means of taking away or adding to matter, all sorts of figures are formed either in clay, wood, wax, stone, or metal. The art of sculpture, in its most extensive sense, comprehends not only carving in wood, stone, or marble, but all enchasing, engraving in all its kinds and casting in bronze, lead, wax, plaster, as well as modelling in clay, wax, or stucco. See STATUARY-FOUNDING; PLASTER CAST; MODELLING; STUCCO.

Sealing-wax Impressions. — Sealing-wax is a very handy and useful substance for obtaining any particular impression to be afterwards inclosed within or attached to a pattern for moulding in sand. The wax must be of good quality and melted in a metal vessel over a lamp, after which the pattern can be pressed down upon the wax just before it congeals, and a beautiful impression will result if the pattern is thoroughly clean. Sealing-wax impressions make good moulds for plaster.

Sea-coal Facing.—See COAL-DUST.

Sea-water is water impregnated with salt in solution. It is generally composed of chloride of sodium 2.50, chloride of magnesium 0.35, sulphate of magnesia 0.58, carbonate of lime and carbonate of magnesia 0.02, sulphate of lime 0.01, water 96.54.

It will be seen from the above why sea-water is utterly unfit for foundry purposes, as, in the subsequent process of evaporation, the chloride of sodium or common salt is deposited in innumerable crystals among the sand; and this deposit being volatile at furnace heat must flow as a slag immediately it is brought in contact with the molten metal. This explains why, where sea-water is employed, castings invariably show dull gray deposits on the surface, which utterly destroy all beauty of finish, and render them unfit for any but the commonest purposes. The slag produced is also a source of annoyance when the castings must be tooled. See Salt; Daubing.

Seating.—A guide-bearing or rest for cores or mould sections. In vertical loam-work the cope or the core, and sometimes both, are made as separate portions of the mould, and must be lowered into their respective positions when the mould is closed together in the pit. In order that this may be done accurately, a tapered seating is formed at the bottom of the mould, extending some few inches below the casting. By this device the smallest end of the core is made to enter at the widest diameter of the seating, and is thus guided to the bottom-bearing, when the sides meet close together at a true centre. The cope is the opposite to this, its widest diameter seeking a true location by inclosing the small end of the seating first, and gradually embracing it closer and closer until the bottom-bearing is reached, when the diameters correspond and the section is central. The tapered sides of an ordinary core-print represent the seating for a core. See Cope-ring; Print; Guide.

Semilor.—A cheap imitation of gold, used for common articles of jewelry. The composition varies from 2 to 5 copper, and 1 zinc. See Gold; Tombac

Semi-steel.—See Puddled Steel.

Separating-machine (Woodruff's) is an ingenious combination of vibrating screen and fan for extracting shot and other small iron from foundry refuse. It occupies ground space about four by eight feet; requires about one and a half to two horse-power to drive it; can be set up anywhere, in doors or out, under shed, where power can be had.

A barrowful of refuse will pass through the separator in three or four minutes, all the iron being deposited in box provided for it, and all other materials thrown to rear of machine.

Separating Metals from their Alloys.—Tin may be separated from copper by digesting in nitric acid, which dissolves the copper—the tin remaining in an insoluble peroxide.

Copper is separated from lead by adding sulphuric acid to the nitric solution and evaporating to dryness, when water digested on the residuum will dissolve out the sulphate of copper, leaving the sulphate of lead behind. From this solution the oxide of copper may be precipitated by pure potassa. The precipitation of copper in the metallic state is obtained by immersing polished steel into the solution.

Copper is separated from zinc by sulpuretted hydrogen, which will throw down a sulphuret of copper, which may be dissolved in nitric acid and precipitated as before.

Silver is separated from copper by first reducing the alloy to powder, and then digesting in a solution of chloride of zinc, which dissolves the copper, leaving the silver unchanged. Or, mix sulphuric acid 1 part, nitric acid 1 part, water 1 part; boil the metal in the mixture till it is dissolved, and add a little salt, which will cause the silver to subside.

Copper is separated from its numerous alloys—as lead, tin, antimony, iron, bismuth, etc.—by melting the alloy, and fusing for about an hour with one part each of black oxide (copper scales) and bottle-glass to every ten parts of the alloy. The copper will fall to the bottom of the crucible; the other metals and impurities either volatilize or dissolve in the flux.

If lead and tin are in solution, the lead may be precipitated by sulphuric acid, and the tin with sulphuretted hydrogen gas. In an alloy the lead will dissolve in nitric acid, leaving the tin as an oxide.

Zinc and iron may be removed from plumber's solder by digesting the grain metal in diluted sulphuric acid. The acid first dissolves the zinc, then the iron, and all traces of these metals are removed by subsequent washing.

Tin may be separated from Britannia and similar alloys by melting the metal and sprinkling sulphur over it; after which stir the metal in the crucible for a while, and the other metals will burn out, leaving the tin pure.

Gold is separated from silver by melting the alloy and pouring from a height into a rotating vessel containing cold water. This granulates the alloy, which is then treated with nitric acid and heated. The product is nitrate of silver, which is reduced in the ordinary manner, and metallic gold as a black mud, which is washed and remelted.

Setting.—This term is applied to metal as it passes from the fluid to the solid state. When the metal has concreted into a solid mass, it is termed "set" or "frozen," both of which terms are in the foundry synonyms for congelation. See CONGELATION; FREEZING.

Shackle.—A link with an open end, the extremities of which are forged to receive a pin or bolt, by which means a connection may be made with a chain; or it may be employed to join two chains together. Some are made link-form, and others are made like a ring. Their chief use in the foundry is to handle heavy cores and flasks, for which reason the eyes should be always made large in order that strong pins or bolts may be inserted. If pins are used, one end should be jumped and the other keyed, to prevent slipping out. The nut answers this purpose when a bolt is used.

Shakdo is a Japanese bronze of great beauty, the composition of which consists of copper containing from one to ten per cent of gold. Its bluish-black color is preserved by boiling the polished article in an artificial bronze solution composed of sulphate of copper, alum, and verdigris. See BRONZE.

Shale is a hard, slaty clay composed chiefly of silica and alumina, but in some instances containing lime and oxide of iron. It forms in the coal-measures and often contains a quantity of bitumen: it is then known as bituminous shale, from which variety shale-oil is obtained by distillation. Shale has a slaty structure, generally grayish black in color, but red when iron is present. Slate-pencils are made from it, and when free from iron and lime it is ground up and used for making fire-bricks. See BITUMEN.

Shank.—A foundry-ladle for holding molten metal. It is distinguished from the hand and crane ladles by its mountings, which consist of an encircling wrought iron belt, to which is welded the single and double ends for carrying it away by hand. Shanks are made of both cast and wrought iron (the latter to be always preferred), and their capacity ranges from 100 to 400 pounds. Small shanks are managed by two men, the larger ones requiring from three to five men, according to the weight of metal carried away. They are sometimes made to hold a ton or more, but are then lifted in a bale by means of the crane, and these are neither as safe nor as handy as when suitable gearing is attached. See LADLE; HAND-LADLE; CRANE-LADLE.

Shears.—A machine used in forges and rolling-mills for cutting up puddle-bars into suitable lengths for piling, trimming the edges of sheets, plates, etc. Crocodile or alligator shears are generally some form of lever-shears consisting of a fixed bottom jaw or knife, to which at the root of the knife is attached the vibrating-arm or lever-jaw. A crank or excentric at the opposite end of the lever causes the upper jaw to open and shut after the manner of an alligator's mouth; hence the name. The plate-shearing machine is made with diagonal-edged knives of considerable length; the bottom one is fixed, and the upper has a vertical motion within parallel guides. These are employed for sheet and plate work. Guillotine-shears are similar in design to plate-shears; but, as their use is for cutting up the hot steel ingots into lengths suitable for subsequent operations in the mill, the knives are much shorter and the guides closer together, giving the machine an appearance of the instrument from which it derives its name. There are also numerous designs of combined shear and punch, both of which motions are derived from gear connection with the fly-wheel. Hydraulic shears may be of two forms: the stroke is either upward or downward, according to the position of the press.

Shear-steel.—Shear-steel of commerce is classified as *double* and *single* shear steel. Owing to the imperfections of *blister-steel,* it is not suitable for the manufacture of cutting instrument, as shears, knives, etc., until it has undergone the processes of cutting, piling, reheating, and welding together again under the hammer or by rolling. The resultant bar is *shear-steel;* this, when cut up or doubled upon itself, reheated, and again hammered or rolled, is *double-shear steel.* See BLISTER-STEEL.

Sheathing-metal is a metal or alloy which, when rolled into sheets, is employed for covering the bottoms of wooden ships to protect them from worms, etc. Muntz's metal for this purpose is copper 60, zinc 40; but he states that any proportions between the extremes of copper 50, zinc 50, and copper 63, zinc 37, will roll and work at a red heat; but copper 60, zinc 40 is always to be preferred. The cast ingots of this alloy are heated to about 200° and rolled into sheets, the same heat serving for working this alloy into other shapes, as bolts, etc. Numerous other alloys are employed for this purpose, amongst which may be noticed: Mushet's—copper 100, zinc $\frac{1}{8}$; Collins's red sheathing-metal—copper 8, zinc 1; Collins's white metal—copper 1, zinc 16, tin 16; Pope's—lead 1, zinc 3, tin 2; all of which may be heated and worked as previously described. The nails used for fastening the sheathing are composed of an alloy of copper and tin. See BRASS.

Sheet Iron is rolled from the bloom direct, or from slabs and piles. It is brought to a welding heat and passed through the slabbing or roughing rolls, end and sidewise, according as it appears to require distention, until the mass has been reduced sufficiently for final rolling in the finishing-rolls where, being now brought by the previous operations to the required width, it is passed through entirely in the direction of its length. Gauges of the length, breadth, and width indicate when to discontinue rolling. The exact size is obtained by means of plate-shears. See MALLEABLE IRON.

Sheet Lead.—One method of making sheet lead is to suffer the melted metal to run out of a box or vessel through a long horizontal slit, upon a table covered with sand, when the box is drawn over it, leaving the melted lead behind to congeal. These sheets may then be rolled to any desired thickness, and also made more uniform. A later improved method is to cast thick square blocks of lead, which are subsequently drawn into long sheets between two heavy rolls; the sheet in the meanwhile being supported upon a long table which travels on wooden rollers. Another method is to force the metal by hydraulic power through the annular space formed by an outer cylinder and central core. This makes lead-pipe, which may be slit lengthwise and opened out into sheets. The Chinese pour melted lead upon a paper-protected flagstone, and press it down into a sheet by applying another similarly prepared stone above. See LEAD.

Shell-gold.—The thin beaten gold used by decorators. See GOLD.

Shell-lac.—A resinous exudation from the branches of several trees in the tropics. The crude lac is called *stick-lac;* this is bruised, the fragments of wood removed, and the resin digested in weak carbonate-of-soda solution. The residue is the *seed-lac* of commerce, which when melted down becomes *shell-lac.* See RESIN.

Shell-moulding.—See HOLLOW SHOT.

Shells.—The shells of oysters, clams, etc., and of the eggs of birds, are composed almost wholly of carbonate of lime, cemented by a very small portion of animal gluten; while those of lobsters, crabs, etc., generally consist of only half carbonate of lime, the remainder being animal matter with a small proportion of phosphate. See CARBONATES; LIME

Shingling.—The process of detaching impurities, as cinder, etc., from the blooms of puddled iron by hammering or compressing the ball, and thus preparing it for immediate conversion into bar iron by rolling. See MALLEABLE IRON; ROTARY SQUEEZER.

Short-run.—A foundry appellation for a mould or casting which has been spoiled by being only partially filled with molten metal. See RUN-UP.

Shot.—See HOLLOW SHOT; LEAD-SHOT; PROJECTILES.

Shot-metal.—See LEAD-SHOT.

Shot-tower.—See LEAD-SHOT.

Shovel.—An instrument consisting of a flat or scooped blade and a handle; it is used for digging and throwing sand, earth, etc. Moulders' shovels are of two kinds—heavy and light, the former for digging, the latter being specially made to meet the requirements of stove-plate, bench, and other light-work moulding; but both classes of shovels should be made of the best cast steel, and well polished. The handsomer and better the tool, the greater will be the care exercised to preserve it, so that in the end the best is the cheapest. Besides this fine grade for moulders, there are plain black polished ones of a stronger make, adapted for rough use on the gangway and scrap-piles, which answer these purposes just as well as the best, and are much cheaper. Special shovels and scoops are made for coal; but for coke handling, especially round the cupola, the fork is to be always preferred. The square-bladed digging-tool is usually termed a *spade.* See COKE-FORK.

Shrinkage.—A contraction or shrinking of materials into a less compass as they change from a hot to a cold state. Some hard irons shrink or contract $\frac{3}{8}$ of an inch in 12 inches, while soft irons of choice grades will sometimes not exceed $\frac{1}{16}$. Medium grades of good quality generally shrink about $\frac{1}{10}$ of an inch in 12 inches when used in heavy castings; but in light castings the same brand will as a rule show $\frac{1}{8}$ of an inch in 12 inches. Bronze shrinks about $\frac{3}{16}$ of an inch in 12 inches. General brass work, according to mixture, will shrink from $\frac{3}{16}$ to $\frac{1}{4}$ of an inch in 12 inches. Copper shrinks $\frac{3}{16}$, tin about $\frac{1}{8}$, silver $\frac{1}{8}$, lead $\frac{5}{16}$, zinc and bismuth each $\frac{5}{16}$ of an inch in 12 inches. These can only be approximate measures of shrinkage; the exact amount which takes place in any particular casting must necessarily be determined by its general outline and bulk, and to some extent by the temperature of the metal used for casting with, dull metal always favoring the least contraction. Very little if any shrinkage would seem to occur in heavy castings of limited compass, but what in this instance seems to be lack of shrinkage is in all probability to be attributed to distention of the mould under extreme pressure. The metal remaining fluid a longer time in this class of moulds than is ordinarily the case, gives ample opportunity for the pressure to act upon the mould surfaces to severely try them. Bottoms of cylinders and pipes would appear to shrink more than the tops; but it is a mistake to say they do. The smaller diameter at that point is because the material of which the core is composed cannot effectively resist the extra pressure to which the lower portions of all deep moulds are subjected. When 12 feet added to the depth will make a difference in pressure equal to about 37 pounds per square inch, it is plain that unless extraordinary measures are adopted to resist this added pressure, cylinders will always appear to shrink more at the bottom than top. The commonly accepted theory that castings shrink less vertically than in any other direction is undoubtedly wrong also, and similar reasons may be advanced to refute this as in the case above, especially when the upper flask or covering-plate is connected with a system of coring, the bottom surfaces of which extend a considerable distance down. These extra strains, if not resisted absolutely *both at the top and bottom,* gives an increased length to the casting, which in many instances exceeds the legitimate shrinkage. Gear-wheel rims shrink less when the arms and hubs are cast on than when made as a separate casting, and it may always be expected that the heaviest wheels will shrink the least. The same may be said in reference to other classes of castings, which are composed of cross-ribs and plates internally; these will invariably shrink less than open castings, such as plain frames, etc.

Shrink-head.—See Riser; Feeding-head.

Shutter.—The cast or wrought iron plate which, when suitably prepared with a loam daubing on both its sides, is set before the flow-hole inside the dam for the purpose of regulating the stream issuing from thence. A lever is usually employed to control it. Smaller shutters are employed to check or turn the stream of metal issuing from the furnace to a mould direct. When the metal is allowed to collect in a large sand-basin before entering the mould, the shutter controls the stream. See Dams.

Siemens-Martin-Steel. — See Open-hearth Steel; Regenerative Furnace.

Sieve.—A fine riddle, usually made from brass wire, and used for mixing and separating the finer grades of sand, etc., in the foundry. See Riddles.

Silex.—A generic name given to flint-stone, pure quartz, silica, and all minerals in which a large proportion of silica is present. See Silica.

Silica.—One of the most abundant substances found in nature. Silica is the chief component of a number of precious stones, of rock-crystals, agates, porphyry, granite, flints, sandstone, and sand. When perfectly pure it is a fine powder, very hard, and will wear away glass. When mixed with water it does not adhere, but falls to the bottom, leaving the water clear. It fuses in the oxyhydrogen blowpipe, and may be drawn into threads after the manner of glass. When silica is mixed with alkalies it melts at a lower temperature, and combines with them to form glass. The minerals, feldspar, mica, hornblende, serpentine, etc., which form the granitic and many other rocks are silicates of the alkalies and alkaline earths. Glass and pottery are compounds of silica with various metallic oxides. See GRANITE.

Silica Bricks are made by incorporating about 50 pounds of lime-paste with a ton of crushed Dinas rock from the Swansea Valley. This rock contains about 97 per cent of silica, and the bricks produced from it are employed chiefly for the roofs and all exposed parts of the open-hearth steel-melting furnaces, and other similar purposes where the operations demand the most intense heat. See OPEN-HEARTH CAST STEEL.

Silicon.—This substance is the base of silex or silica, and is now supposed to be a non-metallic element. More or less of this element is present in all varieties of pig iron, but whether in chemical combination or otherwise it has not yet been satisfactorily determined. Silicon acts to change the combined carbon in cast-iron to graphitic carbon. Describing the result of his experiments for ascertaining the influence of silicon upon cast-iron, W. J. Keep says: "We have seen, however, that a white iron which will invariably give porous and brittle castings can be made solid and strong by the addition of silicon; that a further addition of silicon will turn the iron gray, and that as the grayness increases the iron will grow weaker; that excessive silicon will again lighten the grain and cause a hard and brittle as well as a very weak iron; that the only softening and shrinkage-lessening influence of silicon is exerted during the time when graphite is being produced, and that silicon of itself is not a softener, or a lessener of shrinkage, but through its influence on carbon, and only during a certain stage, it does produce these effects."

To produce highly siliceous iron, or siliconeisen, in the blast-furnace the blast requires to be extremely hot, the furnace driven slowly, and the charges, while containing much silica, must be highly aluminous and not markedly calcareous.

When 20 per cent of silicon is present in siliconeisen the amount of carbon in the alloy is very low.

To prevent honeycombing in soft cast steel which contains very little carbon, an alloy containing 8 per cent silicon, about 15 per cent manganese, and 1.3 per cent carbon is employed extensively in some steel manufactories. The presence of silicon along with manganese acts to diminish the formation of honeycomb in steel ingots. See HONEYCOMBING; SOFTENERS; ANALYSIS.

Silicon Bronze.—See TELEGRAPH AND TELEPHONE WIRE.

Siliconeisen.—See SILICON.

Silicon Steel.—This steel is made by adding some siliconeisen or specially prepared siliceous pig along with the ordinary spiegeleisen or ferro-manganese which it is customary to mix with the molten metal, reducing the latter sufficient to admit the siliconeisen. The result is a steel containing from 0.2 to 0.3 per cent silicon, which is largely employed for steel castings.

Silver.—This metal is found native and in combination with sulphur, as the sulphides of lead, antimony, and copper; native silver occurs in fibrous or crystalline masses. The metal is obtained from the sulphuret by mixing the crushed ore with salt and roasting it, by which means it is converted into a chloride which, together with water, iron scraps, and mercury, is revolved in a large barrel. By this process the chlorine is removed by the iron and the mercury amalgamates with the silver, from which it is subsequently freed by distillation. Silver is freed from lead by melting the alloy and cooling slowly; the lead then solidifies in crystals, leaving the almost pure silver. The process of cupellation in shallow porous vessels made from bone-ashes gives a still greater degree of refining. Being melted with access of air, the lead oxidizes; the oxide or litharge melts, and, being absorbed by the cupel, the silver is left pure. Silver is the whitest of all metals, of high metallic lustre, is very ductile and tenacious, may be hammered to the ten-thousandth of an inch thick, and one grain may be drawn into four hundred feet of wire. Polished, it is an excellent reflector of light, and it is a good conductor of heat and electricity. To give silver the requisite hardness for coin and silver-plate, it is usually alloyed with about one tenth of its weight of copper. The specific gravity of silver is 10.5, and it is harder than gold, but softer than copper. See AMALGAMATION; MERCURY METALS.

Silver Alloys.—For silver-plate and medals—silver 95, copper 5. Silver solder for jewellers—silver 19 dwts., copper 1 dwt., brass 10 dwts. A hard silver solder is composed of silver 6, brass 2; the one most common, and which is softer than the last, has silver 4, brass 2. See IMITATION SILVER; MOCK SILVER; GERMAN-SILVER; BRASS.

Silver Imitations.—See IMITATION SILVER.

Silvering.—A silver-plating solution is made and applied as follows: Put together in a glass vessel 1 oz. nitrate of silver, 2 oz. cyanuret potassa, 4 oz. prepared Spanish whiting, and 10 oz. pure rain-water. Cleanse the article to be plated by washing over with dilute nitric acid or potash-lye and prepared chalk, and apply with a soft brush. Finish with the chamois-skin or burnisher.

Silvering with the Plating Powder.—Dissolve silver in nitric acid by the aid of heat; place some pieces of polished copper in the solution to precipitate the silver; wash the acid out in the usual way; then, with 15 grains of it mix 2 drachms of tartar, 2 drachms of table-salt, and ½ drachm of pulverized alum. Brighten the article to be plated with ley and prepared chalk, and rub on the mixture. When it has assumed a white appearance expose to heat, and then polish with the chamois or burnisher. Good for clock-dials and barometer scales.

Silvering Metals, cold.—Mix 1 part of chloride of silver with 3 parts of pearl-ash, 1½ parts common salt, and 1 part whiting. The article to be well cleaned, as before directed, and the mixture rubbed well on with a piece of cork moistened with water. When silvered wash the article in hot water, slightly alkalized; then wipe dry.

Silvering by Heat.—Dissolve 1 oz. silver in nitric acid; add a small quantity of salt; then wash it and add salammoniac, or 6 ozs. of salt and white vitriol; also ¼ oz. of corrosive sublimate; rub them together till they form a paste; rub the piece which is to be silvered with the paste; heat it till the silver runs, after which, dip it in weak vitriol pickle to clean it.

Silvering Solution for Electro-plates.—Nitrate of silver 2 drachms, distilled water 37 drachms. Dissolve, and add salammoniac 1 drachm, hydrophosphite of soda 4 drachms, precipitated chalk 4 drachms. Agitate the preparation occasionally for 12 hours, when it will be ready for use. Apply with a fine sponge.

Silvering Mirrors.—Silver, instead of mercury, is now much used for this purpose. The deposition is effected by pouring over the glass a mixture of alcohol, nitrate of silver, carbonate of ammonia, and ammonia, to which has been added a few drops of oil of cloves. A gentle heat is applied for two or three hours, when the surface becomes coated. The residue is poured off, the film of silver dried and varnished.

Silvering Shells.—Silver-leaf and gum-water, a sufficient quantity; grind to a proper consistency, and cover the inside of the shells. For gold use the gold-leaf in the same manner.

Silvering Glass Globes.—Lead 1 part, tin 1 part, bismuth 1 part; melt, and just before it sets add mercury 10 parts. Pour this into the globe and revolve rapidly. See PLATING; MERCURY.

Silver Lead.—See GRAPHITE; BLACK LEAD; FACING.

Silver-plating.—PLATING; SILVERING.

Silver Powder.—Melt one part each of tin and bismuth; then add one part mercury, just before it sets. When cold this is powdered and used by japanners.

Silver Solder.—See SILVER ALLOYS; SOLDERS.

Silver Steel.—Extra fine steel for the keenest cutting instruments. Some makers alloys this with an exceedingly small proportion of silver.

Similor.—Gold-colored brass. See SEMILOR.

Sinking-head.—So called because the molten metal falls or sinks out of it into the shrinking casting below. See FEEDING-HEAD; RISER.

Sister Chains.–Two distinct pairs of foundry lifting-chains, having similar parts throughout, each one of which is an exact counterpart of the other—as, "sister buckle chains," sister sling chains," etc.

Size.—A kind of soft glue made from skins, hoofs, membranous tissues, and other parts of animals, by boiling for some hours, then dissolving, straining, and again boiling to a jelly-like consistence.

Gilder's Gold Size.—Boiled linseed-oil thickened with yellow or calcined red ochre, ground smooth and thinned with oil of turpentine.

Letters on Glass.—A size for this purpose is copal varnish one part, Canada balsam two parts. Another: pure mastic varnish, or pale, quick-drying copal varnish.

Artist's Size.—Dissolve over the fire in a pint of water 4 ounces of Flanders glue, 4 ounces of white soap; then add 2 ounces powdered alum. Stir the whole and leave to cool.

Size to fasten Rubber to Wood or Metal.—Soak pulverized gum-shellac in ten times its weight of ammonia; in three or four days a shiny mass is obtained, which will become liquid without the use of hot water. This softens the rubber, and becomes, after the volatilization of the ammonia, hard and impermeable to gases and fluids whenever it is used on rubber connected to the wood or the metal of steam or other apparatus.

Skeleton.—A frame made by the pattern-maker from which, by the aid of outside and inside strickles, the loam-moulder constructs his mould without employing a full pattern. A convenient and cheap device for the production of tanks, condensers, etc., that are rectangular in form. Also, for moulding cylindrical objects, as steam-cylinders, etc., in loam. A skeleton-frame for this purpose consists of bottom and top flanges, in the rough, connected by a few lags vertically, which serve to fasten thereon steam-chest, feet, exhaust-belt, brackets, etc., at once, and thus obviate all possibility of the errors which frequently occur when these attachments are built separately into the brickwork. The skeleton-flange rests on the swept seating or guide-bearing. After the cope has been built to a template the screws are taken out from the inside, skeleton-frame taken away, and the loam swept on the surface by means of the spindle and sweep-board. See LOAM-MOULDING; SEATING.

Skeleton Core-iron.—A core-iron consisting of wrought or cast iron rods cast in one or more plates or rings. It is the most efficient and convenient core-iron that can be made for any description of belt or jacket-core having metal on all its sides. Owing to their cage-like appearance, they are frequently termed *cage-irons.* See JACKET-CORES.

Skim-gate is any arrangement of runner that will arrest the skim or slag at some part intermediate to the pouring-basin and casting. If two castings are poured together in one flask, and one of the moulds filled by means of a fountain or horn runner connected with the bottom of that which receives the metal direct from the ladle, it is evident that all the dirt will remain in the latter, while the clean iron only will be forced into the former, thus making one casting a skim-gate to the other. Any intermediate receptacle, not necessarily a casting, may be thus employed to intercept the dirt; but by inserting a spherical object, as a ball, etc., for this purpose, and allowing the metal to enter it at a tangent to the circumference with force sufficient to impart a rapid rotary motion to the entering metal, the lighter scum is forced to the centre and there held until the casting or castings gated from the circumference of the ball are filled with clean metal. In order that this may be effective, the metal must enter the ball with force sufficient to keep it full, so that the castings may be fed from a point below where the dirt is held imprisoned. If a large quantity of metal must necessarily pass through a ball of limited size, a riser on the ball permits the accumulations to mount well above the ingates. See GATES; FOUNTAIN-RUNNER.

Skimmer.—A tool for preventing the dirt and slag from following the stream as the metal flows from the ladle-lip into the runner. They are simply of wood in some foundries; but generally they consist of a long piece of flat iron bent at one end, or a long light bar to which is welded a stronger piece of flat iron bent to fit the ladle-lip. The self-skimming ladle is intended to obviate the necessity for skimming. See LADLE; LIP.

Skin.—The surface, either of a mould or casting, is designated as the skin by most foundrymen. The aim of a conscientious moulder is to produce castings exactly like the model or pattern, externally and internally; free from blown and shrunk holes, no cold-shuts, and to present a clean surface or skin—the last being to him the chief desideratum. To obtain the latter quality in the resultant casting many schemes are practised in order that the intensely hot and liquid metal may be prevented from penetrating beyond the skin of the mould; the chief agent employed for this end being carbon, which is contained in some proportion in nearly all the facings made. See FACING; FACING-SAND; GRAPHITE.

Skinning-loam.—Fine loam or slip which, by means of the spindle or guide and the requisite strickles, gives the final shape to and constitutes the surface of swept moulds. See LOAM; ROUGHING-UP.

Slack.—Fine coal or screenings. See PRESSED FUEL.

Slacked-lime.—See LIME-KILN.

Slag.—Cupola slag is sometimes called "scoria" or "cinder," and consists of the fused compounds of the silica and alumina in the lining, daubing, and dirt which are too frequently thrown in among the iron and fuel. Impure fuel also adds its quota to this readily fusible mass, in addition to that given off by the metal itself. If, on account of burnt or dirty iron being used, it be deemed necessary to employ limestone or anything else as a flux, the quantity of slag is augmented considerably, and means must be provided for conveying some portion of it away, otherwise it will prove a serious detriment to the effective action of the cupola, as at every rise of the metal in the bottom this superfluous slag is forced upwards among the fuel in the immediate vicinity of the tuyeres, where by the action of the blast it is converted into an impenetrable mass, through which ultimately no air at all can be forced. Another evil attendant upon this over-abundance of slag is that it must inevitably make its appearance at the tap-hole on the instant of the issuing stream failing to completely fill the orifice, defiling ladles, and everything else it comes in contact with; making it necessary sometimes to clear all away, and permit its being blown out at the tap-hole into the pit below.

An effective remedy for this is to copy the tymp and dam stone of the smelting-furnace, and, like the smelters, allow this slag to flow away, while the molten iron is allowed to collect comparatively clean on the sand-bed below.

By making a large tap-hole some distance below the tuyeres, at a convenient part back of the cupola, a spout may be attached for leading the liquid slag away. This hole is to be prepared somewhat after the manner employed for the tap-hole, and kept securely plugged when not required. When it is thought advisable to flow off superfluous slag, allow the molten iron to rise in the bottom until the slag makes its appearance at the hole, when the clay plug may be taken out, and it will at once issue forth. If this operation be conducted in a proper manner, and repeated from time to time, there need be no trouble from this source at the spout; and if due attention is paid to the tuyeres (see TUYERES), the duration of a heat in the cupola may be prolonged indefinitely.

When clean pig iron, of good ordinary quality, along with pure cast scraps, free from sand and rust, is melted with coal or coke comparatively free from impurities; and when the operation is conducted according to the best rules for practice, in a well-kept cupola supplied with blast at an adequate pressure for perfect combustion, and no more; and allowing that the melting is not protracted beyond a reasonable time—there is really no need for a flux; and as, under the conditions stated, little or no slag would be likely to gather, it is plain that the need of slagging cupolas will only occur in proportion as such conditions fail of being met. See CUPOLA; CHARGE; RATIO OF FUEL TO IRON; SCRAP; BUGS.

Slag on the Surface of Castings.—See FACING-SAND; SEA-WATER.

Slag-wool.—See Mineral Cotton.

Slate.—A highly metamorphosed clay rock, consisting ing essentially of clay. The particles are so mechanically arranged that it splits into plates that are independent of the layers of deposit, and are of a blue, green, gray, or black color. Its hardness prevents it from injury when exposed to the weather; it is therefore well adapted for roofs of houses, etc., and is in great demand for enamelling mantels and other objects, being by this means made to imitate the most expensive marbles at slight cost. Extensive quarries of this substance are worked in Cornwall, Wales, Ireland, and Scotland; also in Vermont and other States in this country.

Adhesive slate absorbs water readily, and is highly adhesive. *Aluminous slate* yields alum. *Bituminous slate* is impregnated with bitumen. *Hornblende slate* contains feldspar, and is used for flagging. Hones are made from slate, also pencils; and the slate-clay which consists of silica and alumina is suitable for fire-brick. See Alum.

Slicker—sometimes called "sleeker" and "smoother" —is a moulder's tool that usually has some special shape given to it on one side. The other side has a finger-piece or handle, by which means the slicker is worked upon the sand and made to impart smoothness and finish to the surface. These tools are of cast iron, brass, and steel, highly polished on the face side, and are known as *corner, elbow, pipe, button, flange, bead,* and *web slickers,* etc. Considerable dexterity of hand and eye must be acquired before the moulder can use these tools creditably, and only the most skilled workmen should be allowed to use them indiscriminately. Inferior artists are apt to linger too long over the work, and their unpractised eye and lack of taste invariably end in producing lines that bear no resemblance whatever to the original pattern; but on such parts as offer few difficulties they will smooth the surface with such frequency that the alumina in the sand is worked into a clayey skin on the surface, which, if it be not already loosened, will more than likely shrink and break away in scabs when the metal covers it. See SCABBED CASTINGS.

Sling.—A foundry device for handling and conveying flasks and loam-moulds. The stirrup-sling reaches from bottom lugs of a foundation-plate to the binders, or cross for binding the mould together, and serves the purpose of lifting the moulds also. Beam-slings are also stirrup, except that the lower end is usually made to fit the trunnion of a flask; by this means copes are reversed by simply lifting with one sling at each end of the beam. Chain-slings have stirrups, and are joined in pairs generally to one ring. The link-sling is simply a long welded link, and may be round, oval, or square ended. Rope-slings, being flexible, are extremely useful in the foundry. See BEAM-SLINGS; ROPE-SLINGS.

Slip.—A common name for skinning-loam. See SKINNING-LOAM.

Smelting.—Fusing or melting the ores of metals, along with suitable fluxes, in order to separate the metallic part from the earthy, stony, and other parts. See REDUCTION OF METALS; CAST IRON; METALS; ORES.

Smelting Cast Iron.—See CAST IRON; ORES; REDUCTION OF METALS.

Smelting-furnace.—The smelting-furnace for iron is described at "CAST IRON" (q.v.). See also ORES.

Smoothers.—Moulders' tools. See SLICKER.

Snap-flask.—Besides the common snap-flask made at most foundries, there are some very excellent devices made for this purpose by the several patentees. One is an adjustable combination wood and metal snap-flask that can be adjusted to a variety of sizes. The wood parts of the flask are the pieces to which the hinge is attached, and also the parts to which the latch is fastened. The steel pieces are the inside lining. The wood and steel pieces are fastened together with bolts, and by means of a long slot the flask can be spread to the desired size. The wood is $\frac{3}{4}$-inch cherry, and the steel is $\frac{1}{8}$-inch. It is provided with a spring-latch, making it easy to open and close. Similar flasks are made all steel, having the same adjustment. Making them of the latter metal has suggested the round steel snap-flask, which is very light, and requires much less sand than the square one. For all who desire to manufacture their own snap-flasks, trimmings, including latches, hinges, and pins, can be had of infinite variety. Latches are made of malleable iron, with flat, oil-tempered steel spring. When the flask is closed the latch makes a solid locked corner, and it is so placed that by pulling latches together with finger and thumb of one hand, the flask opens freely. Hinges are made with the view of obviating any pinching of sand while closing. Any number of adjustable pins may also be had which can be perfectly fitted in a few moments. See SNAP-MOULDER.

Snap-moulding is bench-moulding; but instead of using the customary iron or wood flasks, the moulder is provided with a "snap-flask," inside of which he rams all his moulds, carrying them to the floor, when completed, one by one, in order for casting. When the snap is removed a flat weight holds it down. A hole in the weight permits the metal to be run down the sprue and pouring all off, independent of the usual surrounding flask. If the sand walls are not able to withstand the pressure exerted when the mould is poured, a light iron band answering to the form of the snap is rammed within it. By this method the moulds are sustained like any other flasked ones, the difference being that the light iron bands are not pinned together. See SNAP-FLASK; BENCH-MOULDER.

Snug.—An attachment cast to or bolted on flasks. Two or more snugs meet at the joint of the flask; one set has pins, the other holes to receive them, constituting a guide. See LUGS.

Soap.—The alkalies used for soap-making are potash and soda. They must be in a caustic state, and this is produced by dissolving them and passing the solution through newly slacked lime, which takes away the carbonic acid. In this caustic lye the fats are boiled, their glycerine set free, and the soap formed in a state of solution in the water. The soap is obtained in the solid form by boiling this solution until the soap ceases to be soluble and rises to the surface, when it is drawn off into moulds. Castile-soap is composed of olive-oil and soda; oxide of iron is the cause of its mottled appearance. See OILS; PANS; SOAP-KETTLE.

Soap-kettle.—Some of the kettles for this purpose are covered in and provided with a large bend-pipe to receive the vapors. The watery matter is condensed, and drawn off at the bottom; the inflammable vapors are drawn under the fire. See PANS.

Soapstone is steatite, and termed *soapstone* because of the smooth, greasy feel it has between the fingers. It is a hydrated silicate of magnesia—a massive variety of talc, which when pure and compact is highly refractory, and suitable for furnace-linings and for the manufacture of fire-brick. Soapstone, ground very fine and mixed with carbon facings, makes an excellent material for coating the moulds of hollow ware and stove-plate castings, being especially useful as a return-facing for printing with. See RETURN-FACING; PRINTING.

Socket-pipe.—A water or gas pipe with a bell and spigot at its respective ends. The bell receives the spigot end of another pipe, with some clearance for lead or other packing with which to make a tight joint. A depression in the bell holds the packing, and the collar on the end of the spigot prevents the latter from slipping out. See CAST-IRON PIPES.

Soda.—A compound of oxygen and a metallic basis called *sodium*. It was formerly called *mineral alkali*, as it is found in mineral seams and crusts, and in great abundance in certain lakes in Egypt being brought thither by the water which enters from the neighboring country during the overflow of the Nile, and precipitated by evaporation during the dry season. Barilla is impure soda obtained by burning plants near the sea. Kelp is obtained by burning seaweed. For the purposes of commerce, soda is obtained from common salt. See SALT; SODIUM.

Sodium.—This is a very widely diffused and abundant element. As *chloride*, it occurs in rock-salt, sea-water, salt-springs, and many mineral waters; and as *silicate*, in many minerals. Metallic sodium was first discovered by Sir Humphry Davy. It is prepared in the same manner as potassium, requires the same measures for its preservation, and exhibits properties similar to those of that metal. See POTASSIUM; SALT; SODA; FLUID ALLOY.

Soft-blast.—The blast is termed "soft" when it is feeble and lacks force. A too low pressure of blast burns the fuel without melting at full duty, and below a certain amount of pressure the fuel would burn away, leaving the metal unmelted. See BLOWER; BLAST-PRESSURE; COMBUSTION.

Soft-centre Steel.—Bar steel with a hard surface enclosing a tough centre core of mild or soft steel. This steel is used especially for making articles that, besides having a hard-tempered surface, must possess the strength of mild steel. The mild-steel ingot is cast, hammered down, and treated in the cementation-furnace until the surface has been carburized to the depth required, when it is again subjected to the process of rolling or hammering down to the size and shape of bar needed. See CEMENTATION; BLISTER-STEEL.

Softeners are a class of pig iron containing such softening qualities as will destroy, or at least neutralize, opposite qualities existing in other irons; or they may wholly consist of another metal to alloy with iron, as aluminum or aluminum ferro-silicons, etc. The softening elements in pig iron are graphitic carbon and silicon, while combined carbon, phosphorus, manganese, and sulphur may be classed as hardeners. It is an established fact that all pig irons low in the latter elements, and which are at the same time high as to the former, are recognized as softeners, because of the remarkable quality of silicon to change chemically combined carbon to graphitic carbon; in other words, changing hard iron to soft, and enabling the founder to use up large quantities of inferior irons, at reduced cost, by the simple admixture of another iron that costs no more than any other ordinary brand; and all this without any deteriorating effect on the resultant castings. See SCOTCH PIG IRON; SILICON; ANALYSIS.

Soft Pig Iron.—This iron is usually termed *gray pig iron,* to distinguish it from the hard irons, which are lighter in color, even to whiteness. A chemical analysis of a really soft pig iron should exhibit about the following percentages of constituent elements:

Graphitic carbon........	3.36	per	cent.
Silicon.................	2.78	"	"
Phosphorus..	0.40	"	"
Manganese.............	0.40	"	"
Sulphur................	0.01	"	"
Combined carbon.......	0.20	"	"

Any addition over the quantities given, except for graphite and silicon, would tend to increase the hardness. See Gray Pig Iron; Softeners.

Soft Solder.—One of the soldering alloys. See Solder.

Solder.—Soldering is a process by which solid metallic substances are united by the intervention of a more fusible metal or solder, which, when placed between them and fused, unites the three parts into a solid mass; sometimes, however, the joining of two edges or surfaces may be accomplished by fusing or melting with the same metal. Solders are made of gold, silver, copper, tin, lead, bismuth, etc.; usually observing that in the composition there shall be some of the metal that is to be soldered, mixed with some higher and finer metals. The coppersmith's hearth, standing off from the wall, is a convenient fire for hard-soldering or brazing. The brazier's hearth is usually an iron plate with fire-box underneath; a convenient aperture in the plate allows the heat to play direct on the work as it rests on the table, the force being regulated by a fan-blast. For fine and complicated soldering, the blowpipe is best;

the wind for which is sometimes obtained mechanically, but more commonly by blowing with the mouth. Jewelry manufacturers employ a trough or shoot of circular form, through which a gas flame is urged by means of a pair of ordinary bellows. The common blowpipe in the workshop is the oxyhydrogen, so arranged that it may be used at any desired angle.

Silver solder is usually employed for fine work in brass, iron, or steel, and the brazing is effected by laying thin plates of the solder on the joints, which have been previously moistened with borax and water. For gold and silver soldering, the borax is usually made into a creamy paste by rubbing with water and then painting over the parts to be joined. Solders of this class are often drawn into wire, but generally they are in thin plates, so that pieces of an exact size may be cut and laid over the work to be soldered.

Before soldering or brazing can be successfully done, the joining surfaces must be made absolutely clean and smooth, and a suitable flux employed in order that the metal or metals will unite to the solder at a low temperature. The flux for *steel* is, sal-ammoniac 1, borax 10—these ingredients to be powdered together, fused, and pulverized; for *iron*, borax or sal-ammoniac; for *pewter*, olive-oil; for *tinned iron*, chloride of zinc or rosin; for *lead* and *tin*, rosin or sweet-oil; for *copper* and *brass*, chloride of *zinc* or sal-ammoniac; for *lead-pipe*, tallow or rosin; for *zinc*, chloride of zinc; for *spelter-solder*, borax.

Owing to the greater affinity of copper for zinc than for tin, some difficulty is usually experienced when zinc is to be soldered with the copper-bit or soldering-iron. This metal seems to remove the tin coating from the copper-bit, causing much trouble sometimes; but this may be obviated by using the soldering fluid as a flux. The latter flux is an admirable one for nearly all other metals, and does not necessitate that degree of cleanness so essential when other fluxes are employed.

Soldering fluid is made by taking two ounces muriatic acid, add zinc till the bubbles cease to rise, then add one half-teaspoonful sal-ammoniac and two ounces water. Iron and steel may be soldered by using this fluid flux without any previous tinning.

Gold is the solder for platinum, with borax for a flux. See GOLD-SOLDER.

A good solder for iron is good tough brass, with borax for the flux. See BRASS.

For the hammered-brass solder add a little chloride of potassium to the borax for a flux.

Iron is soldered to steel or either to brass by applying in a molten state tin 3, copper 39½, zinc 7½ parts.

Cold-soldering (without fire) is done by using a mixture composed of bismuth ¼ ounce, quicksilver ¼ ounce, block-tin filings 1 ounce, muriatic acid 1 ounce.

Cold-brazing (without fire): Brass-filings 2 ounces, steel-filings 2 ounces, fluoric acid ¼ ounce. Place the filings in the acid and, when dissolved, apply the solution to the parts to be joined. Fluoric acid should be kept in lead or earthen vessels.

Brass is readily soldered, in some cases, by first using sal-ammoniac as a flux and then placing a piece of tin-foil between the pieces and applying the hot iron until it melts.

German silver is soldered by first applying the soldering fluid as a flux and using pewter solder with the blowpipe.

When arsenic is mixed with solders it should be added at the last, taking care to avoid the fumes.

When brass is employed as an ingredient it should be added after fusing the other metals, to avoid wasting the zinc. The following are the ingredients used for making solders in common use:

	Arsenic.	Hardening.	Gold.	Zinc.	Tin.	Lead.	Brass.	Bismuth.	Copper.	Silver.	Antimony.
Pewter-solder..............						1		1–2			
Plumber's solder..........					3	5		1			
" "					1	2					
Spelter-solder, for brass...				1					1		
Tinman's "					1	1					
Pewterer's soft solder.....					3	4		2			
Zinc-solder					1	1-2					
Glazier's solder........					3	1					
Black solder				3	2				2		
White solder for raised Britannia-ware........... ..		8			100						8
Hardening for Britannia-ware					1				2		
Soft solder for Britannia-ware					8	5					
Yellow solder for brass or copper................ ..				29	1				32		
Yellow solder for brass or copper, easily fused.....				55					45		
Bismuth-solder					1	3		3			
Solder for brass, to be hammered				17.41			78.26			4	
Brass-solder.......				38¾					61¼		
" " white...... ...				27.99	14.60				57.41		
Solder for steel joints.. ...							2		1	19	
Gold-solder			1						3	2	
" " fine.......			12						2	2	
Silver-solder, hard...... ..									1	4	
" " soft..........	¾						1			2	
Jewellers' solder, hard....				½					3½	16	
" " medium				1					4	15	
" " softer ..				1½					4½	14	
Hard solder................				1					2		
Spelter-solder for copper or iron..................				12					16		

Solids.—Matter exists in three forms—*solid, liquid,* and *gaseous.* When the particles of a body cohere, as in ice, metals, etc., so that they cannot move among themselves, it is said to be a solid. All solids, except clay, are expanded by heat, but not equally. (See EXPANSION.) Clay contracts in baking and ever afterwards remains so. Solids are melted by heat, and the process is termed *liquefaction.* A solid is firm and compact, and, unlike fluids, offers a sensible resistance to penetration and impression. See FLUIDS.

Solid Shot.—See Hollow Shot.

Solubility, or Solubleness, is the susceptibility of a body to being dissolved in a fluid. Solution is favored by whatever weakens cohesion. When the force of adhesion of the particles of a liquid for a solid exceeds the whole cohesive force of the latter, its cohesion is overcome and solution occurs, which means that the solid disappears and mixes uniformly with the liquid. See Saturation; Adhesion.

Soluble Glass.—This alkaline silicate, known as water-glass, liquid quartz, etc., was discovered by Prof. Fuchs of Munich, 1825. It has the property of solubility in water, and may while in that state be applied to glass painting, waterproofing materials, restoration of decaying stone buildings, and as a binding element in artificial stone. When the water has evaporated it leaves a hard, gelatinous, transparent glass, which is impervious to water or destructive atmospheric changes. Mixed with metallic oxides it is a good paint for frescos, and also for commoner purposes. The solution is obtained by fusing together pulverized quartz 15, potash 10, and pulverized charcoal 1. This mass when cold is crushed, and boiled for three hours in five times its weight of water, taking care to supply what is lost by evaporation. The result is a viscid mass, which must be preserved in well-stoppered vessels. The glass may be diluted to suit whatever purpose it is employed for.

Solvent for Gold.—Mix equal parts of nitric and muriatic acids. See Gold; Aqua Regia.

Soot is formed by the fuel which escapes combustion, and is composed principally of particles of carbon from a coal or wood fire. The lighter particles of ash are also mixed with it, as well as hydrocarbons from unburnt hydrocarbon vapors, and some ammoniacal salts. The latter qualities are what makes soot valuable as a manure. See CARBON.

Sour Beer.—This unpleasant wash was formerly in great demand for hardening cores and mould surfaces. See BEER; CORE-WASH.

Sow.—The heavy pig iron which has served as a leading channel from the spout of the blast-furnace, and which serves the purpose of a runner to the pigs when the tap is made. The pigs are forcibly separated from it immediately the iron has solidified. See CAST IRON; PIG IRON.

Spade.—See SHOVEL.

Spanish Tutania.—If 8 ounces of iron or steel be melted with 16 ounces of antimony and 3 ounces of nitre, by adding the latter ingredients in small pieces after the steel is white hot a hardening is made, of which 1 ounce is sufficient to harden 8 ounces of tin. See TUTANIA.

Spathic Iron Ore is the purest variety of clay ironstone in which the metal occurs as a ferrous carbonate. A considerable proportion of the pig iron produced in England is smelted from these ores, the inferior grades of which constitute the clay ironstone and blackband ironstone of the coal-measures. See ORES.

Specific Gravity.—A term used to express the comparative weight of different substances. The specific gravity of a substance is the weight of a given bulk of it compared with the weight of an equal bulk of some other substance taken as a standard. The standard employed is a fixed one, being distilled water at a temperature of 60 degrees. The weight of a cubic inch of silver is $10\frac{1}{2}$ times as much as the same measure of water; accordingly, the specific gravity of water being 1, that of silver is $10\frac{1}{2}$. A cubic inch of cork weighs $\frac{24}{100}$ as much as the same bulk of water; the specific gravity of cork, therefore, is $\frac{24}{100}$ or .24. Mercury, water, and oil if thrown into a tumbler will arrange themselves in the order of their specific gravities: the mercury at the bottom, being the heaviest; then the water; on top of this the oil, being the lightest. Gases, like liquids, differ in their specific gravity. Smoke ascends, being lighter then air. Hydrogen is so much lighter than air that it will ascend with a loaded balloon. Contrary to this, because carbonic-acid gas is heavier than air, it remains at the bottom of wells, etc.

A cubic inch of iron weighs $7\frac{1}{4}$ times as much as a like bulk of water, and will therefore sink in the latter; but if hammered out into a vessel containing more than $7\frac{1}{4}$ cubic inches, the same iron will float, simply because it is lighter than an equal bulk of water. A floating substance displaces its own weight of liquid; and a body immersed in water loses as much weight as the water it displaces weighs. The specific gravity of a liquid is easily obtained in the following manner: Fill a glass vessel, whose weight is known, with water to a certain mark, and weigh it; subtract the weight of the vessel and you have the weight of the water alone. Then fill the vessel to the same height with the liquid in question, weigh it again, and subtract the weight of the vessel as before. To find its specific gravity divide its weight by that of the water.

A simple way of finding the specific gravity of a solid would be to take a certain bulk, as a cubic inch or cubic foot, ascertain its weight, and divide it by a like bulk of water. There is difficulty, however, in obtaining any given bulk exactly, for which reason other methods are adopted.

If the solid sinks in water, weigh it first in air and then in water by means of a balance provided for the purpose. Divide its weight in air by the weight it loses in water, and the quotient will be its specific gravity. This is exactly the same as dividing the weight of the solid by that of an equal bulk of water, for it has been shown that a solid weighed in a liquid loses as much weight as the liquid it displaces weighs. A piece of platinum weighs 22 grains in air and 21 in water. If we divide 22 (its weight in air) by 1 (the loss of weight in water), we obtain 22 for the platinum's specific gravity.

The specific gravity of a solid that floats on water is found by attaching something heavy enough to sink it. These are then weighed in air and in water, and the loss of weight in water found by subtraction, as before. In the same manner find how much weight the heavy body alone loses in water, and subtract this from the loss sustained by the two, which gives the weight of a volume of water equal to the body under examination. Divide the body's weight in air by this remainder, and the specific gravity is obtained.

The specific gravity of gases is found by a similar process to that for liquids. The standard is air. A glass flask with stop-cock is weighed when full of air, and again when the air has been exhausted; the weight of the flask full of air is the difference between these weights. The flask is now filled with the gas in question, and again weighed; this weight, less that of the exhausted flask, is the weight of a flask full of the gas. Divide the weight of the gas by that of the air, and the quotient is the specific gravity required.

If the specific gravity of a body is known, it is easy to discover how much any given bulk of it weighs. A cubic foot of water weighs 1000 ounces, or $62\frac{1}{2}$ pounds. The weight of a cubic foot of any given substance will therefore be equal to $62\frac{1}{2}$ pounds multiplied by its specific gravity; as follows: What is the weight of a cubic foot of silver? The specific gravity of silver is 10.474. This multiplied into 62.5 gives 653.478 pounds,—the weight required. See HYDROSTATIC BALANCE; WEIGHT OF METALS.

Specific-gravity Balance.—An instrument for finding the specific gravity of substances. The hydrometer or areometer is used for finding the specific gravity of fluids. Many kinds of these instruments are employed for this purpose, but they are all dependent on the principle that the weights required to immerse a light bulb of glass in different fluids are in proportion to the density of such fluids. See SPECIFIC GRAVITY; HYDROSTATIC BALANCE.

Specular Iron.—Specular oxide of iron occurs crystallized in a great variety of forms. Some of these crystals have a polish like burnished steel; others are tarnished and appear of a red, blue, or yellow color. The most beautiful specimens come from Elba, where this iron is said to have been worked for three thousand years. Its composition is iron 69, oxygen 31.

Speculum Metals are alloys of exceeding brittleness and hardness, and so brilliant when polished truly as to be used for the mirror-surface of reflecting telescopes. It is therefore called speculum metal. The quality of these alloys greatly deteriorates by a slight deviation to either side of the true atomic proportions. Their extreme brittleness necessitates great care in cooling castings made from them, so that nothing shall interfere to prevent all the parts cooling proportionately. Slow cooling in hot ashes acts beneficially by annealing the metal. As arsenic enters into the most of these mixtures, it is important that a good flux be employed to cause a perfect union with the other metals. One part nitre and two of tartar is a suitable flux for this purpose. The arsenic should be broken in fragments and tied in strong paper; it may then be secured in the tongs and thrust under the surface —after which stir well and avoid the fumes. The following is a table of speculum alloys:

SPECULUM ALLOYS.

	Silver.	Copper.	Tin.	Antimony.	Zinc.	Arsenic.	Brass.
Hard, white		32	15			2	
" " better.............	1	32	15			1	1
" " highly lustrous....		32	16.5			1.25	4
" " " "	1	32	15				1
Steel, hard....................		1	1				
Common		2	1				
Lord Rosse's..................		126.8	58.9				
Sir I. Newton's (yellow)		6	2			1	
White (antimony mix.)		7	1	1			
" (with zinc)..............		7	4		3		

—See Rosse's Telescope; Brass Mirrors.

Spelter.—The plates of manufactured zinc are called spelter in commerce. Spelter solder is made from equal parts of zinc and copper; this is for ordinary use on brass. A little harder, for copper and iron, is zinc 3, copper 4. See Solders; Zinc.

Sphere.—A solid contained under one uniform round surface, such as would be formed by revolving a circle about a diameter thereof as an axis. Every point on the surface of a sphere is equally distant from its centre.

Spider, or tripod, is an end attachment for a core-barrel, to be used when the core must be suspended within the mould by means of bearings at the top—as in guns and hydraulic cylinders. It consists of a central vertical bush, with three arms extending horizontally, on the ends of which are vertical standards which constitute as many legs or feet, which must rest on the outer mould or cope. The central bush encircles the barrel, and is connected with the latter by means of three lugs, which are cast on the barrel, the holes in which correspond to three other holes in the spider. See ORDNANCE.

Spiegeleisen.—A name now generally given to the varieties of pig iron, containing from 10 to 20 per cent of manganese. When the percentage exceeds that amount it is called ferro-manganese. See FERRO-MANGANESE; MANGANESE.

Spike.—A sharpened instrument of iron, used in some foundries for drawing patterns out of the sand. On the whole, they are a very unsatisfactory device; for, whether the pattern is drawn or not, it is certain to be damaged more or less in the operation. A hole bored for a wood-screw is less likely to split the pattern; but the rapping-plate and iron screw is more reliable, and should be adopted on all patterns when practicable. Heavy nails over $4\frac{1}{4}$ inches long are in the foundry usually designated as spike-nails or spikes. See RAPPING-PLATE; SPRING PATTERN-LIFTER.

Spill-trough.—A shallow-dished trough of iron, about 2 feet wide and 6 feet long, supported about 10 inches above the floor on four feet, against which the brass-moulder leans his small flasks on end for pouring with the crucible. The trough catches whatever may overflow at the gate or spill from the crucible; and, besides this, it serves as a general receptacle for every description of brass-scrap that is made. The contents are sifted from time to time and the scrap remelted.

Spindle.—A shaft or mandrel with which to sweep circular moulds in sand or loam. Spindles vary in diameter and length, according to the class of work they are used for. For sweeping ordinary work, the arm to which the sweep is secured is keyed, or otherwise made fast to the spindle, and the latter is made to revolve ; but when a vertical motion must be given simultaneously with the rotative, as in sweeping propeller blades, the arm must be free to slide up and down a fixed spindle. A fixed spindle may be made to answer for all ordinary work by securing a collar at the height desired, and allowing the arm to rest thereon as it revolves. When practicable it is always preferable in long spindles to have a dull point at the bottom end, working in the countersunk hole of an iron block that is sunk level with the floor, and the perpendicular maintained by a suitable arm extending from the wall. The method of making spindles with straight sockets and collars is a bad one, as they are sure to work loose ultimately. A much better mode is to turn a slight taper from 6 to 8 inches high, and cast this end in the block in which it must subsequently work—whether it be in a portable tripod or gig, or even in the central portion of the carriage itself. A little oil and fine parting-sand will protect the smooth iron of the spindle end when it is cast, and an absolute fit may be obtained subsequently by grinding the spindle in its own seat with oil and emery. Spindles over 1½ inches may be made of gas-piping, which, when once straightened in the lathe and taken good care of afterwards, are much easier to handle than solid ones, and just as good. The tripod spindle consists of a central hub with three plain arms, equally divided, radiating therefrom ; the arms have slot-holes cast in them for bolting purposes. This is a useful tool for bolting to foundation-plates when making sugar-pans and other similar castings in loam ; and it is beyond all question the best for setting in the floor, to sweep moulds in green sand. Three blocks on the floor, on which to rest the points of the tripod, with three other smaller ones over them, constitute a very simple contrivance to receive the foundation-plate, the weight of which precludes all possibility of shifting. The gig-spindle consists of a light square frame, with legs, centre hub, and four handles on the corners for carrying it with; this, with a good taper-ended spindle, is extremely useful for numerous uses in both sand and loam. When the use of the spindle is thoroughly understood, a considerable amount of pattern-making may be dispensed with. See LOAM-MOULDING.

Spinning Sheet Metal.—Sheets of silver, Britannia-metal, tin, and other malleable metals are, by motion and pressure, caused to flow or conform to a great variety of shapes. The process depends on the dexterity of the workman, the malleability of the metal, and the time given for the flow of its particles; for it must not be too hard pressed, or the sheet will fracture. Metals are spun in a lathe; a chuck or mould of the article to be made is fastened to the face-plate, and the disk of sheet metal is pressed against it by the fixed centre. An ordinary rest serves as a purchase for the operator to apply the requisite pressure with his pressing-tools and burnishers.

Section chucks, consisting of a central core and surrounding sections, are employed when the nature of the work will not permit a solid chuck to be used. By means of these almost any description of vessel is easily moulded in sheet metal, when the core, being withdrawn, the remaining sections are taken out.

Spiral Conveyers.—A conveying device composed of a central shaft and surrounding spiral screw, which, when revolved within a trough or pipe, presses out at the mouth whatever material is inserted at the opposite end.

This mode of conveying was first invented by Archimedes, who was born at Syracuse in Sicily, about 287 B.C. He used it for raising water from the Nile. See CONVEYERS.

Spiral Drums.—These drums are used at some collieries for drawing coal from the mines. The round wire rope is made to coil in a spiral groove upon the surface of the drum, which is formed by the frusta of two obtuse cone-castings, joined together with their small ends outwards, the idea being to equalize the work of the winding-engine throughout the journey; for when the load is greatest, with the load at the bottom and all the rope out, the duty imposed upon the engine is limited to the length of the drum's least circumference.

There are many ingenious devices for moulding and forming the grooves in these drums; and, besides those employed in Europe, we may mention those by S. B. Whitney, Pottsville, Pa., and P. S. Dingey, author of "Machinery Pattern-making," Chicago, Ill. While the several mechanical contrivances for regulating pitch, etc., may differ in some minor details, the general principles are about the same in all. Mr. Dingey's invention consists substantially of a foot-step, in which a fixed spindle is inserted vertically; the former or sweep is made to travel up and down a screw by pulling round the upper arm, the screw itself being inclined at the required angle. A bevel-gear is made fast to the spindle at the lower end, and the bracket which carries the pinion-shaft works loose upon the spindle. One end of the pinion-shaft is carried by a T-piece that turns on the spindle also, and the other end engages the working-screw by means of a universal joint, the screw itself being carried by adjustable arms at the top and bottom. The nut is prevented from turning on the screw by allowing it to work freely up and down a guide-shaft secured to the upper and lower arms, exactly parallel with the screw itself.

Motion is imparted to the apparatus by drawing the arms around; this causes the pinion and screw to turn, thus making the sweep ascend some distance at each rotation of the arms. The gears determine the pitch of the groove, and different-sized ones can be applied to suit. By simply changing the bevel-wheel and locating the pinion on opposite sides, a left or right-hand groove is produced, and, being operated by a universal joint, it is easily adjusted to any angle of drum required.

Spirit.—This name is usually given to fluids obtained by distillation, and that are lighter specifically than water. Essential oil of turpentine is called *spirit of turpentine;* and the spirits of peppermint, aniseed, etc., are thus denominated because their essential oils have been dissolved in alcohol. Hydrochloric acid is frequently called *spirit of salts.* In its strictest sense, however, alcohol is meant when the term *spirit* is employed. See ALCOHOL; DISTILLATION.

Spirit-lamp.—A lamp in which alcohol is burned. These lamps are employed for their heat rather than for light—especially in the arts and manufactures, air-blast and other contrivances helping to make them more effective.

Spirit-level.—A glass nearly filled with alcohol, just enough air being allowed to remain in it to form a bubble. The tube is then closed and fixed in a metallic or wooden case. See LEVEL.

Sponge-metal Process.—This process of obtaining steel direct from the ore consists in first producing a sponge of malleable iron in vertical brick retorts charged with alternate layers of charcoal and ore, and fired from the outside. It takes about three days to obtain the metallic sponge, when it may be either melted in crucibles, along with substances rich in carbon, for steel; or it can be at once balled, hammered, cut, piled, reheated, and rolled into merchant-bars. See CRUCIBLE-STEEL.

Spouts for Cupolas.—Spouts, as a rule, are made too small. Given plenty of width, there is room to get at the breast, and added depth lowers the stream—a desideratum when a crooked tap is made. They should always be set so that the bottom will be three inches below the sand-bed of the cupola. A slight incline induces motion of the stream. While it is possible to obtain good work from spouts prepared with sand each heat, preference must be given to those made with an internal flange on the front end corresponding to the shape of the spout when formed ; this flange serves to hold securely the fire-bricks with which the inside may be built, thus making an imperishable channel close up to the breast. A slight rub over with fire-clay and a coat of blacking completes the operations at this point. The bricks make a safe abutment for the breast, and when the sand-bottom is made the portion immediately adjacent to the fire-brick bottom of the spout can be made good with daubing mixture stiffened well with the fire-sand. See BREAST-HOLE; SAND-BED; CUPOLA; DAUBING.

Spray-runner.—A long main runner, having sprays that connect with the mould. If one ingate be insufficient to distribute the metal equally hot to all parts of the mould, it is possible by this means to introduce the metal at numerous other parts, without any increase of the number of ladles employed, by simply extending the main channel, and connecting with the mould at such parts; taking care that the size of the channel be proportionate to the sprays flowing out from it. By this method thin plates are successfully run from one or two ladles of hot metal, which otherwise would require four or even six. For work that is rolled over, these sprays are best when formed by a pattern and set against the pattern before ramming the nowel. See RUNNER; GATE.

Sprig.—A small nail. See NAILS.

Spring Chaplet.—A form of stud, usually made by bending a short piece of hoop-iron so that the open end serves to spring back, and hold in place some loose core or piece of mould. Their strength must be in proportion to the pressure to be exerted, and some consideration should be given to the possibility of their melting in places where there is a strong current of molten metal. See CHAPLETS.

Spring Pattern-lifter.—A steel device for drawing very small patterns from the sand. Two fine stems connect with a spring which exerts its power in an outward direction, thus spreading the stems with force in the small hole made to receive it; after the manner of tweezers. See SPIKE.

Sprinkling-pot.—This is simply a gardener's watering-pot, with a rose for sprinkling the water when it is desired to moisten the sand precisely. A special class of goods for the foundry are made of galvanized iron and copper, very strong, and with double bottoms. The regular dealers in foundry-supplies have all sizes in stock.

Sprue.—The small vertical runner usually formed by bench and snap moulders. See GATE-SPOOL.

Square.—A mechanic's square consists of two pieces of wood or metal at exact right angles to each other, and used either for testing or describing work. In geometry, a square is described as a four-sided rectilinear figure, of which all the angles are right angles and all the sides equal.

Squeezer.—See ROTARY SQUEEZER.

Stains for Metals. — Metals may be stained or bronzed almost any color by simply immersing the article in a suitable liquid bronze. The action is in most cases immediate. Brass may be stained: *brown* and intermediate shades to *black*, by immersing in a liquid composed of water 1 pint, nitrate of iron 5 drachms; *black*—water 1 pint, permuriate of iron 2 pints, muriate of arsenic 10 ounces; *brown* to *red*—water 1 pint, nitrate of iron 16 drams, hyposulphite of soda 16 drams; *steel color*—water 1 pint, muriate of arsenic 1 ounce; *yellow* to *red*—water 1 pint, tersulphide of arsenic 30 grains, pearl-ash solution 6 drams; *blue*—water 1 pint, hyposulphite of soda 20 drams; *orange*—water 1 pint, potash solution of sulphur 1 dram; *olive-green*—water 2 pints, permuriate of iron 1 pint.

Copper may be stained: *brown* to *black* by immersing in a liquid composed of water 1 pint, nitrate of iron 5 drams; *brown* to *drab*—water 1 pint, nitrate of iron 5 drams, sulphocyanide of potassium 2 drams; *red*—water 1 pint, sulphide of antimony 2 drams, pearl-ash 1 ounce; *red* to *black*—water 1 pint, sulphur 1 dram, pearl-ash 1 ounce; *steel color*—water 1 pint, muriate of arsenic 1 dram; the liquid in this case must be heated to 180°.

Zinc may be stained: *purple* by boiling in logwood infusion; *red*, by boiling in garancine infusion; *black*—immerse in water 1 pint, nitrate of iron 5 drams; *copper color*—water 1 pint, sulphate of copper 8 drams, hyposulphite of soda 8 drams (this will need some agitation); *dark gray*—water 1 pint, protochloride of tin 1 dram, sulphocyanide of potassium 1 dram; *green* to *gray*—water 2, muriate of iron 1. See PICKLING; DIPPING; LACQUERING.

Stake.—A foundry device for guiding flasks, draw-backs, and other portions of a mould, independent of either pins, slides, or hinges, and for all of which modes the stake is a substitute. For instance, a cope is employed to cover the mould which is bedded in the sand floor; a stake driven into the floor at each corner against a suitably provided guide-piece furnishes the means for closing exactly similar to an ordinary slide in a flask part. Iron stakes close better than wood, and may be from 1 inch to 2 inches square or round. If not firm enough when driven down and rammed, they are readily stiffened by driving a short wooden one of larger diameter behind. See FLASKS; PIN.

Stalactites.—Water containing carbonate of lime in solution deposits a portion of it on free exposure to the air. This is often seen in calcareous caverns. The water, as it trickles from fissures in the roof, deposits its carbonate until pendent masses form there. These are called *stalactites*. Where the water strikes on falling, other forms similar to those above gradually grow on the floor, and are called *stalagmites*. When these meet and unite they form a column.

Stamping Metals.—Many kinds of metal-work formerly bent into shape by the hammer and punch are now struck into shape by means of a pair of dies—one relief, the other intaglio,—between which the metal is pressed. Articles of considerable size are now made in hydraulic presses by means of a number of graduated dies, each pair coming gradually nearer the desired shape, but none of them making an impression deep enough to strain the metal.

Stamp-mill is used chiefly for crushing or bruising ores, and consists of several vertical shafts which are made to descend with force by either water or steam power. See Ores.

Stands for Moulds are contrivances for blocking parts of moulds above the floor. Too often these are simply a makeshift. An excellent stand is readily made by moulding an open-sand ring about 18 to 24 inches diameter, in which are cast three or more vertical rods with their top ends leaning inwards, so that when the ring has been cast the whole may be reversed, and the loose ends cast into another open-sand mould about 6 or 8 inches diameter and of sufficient depth to bind all the rods firmly together. There is hardly any limit to the usefulness of these stands, as they may be made to any height convenient at a slight expense.

Starch is found in the grains, seeds, roots, pith, and bark of plants. It is a snow-white, glistening powder when pure; its round or oval grains varying in size from $\frac{1}{100}$ to $\frac{1}{4000}$ of an inch in diameter. The granules of potato are larger than those of rice or wheat. Starch is insoluble in cold water, alcohol, or ether, but swells up and is converted into a paste in water containing 2 per cent of alkali. If heated in water to 140° the grains swell and burst, producing gelatinous starch, or *amadin*. Starch from grain is prepared by mixing the meal with water to a paste and washing the mass upon a sieve; a white insoluble substance called *gluten* is then left. This gluten in wheat-flour is extremely tenacious and elastic, and this is why free sands are made adhesive and strong by its use. See Flour; Gluten.

Statuary-bronze.—A bronze composed of copper 9 and tin 1 is sometimes employed for statuary, but large statues are seldom cast of these two metals alone. For this reason it would be more correct to call the several alloys *statuary brass*. A brass used by the Egyptians consisted of brass 2, copper 1. Grecian and Roman, brass was an alloy of brass 2, copper 1, silver $\frac{1}{20}$, lead $\frac{1}{10}$. The French sculptor Kellar, 1669, used copper 326.43, tin 25.35, zinc 4.21, lead 1. Modern alloys are composed chiefly of copper 2, brass 1. For general artistic purposes more zinc and tin are added, as they answer as well, are more easily worked, and are cheaper. See STATUE-FOUNDING.

Statue-founding.—Whether the model from which bronze cast is to be taken be of wax, clay, plaster, or any other material, the customary mode of constructing the mould by the *cire-perdue* or waste wax-process is substantially as follows: The outside mould or matrix is first obtained in convenient plaster sections. The sections, either separate or together, according to convenience, are thicknessed with wax, and secured in their respective positions to form the mould, into which a core composition, usually consisting of a creamy paste made from 2 parts of brick-dust and 1 part plaster of Paris, with water, is introduced. Should the core be massive or complicated, a skeleton core-iron is constructed, and such other preparations are made as may be needed to convey away the gases therefrom at the time of casting. When the core composition has set, the sections of mould are carefully taken off, leaving the wax thickness adhering to the core—a true representation of the original model, which, when made perfect at such parts as may have been injured, is then ready to receive a thin coat of very fine composition, usually applied with a brush, over which another coat more porous than the first is laid, and again a subsequent backing of a very open nature is applied until the requisite stiffness is acquired. Coarse composition alone serves this purpose when the objects are small, for larger ones bricks, loam, etc., are often employed. When core and matrix have been thus constructed, heat is applied, and the wax forthwith evacuates the mould, escaping at the lowest points of every portion of the figure through holes previously provided for that purpose. When the mould has been thoroughly dried, the space originally occupied by the wax is filled with metal by means of gates which are suitably disposed when the outer mould is constructed. Small statuettes and other figures are very easily made in the foundries by first carving a composition core, around which the sculptor lays a wax thickness and models his figure. A wire or perhaps two wires are then thrust through the figure, leaving the ends projecting; it is then placed within an iron frame or box, and the surrounding space filled with composition. When this has become hard, the wax is made to pass out by the application of heat, as before explained, the core remaining as a permanent fixture by reason of the projecting wires, which are firmly imbedded in the matrix.

Hollow casts in zinc, lead, and tin are obtained by filling sectional brass moulds with molten metal at the open end, and allowing sufficient time for a shell to congeal on the surface, when the remainder is allowed to escape by inverting the mould.

For statuary, as above described, the sculptor produces his casting alone; but when the metal employed is cast iron, he must secure the services of a competent moulder, who first builds a core *in loam*, around which the sculptor fashions his figure in clay.

The moulder then proceeds to form a cope in as many divisions as are needed for obtaining a perfect impression of the figure, by the processes common to loam or sand moulding. These several divisions being lifted away, the thickness is removed, core and cope duly finished and dried, and subsequently closed together again, and the mould cast.

Many colossal statues are made in sections and pinned together over a stout iron or steel frame, and numbers of large plaster models are now sawn into convenient sections for moulding in sand, and cast either green or dry, according to circumstances. See PLASTER-CAST; CIRE-PERDUE; MODELLING; STATUARY-BRONZE.

Steady-pin.—An extra-long box-pin or slide, for maintaining a true vertical position when a cope with a deep straight lift is being raised. Also, a long, straight attachment to a pattern, or card of patterns, that extends some distance below in order to assure a true horizontal and vertical position during the process of drawing from the sand. The pin that is fixed on a pattern directly over where it is intended that a core shall protrude, to form a hole through the cope into which the top end may be guided, and thus keep it in a horizontal position, as well as permitting a vent to be carried off safely, is also termed a *steady-pin*. The wood or iron projections for guiding the halves of patterns and holding them to match are often called by that name. See PIN; FLASK.

Steam-crane.—A crane operated by a steam-engine. See CRANES.

Steam-hammer.—This powerful hammering-machine was originally invented by Mr. Nasmyth, Patricroft, England, in 1842, and is used for the purpose of beating malleable materials into the required form, etc. In its original form it consisted of an inverted cylinder, to whose piston an iron block which formed the hammer-head was attached. This hammer was raised by steam entering below the piston, and the hammer fell when the steam was allowed to escape.

Steam-jet Cupola, patented by Herbertz, who claims it as one of the most important metallurgic inventions of modern times. He further says "that it will surely have a great future by reason of its enormous advantages over the systems now in use. It is not merely an improvement of the present system, but a complete revolution.

"It naturally follows that there will have to be a complete change in the manner of doing business wherever smelting-furnaces are used. Up to the present time all cupolas were worked by blast-air. To produce this, complicated machinery was necessary, and large and expensive buildings. A hearth solidly built in masonry was indispensable, and this had to be hermetically sealed on account of the heavy interior pressure.

"The steam-jet cupola is the exact reverse of this. It works by means of atmospheric air breathed or sucked into the furnace by a jet of steam placed in the upper part of the shaft. It has a movable hearth, which can be raised or lowered at will, and which forms with the shaft an annular opening by which the air needed for combustion is introduced. This cupola requires no motive force, and the vacuum produced in the shaft by the suction allows every stage of the smelting process to be observed by means of valves and tubes placed at different heights, thereby furnishing a convenient means of controlling the work.

"The furnace and the hearth are rendered independent, the work may be carried on under perfect control, and necessary repairs can be easily and promptly attended to—a most embarrassing thing in the old furnaces with solid mured hearth.

"The workings of the steam-jet cupola can be divided, accordingly, into the following groups and sub-groups:

"I. Smelting of metals:
1. Smelting of pig iron;
2. Smelting of steel and malleable cast iron;
3. Smelting of other metals and metallic ores.

"II. Production of metals by the reduction of their ores or slags:
1. Production of pig iron;
2. Production of lead;
3. Production of raw copper, copper-scoria, and copper-slate.

"III. Calcination of ores and minerals, such as lime, dolomite, malachite, etc., for instance, minerals, demanding the expelling of carbonic acid; also, for smelting glass."

Steam-winch.—A hoisting-crane to which a steam-engine is attached, the power acting on the winding-drum by intermediate gearing, or direct from the piston-rod. See CRANES.

Stearic Acid.—See OILS.

Steatite.—See SOAPSTONE.

Steel.—This wonderful modification of iron is a compound of the metal with from .833 to 1.67 per cent of carbon. In its properties steel combines the fusibility of cast iron with the malleability of wrought iron. Its value for cutting instruments, springs, etc., depends upon its quality of being tempered. When heated to redness and plunged into cold water it becomes hard enough to scratch glass; if again heated and cooled slowly, it becomes as soft almost as ordinary iron, and between these two extremes any required degree of hardness is obtained. As the metal declines in temperature, the thin film of oxide upon its surface constantly changes its color, and it is by these tints that the workman is guided. Thus, a straw-color indicates the degree of hardness for razors, a deep blue for sword-blades, saws, and watch-springs. Steel receives a higher polish than iron, and has less tendency to rust. Nitric acid corrodes it, and leaves the carbon as a dark-gray stain. For the various processes of manufacture see India Steel; Puddle-steel; Blister-steel; Crucible or Cast Steel; Bessemer Steel; Open-hearth or Siemens-Martin Steel; Chromium Steel; Damascus Steel; etc.

Steel Bronze is the invention of Col. Uchatius, of the Austrian arsenals. It is simply a substitute for steel in the manufacture of guns. The alloy consists of about 90 copper and 10 tin, and is cast in an iron mould round a forged copper core. The resultant casting, after being turned and bored, is subjected to a process of opening and elongation by means of a conical steel-plug forced through by hydraulic power, resulting, it is claimed, in a tube of equal quality to the best steel tubes. See Bronze.

Steel Castings.—The chief desideratum in melting steel in an open-hearth furnace when the metal is intended for castings is to melt as hot as fuel will make it and keep oxidization as low as possible in the bath, by admitting only just enough air to insure thorough combustion. The charge usually consists of pig iron containing about 8 per cent of manganese. Spiegeleisen containing perhaps 14 per cent is sometimes used, along with enough of other pig free from manganese to procure that percentage in the resultant mixture.

The quality of steel required determines subsequent operations for softening, refining, etc., which is accomplished by additions to the bath of such materials as will favor the change desired. Various kinds of scrap, blooms, etc., are introduced in a semi-molten condition, so as to prevent any sudden reduction of temperature in the bath. Tests are made by dipping and pouring a small ingot which while red-hot is hammered down to a thin plate, and by its resistance to flexure, etc., indicates the condition of the metal and its fitness for casting. In some steel-foundries this knowledge is obtained by cooling the test-piece in water and breaking it on an anvil. When the metal is found to be sufficiently soft and pure, the final ingredients for converting it into steel, consisting generally of a specially manufactured pig iron containing manganese and silicon (silico-spiegel), is introduced, along with more or less ferro-manganese. The whole is then stirred well with a rabble, and if found correct is ready for tapping.

Many small castings are sold for steel that have been simply cast from good white pig iron very low in phosphorus and silicon, and afterwards annealed in hematite ore or smithy scales, after the manner of malleable-iron castings. See MALLEABLE-IRON CASTINGS.

An opinion that gains favor rapidly is that the Bessemer process of manufacturing steel will be ultimately recognized as superior to the open-hearth. Even now, owing to the fact that hot metal of any desired mixture may be obtained from the converter more frequently throughout the day than is possible in the open-hearth, which is limited to about three heats a day, many firms are working a small Bessemer converter for the lighter class of castings.

As steel castings must be poured from the bottom of the ladle by means of a stopper, just as ingots are filled (see INGOTS), there is practically no difficulty in delivering the metal clean, as the slag is all held on the surface above; but, owing to the liability of leakage when the stopper is damaged, it requires considerable dexterity to fill a number of small moulds successfully by this means. The larger ones are simple enough.

If all the runner system cannot be contained within the flask, and the mould must necessarily be rammed in the pit, runner-cores made specially from very refractory materials are set against the gate apertures and continued one upon another up to the surface, where suitable arrangements are made for receiving the stream from the bottom of the ladle. By this means the molten steel is prevented from encountering the non-refractory materials composing the pit-sand and runner as well as casting is contained in a dry-sand mould.

Hot as it may appear when melted, steel is by no means as fluid as cast iron, for which reason the runners and gates must always be made proportionately larger; but, like cast iron, it is always easier on the mould when the metal enters from the bottom. Of course it is necessary in very large castings, whether cast vertical or slanting, that additional runners be placed near the top also.

Risers on steel castings should be markedly heavy in proportion, and preference should be given to a position that will favor an equal distribution of the liquid pressure exerted; yet the highest heavy portions of the casting are properly chosen as a rule. An important feature in these heavy risers is to give them taper sufficient to favor an easy withdrawal from the hard sand when contraction commences; otherwise they are liable to draw the casting apart.

To discover a facing that would successfully resist the intense heat of molten steel and produce a smooth casting like cast iron has been the aim of very many who have engaged in this business. Very naturally such substances as were commonly employed for furnace construction, melting-crucibles, etc., were among the first employed. Pulverized fire-brick, with some clay and a wash over with brick-dust and water, was one of the earliest facings used. Moulds made from sands or other mixtures that are stiffened with flour are apt to crumble away at the slightest touch if the heat applied to dry them has been sufficient to burn the flour; and this is why molasses, which makes equally as good a bond if intimately ground into the sand, is now preferred. A ferric clay found in Switzerland, containing oxide of iron 40 per cent, graphite 2 per cent, is employed as a facing in some foundries. It dries exceedingly hard, will take about one third silica sand, and makes good moulds and cores and moulds for light work. It may be mixed with water for loam. The chief objection to its use is its extreme hardness, which compels the use of softer material wherever contraction is likely to be intercepted. In some parts coke, old fire-bricks, crucibles, the artificial graphite from gas-retorts, and many substances of a like nature, constitute the chief materials used for mixing with the sand employed for facing.

One of the best facings for ordinary steel castings is simple silica sand (the purer the better) and molasses, brought to the proper consistency by grinding well together.

To obtain a core that will meet every requirement in very large castings is still an unsolved problem; for if a mixture be made with the softer material, to favor easy extraction, it yields to heat and pressure, and invariably forms a mixed mass of steel and sand, while the harder and more refractory material bakes almost solid. Ordinarily the silica sand mixed with coal-tar or molasses is the best. The artificial hardness imparted by these ingredients is dissipated by the intense heat, the sand is again friable, and it falls out.

Shrinkage in steel amounts to more than double that of good cast iron—from $\frac{3}{16}$ to $\frac{5}{16}$ in a foot. This, in conjunction with the more rapid cooling compared with cast iron, necessitates a plentiful use of ashes, or their equivalent, in both cores and moulds, at such places as would be likely to interfere with a free and uninterrupted contraction of the whole. If liberty cannot be obtained by this provision, then the hard mould must be weakened by digging away the sand in the immediate vicinity of whatever is being obstructed, or perhaps lifting the casting out of the flask entirely and covering it with sand or hot ashes. Sometimes this is done, and the casting, instead of being covered, is at once consigned to the annealing oven. Castings that are well proportioned seldom betray the slightest sign of cracking when the latter method is adopted.

In extreme cases, where joining portions are liable to be separated through a more than ordinarily rapid contraction, the parts apt to yield may be thrust forward by means of a set-screw in the side of the flask, acting upon a plate previously set in the mould for that purpose.

Various means are employed to hold straggling parts of steel castings to the main body. There being little or no fibre to the metal, they snap off short at the least provocation; every sharp angle in the mould is a source of danger on this account. It is customary, therefore, to connect each of these weak extending parts to the body of the casting by a bracket or brackets, which are subsequently removed; angles of every description are eradicated by strict attention to filleting, or rounding every corner.

Cast-iron *chills* also serve a good purpose on these castings, for, besides imparting a smooth surface, *without chill*, wherever they are placed, they at once absorb the heat, congeal the surface, and thus in a very simple manner prevent contraction fractures in many instances.

Fins cut at certain parts will sometimes induce almost immediately congelation, and prevent rupture by the added strength of the comparatively cold metal, which extends its strengthening influence, more or less, into the casting by reason of the prematurely local shrinkage created.

Not unfrequently parts that are dissimilar in magnitude are drawn apart by the antecedent shrinkage of the thinner body of metal. This too may often be prevented by attaching a thin connecting web or webs, extending some distance beyond the point of junction, either way; the web being thinner, sets more rapidly than either of the other divisions, and holds them together by reason of a prior contraction.

Steel-faced Castings.—A face of steel may, under favorable conditions, be given to castings in iron, by making the steel red-hot, and placing it within a dry-sand mould. If possible, drop the molten iron immediately over the steel to be welded, by runners sufficient to cover the piece and effect a junction quickly; otherwise the process is rendered inoperative by the metal simply running over it and out at the escape, at a gradually decreasing temperature—just so much waste. A very superior union is always effected when the body of cast iron is large, the steel being under the influence of fluid metal for a less space of time in proportion as the body becomes thinner. Sometimes these junctions are effected, apparently, by forcing a large quantity of molten metal through the mould; but if the steel is not subjected to the abrading influence of a direct fall, it can hardly be expected that a solid weld will be made.

Steel Furnace.—See Crucible Steel; Bessemer Steel; Siemens-Martin Steel; Open-hearth Steel; Steel Castings.

Steel-press.—Metallic moulds receive the molten steel through suitable runners, after which mechanical means are employed for exerting a pressure on the fluid metal to force out the gases and give greater density to the steel. See PRESSING FLUID STEEL.

Steering-bar is generally a long iron shank, swaged on one end to fit either a round or square shaft which projects beyond the bale of a geared or other crane ladle, on the opposite side to the man who pours, to steer the ladle during the operation. Ladles are also steered with a long rod having two projecting fingers forged at the end at right angles with the rod. These clip the bale or beam of the ladle, and thus control or steer it. See LADLES.

Step-metal.—See ALLOYS; BRASS MIXTURES.

Stereotype-metal.—See STEREOTYPING; TYPE-METAL.

Stereotyping.—The art of obtaining metal plates about $\frac{3}{16}$ inch in thickness from pages of type previously set up in the ordinary manner. The art was invented by William Ged of Edinburgh, 1725. The forms of type are first laid on a smooth table, face upwards, oiled, and after the frame or flask which regulates the depth of plaster has been placed around, the surface is covered and swept off even. This cast is then dried, and afterwards turned face down on an iron *floater*, and the whole is placed within the *dipping-pan*, the lid of which fits the pan except at each corner, where provision is made for the entrance of the fluid metal. A clamp stretching across the pan serves to bind all together, and furnishes means for suspending and lowering into the bath, where it is immersed well down, to create a pressure, which causes the metal to spread and fill every cavity precisely, the thickness being regulated by an adjustment between the plaster-cast and floating-plate. The metal used for this purpose is various; some use type-metal; others, lead 100, antimony 15; and, again, lead 4, antimony 1, tin 1; but generally the alloys contain from 4 to 8 lead to 1 of antimony, according to hardness required. It must be understood that antimony acts to neutralize the contraction of lead, and causes the alloy to give a correct impression of the mould. See TYPE-METAL.

Sterro-metal.—A gun-metal alloy of remarkable strength invented by Baron Rosthorn, Vienna. See DELTA-METAL.

Stewart's Rapid Cupola.—This cupola embodies the principle of tall stacks and small diameter, which now seem to be gaining favor as fuel-savers, being, according to reports, far more economical than low ones of large diameter, which are now so common almost everywhere. The principal dimensions of a Stewart Rapid Cupola capable of melting 7 to 10 tons of thoroughly mixed and very hot iron per hour is as follows:

	Ft.	In.	
Outside of ordinary shell	7	0	diam.
" " chimney	6	0	"
" " air-belt	9	2	"
" " receiver	4	0	"
Inside of receiver	2	6	"
" " cupola-lining at tuyeres	2	11	"
" " charging-door	5	3	"
" " at chimney	4	3	"
Total height of cupola proper (exclusive of top bracket)	46	0	"
To the extreme top of bracket	52	0	"
Height from ground level to charging-platform	22	0	"
Height from charging-platform to sill of charging-door	2	0	"
Height of air-belt	3	3	"
" " receiver-shell	3	9	"
" from ground-level to tapping-hole	3	3	"
Area of outlet-chimney (inside of lining)	3	6	square
Outside size of "	4	9	"
Capacity of receiver (molten metal)	2 tons		

The cupola is fixed upon a strong cast-iron base-plate 7 feet 6 inches square by 3 inches thick. This base-plate is cast in halves across the corners, so as to allow of expansion with the cupola-shell. It is supported by four cast-iron columns 5 feet long by 10 inches in diameter, which are bolted to the cast-iron base-plate. The cupola base-plate is provided with a wrought-iron hinged drop-bottom door, which is also in halves, opening from the centre of base-plate. There are three rows of tuyeres to supply zones of oxygen, necessary for a thorough combustion of the fuel, enclosed in the air-belt, each zone acting independent of the others. A chief feature in this cupola is the brick-lined receiver for the melted metal, by which means the heat is retained and oxidation prevented, while the blast-pressure maintains an agitation conducing to a thorough mixing together of the various kinds of metal entering into the charge. The waste heat is utilized by passing up a gannister-lined pipe entering the cupola just above the air-belt. This cupola is hooded, an escape for waste gases being regulated by a flap-door at the side. The charging-platform is entirely constructed of wrought-iron crossed beams and plates, the joints of the plates being carefully planed and the plates riveted to the girders to insure perfect safety to the workmen below and above. This platform has an area over 1200 superficial feet, and is covered by a wrought-iron roof with provision for lighting and ventilation. The platform is connected with a hydraulic hoist.

Stibnite, or Sulphuret of Antimony, is the ore from which the antimony is obtained. It is found in primitive and secondary rocks associated with sulphurets of lead and zinc, and with ores of copper, iron, and arsenic. Its composition is antimony 74, sulphur 26. Lead, gray in color, occurs massive, composed of delicate threads closely aggregated, and sometimes so fine as to resemble wool. See ANTIMONY.

Stone.—The substances which enter into the composition of simple stones are silica, alumina, zirconia, glucina, lime, magnesia, etc., and the oxides of iron, manganese, nickel, chromium, and copper; and it is seldom that more than four or five of these substances are found combined in one stone. (See SILICA; SANDSTONE; ROCK; etc.) Artificial stone is produced by the cementing properties of soluble alkaline silicates on sand. Sand 10, glass 1, clay 1, silicate of soda 1, is brought to the consistency of putty in a pug-mill; this is moulded, dried, kilned at a red heat, and allowed to cool, thus forming a vitrified mass similar to sandstone. A later method produces the stone without baking by effecting a double composition with the silicate of soda and the chloride of calcium. See SOLUBLE GLASS.

Stone-coal.—A common name for anthracite coal. See COAL.

Stoneware.—Coarse porcelain, a very hard kind of pottery made from clay containing ferric oxide and some lime, to which it owes its partial fusibility. The glazing is done by throwing common salt into the furnace; this is volatilized and decomposed by the joint agency of the silica in the object and of the vapor of water always present; muriatic acid and soda are thus produced, the latter forming a silicate, which fuses over the surface of the ware and leaves thereon a thin but excellent glaze. See POTTERY; PORCELAIN.

Stopping-off.—A foundry designation for the methods employed to produce castings which differ in dimensions and form from the pattern supplied. The operations consist essentially of cutting off and adding to portions of sand by means of the regular tools, aided by "stopping-off pieces." Superior workmen are employed on this work. See JOBBING-MOULDER; TECHNICAL EDUCATION FOR THE MOULDER.

Stopping-up.—A phrase employed when the tap-hole is being plugged with clay by the cupola-man. See BOTT-STICK; BOTT-CLAY; TAPPING-HOLE.

Stourbridge Fire-clay.—A well known fire-clay. The average analysis is: silica 63.30, alumina 23.30, lime .73, ferrous oxide 1.80, water (hygroscopic) 10.30. See FIRE-CLAY; SILICA.

Stove.—A very common name for the foundry oven. See OVEN.

Stove-plate.—A general name for all the thin, flat castings used for the construction of stoves.

Straight-edge.—A strip of wood or metal with which to test the accuracy of an edge or surface. See PARALLEL STRAIGHT-EDGE; BED; LEVEL.

Straightening Castings. — Many methods are practised for restoring crooked castings to the proper shape, but the best, when practicable, is to make them red-hot in a heating-furnace, and employ such means afterwards as will hold them in shape until they are cold. Perhaps it will be necessary to bend a little in the opposite direction before they can be made to assume their true shape. In proportion as this effective means of heating can be approached by outside firing, so will the measure of success be. Especially is this the case with large, complicated castings. Crooks in castings are seldom abrupt; the line invariably forms a true curve. To bring this back again correctly it is absolutely necessary that the whole be heated; otherwise it will simply yield at the heated spot or spots, leaving two or more short bends in place of the original regular curve, or, what is still more likely, break the casting. See PEENING.

Strap.—The belt, of leather or other material, used for lifting cores into the mould. Also, a strip of flat iron screwed fast to a pattern for the purpose of pulling it out of the sand. A hole at the top serves to insert the hook, and a toe set in under the bottom materially assists the short screws which bind it to the pattern. Straps are always best when they are inlaid flush with the face. Long iron straps with two or more tapped holes are to be preferred for securing sweeps to the spindle-arm; they are better than washers and nuts, especially when each bolt has a hole forged at the end for a pointed bar, instead of the usual head for the wrench. See BELT; SWEEP-BOARD.

Straw Rope.—Straw twisted into a rope for wrapping core-barrels, and other purposes for which hay is used. See HAY ROPE; HAY-ROPE TWISTER.

Strength of Materials.—The strength of materials is governed by their physical constitution, or by their form, texture, hardness, elasticity, and ductility; and they are tested in reference to various strains—as tensile, crushing, transverse, shearing, and torsional strains. *Tensile* is represented by suspending a rod vertically and attaching weights at the other end, which will tend to tear it asunder. Its strength depends on the strength of each individual fibre, and upon their number. *Crushing.*—The strength of individual pieces of material whose height is small in proportion to their area, and which are absolutely crushed under the strain, is proportionate to the area of their horizontal section. *Transverse.*—A beam is bent from its horizontal shape if one end be fixed and the other loaded. It is supposed that the compressions and extensions for the given strain are about equal if the beam be not strained beyond the limit of its elasticity; we approach the *breaking-strain* if we go beyond this limit. *Shearing.*—The shearing force is exerted when the particles in one plane are caused to slide over those in another, as in cutting plate-iron with the shears. *Torsion.*—If we make one end of a shaft fast, and exert a force to cause it to rotate, we may twist the shaft asunder at its weakest part. In this case the fibres farthest from the centre will resist the most, diminishing in proportion as the centre is reached.

STRENGTH OF MATERIALS.

Substances.	TENSILE STRENGTH. Weight required to pull a bar 1 inch square asunder.	CRUSHING STRENGTH. Weight required to crush 1 inch square.	TRANSVERSE STRENGTH. Bar 1 inch square and 1 foot long. Weight suspended at one end.	TORSION. Relative strength to resist torsion Lead being 1.
Cast iron	25,000	120,000	600	9
Wrought iron......	60,000	50,000	900	10.1
Steel	90,000	125,000	1,500	16.6
Gold, cast.........	20,000	35,000	....	....
Silver, cast........	40,000	....	500	....
Copper, cast.......	20,000	100,000	....	4.3
Tin, block	4,000	15,500	50	1.4
Zinc, cast.........	2,500	....	30	....
Brass, yellow	28,000	....	....	4.6
Bronze { Copper 10. Tin 1..... }	36,000	....	....	5
Lead, cast.........	1,800	7,000	20	1

—See WEIGHT OF METALS.

Strickle.—A straight edge may be classed as a strickle when the edge is bevelled for the purpose of cutting sand or loam.

Any board or iron plate used for fashioning cores or moulds, loam-boards for pipe-cores, pipe-sweeps, loam-moulders' sweep-boards, etc., are all classed, according to locality, as strickles, strikes, or sweeps. In skilful hands the strickle affords an excellent opportunity for the display of high-class moulding. Each of the devices mentioned are explained in order as they occur. See FORMER.

Strike.—Same as strickle. See STRICKLE.

Strong Facing.—Facing-sand is termed *strong* or *weak*, in proportion to the amount of clay present, or the quantity of coal used in the mixture. See FACING-SAND.

Strontium.—This metal resembles barium in its appearance and properties. The nitrate of strontia is principally in the composition of the well-known *red-fire* of the pyrotechnist. These metals occur abundantly as sulphate and carbonate, forming the vein-stone in many lead-mines. They are malleable, melt below a red heat, decompose water with evolution of hydrogen, and gradually oxidize in the air. See METALS.

Stucco.—A common term for various kinds of composition used for the finer parts of plaster-work on masonry and interior decorations. By the addition to common plaster of other suitable ingredients it is made to resemble the various kinds of marbles. See GYPSUM; PLASTER CAST.

Stuckofen Furnace.—This furnace or bloomary was formerly employed in some parts of Germany as a direct method of producing malleable iron from the ore, but it has been gradually abandoned in favor of the less direct but more economical methods now in vogue. The furnace is about fifteen feet high and thirty inches in diameter at the hearth—the latter having but one arch, which serves for inserting the tuyere, and also for taking out the bloom.

The hearth is first filled with charcoal and lighted, after which the roasted ore and charcoal charged alternately, when the tuyere is inserted and blast supplied from a bellows driven by a convenient water-wheel. Slag is tapped from time to time and the metal falls to the hearth. After about twenty-four hours have elapsed the blast ceases, the tuyere is drawn out, breast removed, and the bloom lifted out and conveyed to the shingling-hammer for consolidation. Subsequent operations after the usual methods result in bar-iron. See SHINGLING; PUDDLING; etc.

Stud.—See CHAPLETS.

Sturtevant Pressure-blower.—The vanes of this instrument are supported by spokes radiating from an axis having conical annular disks mounted on the same axis, and the fan is driven by two belts, to prevent wobbling. The air enters between the spokes around the axis, and is forcibly driven by the curved floats which span the space between the annular disks, being discharged into the circular chamber connecting with the blast-pipe.

In addition to its use for cupola-furnaces and forge-fires this is a very efficient machine for producing the blast in sand-blast machines, for forcing air long distances in connection with the pneumatic-tube delivery system, or in any cases where a high pressure or strong blast is required.

It is built heavier and stronger than formerly, particularly in the running parts, which are most subject to wear.

The high speed at which pressure-blower belts must run renders it necessary that especial attention should be given them. If, while a heat is on in the foundry, the belts begin to run loose or slip, a stoppage is usually necessary to take out the slack; but by means of an arrangement consisting of a blower, adjustable by a screw, on a wrought-iron frame-bed, any required tension may be brought upon the belts while running, thus preventing the inconvenience and loss incident to a stoppage of the blower while work is in progress.

The use of this bed will be found to result in a decided saving in belts. Relacing for the purpose of taking out slack is, on account of the time required, ordinarily put off until the belt will run no longer; but a turn or two of the nut on the end of the adjusting-screw and retightening the holding-down bolts takes but a moment, and is more satisfactory than relacing. See BLOWER.

Sublimation.—A process by which certain volatile substances are raised by heat and again condensed by cold into a solid or crystallized form, as iodine, sulphur, arsenic. Camphor thus vaporizes and condenses in crystals on the sides of the chemist's jars by the rise and fall of ordinary temperatures. It is possible, by decomposing a compound liquid or gas, to obtain one or more of its constituents crystallized. Various gases when passed through red-hot tubes deposit crystals. Metallic solutions are decomposed by passing a galvanic current through them, the metals being deposited in the crystalline form. See SULPHUR; ARSENIC.

Sugar-pans.—See PANS.

Sullage.—Dirt and scoria that accumulate on the surface of molten metal during the process of filling moulds. In this case it consists of the melted particles of sand, etc., gathered from the mould itself as well as that which passes therein from ladle and runner surfaces, which latter will always be in proportion to the amount of care exercised to prevent it by suitable skimming arrangements. Cupola and ladle slag is frequently termed sullage. See SLAG; SCORIA; SKIMMING-GATE; SKIMMER.

Sullage-head.—See HEAD.

Sulphates are definite compounds of sulphuric acid with the salifiable bases.

Sulphites are definite compounds of sulphurous acid with the bases.

Sulphur, usually called brimstone, is sold in powder and in solid pieces. This substance exists abundantly in nature, both free and in combination. It is found in the neighborhood of volcanoes, especially in the island of Sicily. It exists in combination with various metals, forming sulphides, and as a constituent of sulphuric acid it is met with in gypsum and other minerals. It is volatile, and sublimes by heat. Advantage is taken of its volatility to separate it from the mineral impurities with which it is found associated. Iron pyrites contain 50 per cent of sulphur, which is separated by roasting or heating the pyrites in tubes and running off the sulphur into vessels of water. Sulphur melts at 239° F. At this temperature it is thin and fluid as water; when further heated it thickens, with a darker color; and at 480° F. it is so tenacious as to almost refuse to run. Poured into water in this condition it will retain for a long time a very tenacious and soft condition, followed by a state of brittleness again. In its soft condition it is sometimes called *putty sulphur*. In this state it may be used to take impressions of medals, coins, etc. See SULPHUR IMPRESSIONS.

Sulphurets are sulphides or combinations of alkalies or metals with sulphur.

Sulphuric Acid (the *oil of vitriol*, or *vitriol* of commerce) is a powerful acid of great interest to chemists and manufacturers. It is found in the craters of volcanoes and in mineral springs; but it is generally procured by burning nitre and sulphur in large furnaces, the fumes from which are delivered into large lead chambers, where, by the action of steam and air introduced, it is deprived of an atom of oxygen and becomes sulphuric acid. See NITRE.

Sulphur Impressions.—These impressions of medals, gems, or any other delicate object may be obtained easily by using sulphur when it has been made to assume the soft or pastry condition (see SULPHUR). Or, melt the sulphur and increase the heat until it becomes brown; then pour into a vessel, and just before it hardens press the object enough to obtain a good impression. See MEDALS.

Swab.—A substitute for a brush; a hemp contrivance for holding and delivering water, made either by wrapping one end of a piece of rope and combing out the rest, or from new hemp, which needs only to be wrapped at the end. Large ones serve to moisten joints, etc.; small ones are useful to hold in the hand, and by a gentle pressure cause a fine stream of water to flow upon an edge, etc. Swabs are extremely useful for spreading blackening upon dry-sand moulds made from soft friable sands, as they do not tear up the surface in the manner a bristle brush invariably does. Dealers supply good swabs at a price slightly in excess of what the best hemp costs.

Swab-pot.—The iron pot containing water and swab used by the moulder. See SWAB.

Sweep.—See STRICKLE.

Sweep-board is essentially a strickle, but this term is invariably used for all boards that are intended to sweep circular moulds by means of the spindle. The sweep-board is bolted to the spindle-arm, and, being revolved, imparts to the finished cope whatever design has been carved on its edge. See STRICKLE; SPINDLE; LOAM-MOULDING.

Swelled Castings.—See RAMMING; VENTING; TRAMPING.

Swivel.—In foundry nomenclature swivels mean the trunnions of a flask. Properly speaking, a swivel consists of a link made to turn round on a headed pin. See FLASKS; CHAIN.

Swivel-chain is a chain supplied with a swivel-link to permit an even disposal of the links, free from twisting or kinks. This may be accomplished in a superior manner by inserting a long flat link, which, besides working loose on a link-pin at one end, is also tapped at the other end to receive a long threaded link-pin, by which means several chains may be readily adjusted to any required variety of lengths, and thus effectually dispense with the dangerous method of twisting the chains, so prevalent in some foundries. A chain made in this manner is commonly termed a buckle chain by foundrymen. See CHAIN; SWIVEL.

T.

Tabor Moulding Machine.—See MOULDING-MACHINES.

Tackle.—See RIGGING.

Talc occurs in primitive rocks, as granite and serpentine. It somewhat resembles mica, but the latter is both flexible and elastic, while talc is elastic but not flexible. Its composition is silex 61, magnesia 30.5, potash 2.75, oxide of iron 2.5, water 0.5. It is used for crucibles, the manufacture of crayons, porcelain, etc. It is a soft white, transparent or translucent mineral, and is commonly termed steatite when massive. See SOAPSTONE.

Tamping is the process of filling the hole above the charge when blasting rock, so that the force may be expended laterally, and thus rend the rock asunder.

Tam-tam.—A Chinese gong. See GONG-METAL; ALLOYS.

Tank.—See RESERVOIR; DAM.

Tap.—The quantity of metal which runs from a furnace or cupola, from the time of opening or tapping to that of closing or botting up, is called a tap. A large ladle is said to be filled at one or more taps, as the case may be.

Tap-cinder.—See MILL-CINDER.

Taper is draught given to patterns and models to make their withdrawal from the sand easier. In other words, the lowest parts of a pattern are made smaller in dimensions than the upper, in order that a gradually increasing clearance shall occur as the pattern is being drawn from the sand. This not only minimizes the damage to the mould, but to pattern also; the straining and rapping being always in proportion to the amount of taper given. See DRAUGHT.

Tapping-bar.—A pointed iron bar for removing the clay bott when it is desired to let metal out of the cupola.

A set of bars for this purpose should include, first, a scoop-shaped tool about 3 feet long, with which to remove all superfluous clay from the orifice of the tap-hole before the final impression is made, with a longer one having a point, the idea being to clean all the clay out of the spout with the scoop before the stream is permitted to run, and thus prevent its being carried down into the ladle. Besides these it is always prudent to have another of larger dimensions, made of steel and drawn to a square point; this should always be ready, along with a good sledge, in case the plug should congeal and require to be driven in. A large bar of common iron is useful, at times, for a thorough opening out of the hole during protracted heats. See BOTT-CLAY; TAPPING-HOLE; CUPOLA.

Tapping-hole is the hole provided at the bottom of the furnace through which the molten metal is allowed to run at intervals during the operation of melting. Ordinarily, for the cupola, it is made new, along with the spout, for every cast. When it is time to form this hole, a round bar from 1 to 2 inches diameter, according to dimensions of cupola, is thrust into the burning fuel at the breast, taking care that it rests solid on the bottom, after which the breast-hole is rammed with sand and the bar withdrawn. The above is a general view of this operation, but it is well to observe some of the special features connected with it more particularly. In the first place, a short hole is always best, there being then less danger of the metal congealing in the tap-hole; this is accomplished by reducing the brickwork of the lining inside the cupola at this part, and the length may be still further reduced by widening the orifice at the front until not more than 4 inches of straight hole remains. This of course brings the bott end of the molten plug nearer to the molten iron inside the cupola, and thus prevents freezing. If the outer edge of the tap-hole be made slightly funnel-shaped for about 2 inches in, there will be less difficulty in pressing in the bott than is experienced when the hole is parallel all the way through. This is all-important where all the metal the cupola will hold is allowed to gather in the bottom before it is tapped. An important feature in the bricked spout is that it provides a safe abutment for the breast, making it impossible for the inside pressure to force it back. If the cupola-daubing, tempered with fire-sand, be used in immediate contact with the bar when the tap-hole is being formed, and for the bed next the spout also, all possibility of slag forming at the tap-hole is obviated, the substances composing this daubing being too refractory to melt at that temperature. Let the first bott always be a long one, reaching well into the tap-hole, for reasons above described, and in order that it may be easily taken out when it is desired to make the first tap; make a hole through the bott, after it has been formed on the stick, and fill it with common black sand off the floor; by the time this has been pressed well into the tap-hole there remains little but sand to be removed—an easy operation. See Tapping-bar; Bott-clay; Cupola; Breast; Spout.

Tar.—A viscid liquid, usually from brown to black in color, obtained in the destructive distillation of organic matters. Wood-tar is obtained in the manufacture of wood vinegar, and yields, on repeated fractional distillations, creosote, paraffine, picamar, etc. Stockholm-tar is obtained in the same manner from roots and other useless parts of resinous pines. Coal-tar comes from the destructive distillation of coal in the manufacture of coal-gas, and when distilled yields carbolic acid, cresylic alcohol, etc.; also the liquid hydrocarbons benzol, toluol, etc.; the solid hydrocarbons paraffine, napthaline, and the compounds coridine, piciline, aniline, etc. See Pitch.

Tartaric Acid.—An organic acid found in grapes, the tamarind, unripe berries of the mountain ash; and in small quantity in some other plants. In grape-juice it is present as a bitartrate of potash or cream of tartar, and it forms on the insides of wine-casks as a hard crust. The acid is obtained from the bitartrate by the action of chalk and sulphuric acid. When pure, its crystals are colorless and transparent, and in dry air they remain permanent. Mixed with bicarbonates of the alkalies it forms the soda-powder for effervescing drinks. When heated to redness in a covered crucible it forms the mixture of carbon and carbonate of potash known in the laboratory as *black flux.* When it is calcined with twice its weight of water, white flux is formed. SEE FLUX.

Technical Education for the Moulder.—We are told that technical education has for its object the training of persons in the arts and sciences that underlie the practice of some trade or profession, and embraces all kinds of instruction that have direct reference to the career a person is following or preparing to follow.

Owing to the gradual breaking up of the apprenticeship system, the ranks of the skilled foundrymen have been woefully reduced, and must continue to be indifferently recruited from among the foreign workmen who arrive here, if something be not done at once to check the evil. The question naturally arises at this crisis, Will the technical schools furnish the remedy?

A thorough apprenticeship means such instruction in the trade as will give the young man an intelligent knowledge of all its branches; but this means that he shall be gradually advanced, step by step, and receive special instruction and practice in each department—a system entirely at variance with what are now considered to be the best means for rapid production.

Under the old *régime* the boy received the fullest share of attention from his so-called "master," and it was reasonable to expect that he would be taught all that it was possible to teach, if the true spirit of the indenture were carried out. The "master" was bound to teach the boy all of his trade, omitting nothing. Under such circumstances every detail of the craft was learned, and on the termination of the contract he who was the obedient apprentice rightfully became the competent journeyman.

If we look carefully into the subject we shall discover that *production on a large scale* has been the means of inaugurating a new system of dividing labor. Now, this system works advantageously to the employer, because, keeping a boy constantly on one particular branch of work, he naturally becomes more expert, and the total output of his work is proportionately increased thereby. The result of this new order of things has been to limit the boy's ideas of moulding to that particular part upon which he has spent his effort, to the exclusion of the greater part of what constitutes the full and legal measure of a journeyman's knowledge of the trade. In other words, he is launched into the business world a thoroughly *incompetent* moulder; and there are to-day hundreds of such graduating in the large pump, architectural, and stove corporations, in the foundries of which boys are kept at one job throughout the whole course of their servitude.

This apparently unpreventable condition of things has, more than any other cause, created the necessity for technical education of a kind that will, if possible, not only train the minds of our youth in the arts and sciences underlying their trade, but also practically make good the deficiencies of such an incomplete apprenticeship.

The difficulties in obtaining a sound technical education are, we admit, very great; and it would be unreasonable to expect that the theoretical and practical could ever attain to the highest degree of excellence in the one individual. The requirements in each case are necessarily of a different order, each demanding special and distinct lines of thought and action—for which reason the likelihood of such a union is rendered very doubtful. It must be conceded, however, that to the acknowledged advantage of a technical training, as affecting the moulders themselves and the welfare of the foundry generally, we must add the certain improvement that must take place in the work produced, resulting from the superior and better-trained intelligence of those who would be benefited by such instruction.

Some writers have been uncharitable enough to suggest that this superior knowledge, once gained, would generate in the workman a dislike for the ruder and more active parts of his trade. The writer of this hastens to correct all such ill-timed and unwise conclusions. We have always found the opposite to obtain in every instance: the greater the intelligence of the workman, the more diligent he becomes. His superior knowledge imparts a stimulus to the efforts he puts forth; and the result of his labors, being manifestly in advance of his less intelligent fellow-craftsmen, meets with substantial and well-merited approval. This, of course, is the legitimate reward, and constitutes a fitting accompaniment to the inner satisfaction he enjoys. But, rest assured, the moulder possessing these superior attainments will not long remain in the ranks: he will undoubtedly be called into higher spheres of usefulness, where opportunities will be afforded for a fuller and more effective display of his talents.

The fact that it is a matter of some difficulty to obtain competent foremen for some of the mammoth foundries now being erected is made more apparent every day. In order that there should be nothing lacking in the management of such concerns, proprietors have in many instances been compelled to engage the services of an educated superintendent, whose chief business is to overlook the foundry generally, and see that every action of the more active foreman is directed in channels that run in harmony with known physical laws.

Why the moulders of to-day are incompetent for such positions is attributable to two causes—the first being the altered condition under which foundries are now being conducted, rendering it simply impossible for the ordinary workman to acquaint himself with all the details connected with the trade. The second cause will be discovered to be a natural result of the rude awakening experienced in the foundry interest generally to the fact that they were wretchedly behind every other branch of the iron industry in the application of modern improvements, mechanical and otherwise, and in their pardonable haste to redeem themselves appliances have been added in such number and kind and with such precipitancy as to change the nature of things in the foundry altogether.

The suddenness of these late innovations has been almost bewildering in its effect upon the old systems of management; but if, during the time this forced exodus of old-fogyism was taking place, the foreman had been supplementing his daily shop practice with evening instruction in some well-conducted technical school, there is no doubt that he would have been equal to the emergency, as the knowledge there obtained of the new requirements would have qualified him to adequately fill the position, even with the increased responsibilities consequent in the changes spoken of.

We regret to notice that (excepting one or two noble examples) as yet there does not seem to have been any genuine effort to make the foundry department in most of the existing schools equal to the requirements. We need never expect these schools to give the requisite instruction for overcoming the difficulties above described while the present system of choosing instructors is maintained. The latter-mentioned dignitaries are, as a rule, very deficient in all that pertains to a correct knowledge of founding; nor need we wonder at this when we consider that the salaries offered for such instructors are usually much below the remuneration a good journeyman moulder receives at the foundry. The sooner this phase of the subject is thoroughly investigated by the authorities in these matters the better it will inevitably be for all concerned.

We have reason to believe that, if more latitude were given the professors in selecting instructors of founding, a much better state of things would prevail. They would naturally look about for the most suitable person, and offer such inducement as would be likely to secure the worthiest men for candidates. As matters appear to stand at present, the trustees of these institutions, who, we may surmise, are as a rule unacquainted with the actual requirements for such a position, allow feelings of prejudice and mistaken notions of economy to prevail; and as a consequence, instructors are appointed without reference to capacity, their chief recommendation being the diminutive compensation claimed for such valuable (?) services.

Foundry instructors should be unmistakably acknowledged masters of the art of founding; and their education should, at least, measure up to a standard that will enable them to explain in an intelligible manner every operation involved in the production of all kinds of castings, as well as the concomitant qualities of an executive order. The moulder whose career has been a marked success in the foundry, and who has graduated in the sciences directly bearing on his trade at one of the schools, is undoubtedly one of the very best candidates for the position of instructor of founding at the technical schools; and none of the very questionable reasons above mentioned should be allowed to operate against the appointment of such candidates.

This degree of qualification can only be attained by men who, having realized the necessity of such attainments, have diligently studied the theoretical as well as practical part of their trade. It is in this very particular that the present technical-school system offers perhaps the best opportunity yet known for the aspiring founder to advance himself.

A highly reprehensible feature in some of these institutions is the placing of one person to instruct in two or more departments. To expect that one teacher, no matter how extensively read he may be in the text-books, can correctly teach several trades is preposterous. Such a system, if persisted in, must assuredly result in failure and disgrace. The engineer, no matter how profound and extended his general knowledge may be, would naturally shrink from the task of instructing a moulder in all the niceties and perplexing phases connected with the art of founding, as would also the intelligent boiler-maker, if he were asked to instruct a class in modelling; and yet it is a fact that such impossibilities are attempted, with what results we may readily infer.

We confess to being somewhat amused when we read and hear the constant complaint about "the inaccuracies of the average moulder;" but we happen to know that the slipshod methods of working, so prevalent in some places, is mainly owing to the fact that ignorance of the real necessities of the foundry on the part of the management has tended to the withholding of such appliances as would insure the accuracy looked for. Consequently, for lack of encouragement, the moulder has been forced to invent some makeshift for the occasion; hence it is common to hear the expression, "Anything will do for the foundry."

The spirit of contempt for foundry needs and conveniences has at last received its death-blow in the manufactories, as we have endeavored to show; but, strange to say, it has again risen phœnix-like in the schools—the very last place we should have expected to find it. Pass through the several departments of the general order of technical schools, and you will find that the equipment is on a grand scale for almost every section except the foundry. The engine-room is a model of perfection, as it ought to be; the fitting, turning, and general machine-rooms are elegantly provided with the most modern machinery; the forging department has all that could be desired to make it of real service, while the carpentry and other wood-working sections are lacking in nothing to make instruction effective. Last, but by no means least in importance, is the foundry, where we find almost everything narrowed down to a mere shadow of what ought to exist in this department if it is to be of any practical benefit whatever.

The young men from our foundries, who are anxious to supplement their daily practice with such instruction as might very readily be given in these schools, are instantly provoked to laughter when they first contemplate the meagre and insufficient means usually provided for illustrating the art of founding—in some instances not going beyond the antiquated sand-tub of our respected forefathers, with a few small flasks which bear no resemblance whatever to those used in actual practice. This, in conjunction with the very indifferent cupola arrangements, constitutes in some schools what is considered sufficient for foundry instruction. Such means are undoubtedly inadequate for any other purpose than to furnish occasional amusement to the general order of students, who have not the remotest idea of ever engaging in the business of founding.

These excellent institutions may be made invaluable to the moulder, if the regularly constituted authorities can be brought to grasp the situation. No general treatment will answer his case fully; there must be a special and clearly defined course of instruction, excluding all subjects that have no direct bearing on the subject of founding. This special education should include chemistry, because by its aid much of that which is enigmatical in foundry practice, and which to the unlearned is still a positive mystery, can be made plain and intelligible. A knowledge of this science would so change the order of things as to make what has heretofore been a monotonous drudgery an extremely agreeable occupation. Another important result of this increased intelligence would be a sensible diminution of the failures and loss incident to practice founded on nothing more than the merest chance.

The need for a more extended application of the science of chemistry is constantly being forced on the founder in some way or other. Chemists whose occupation has been in line with the foundry are now telling us that the methods usually adopted for ascertaining the nature and quality of pig iron are untrustworthy, and must ultimately give place to the more scientific mode of analysis. The latter method, they claim, will enable the founder to determine the mixture from the analysis furnished by the makers, before it is charged into the cupola, to a certainty; because, having a knowledge of the properties common to the several elements present, he will be able to blend the several brands in such proportions as will produce the desired qualities in resultant mixture.

A practical demonstration of this and other theories could be readily made in the technical schools by successive mixtures melted in crucibles; the formula for each mixture could be changed, and a record kept of the changes caused by the varying quantities of the several elements entering into each test. The physical results, such as hardness, fluidity, chill, shrinkage, strength, etc., could be satisfactorily determined by Keep's Testing-machine—a knowledge of the use of which should be taught in every school of technology.

Some natural philosophy as well as mathematics must enter into this special course, in order that the laws relating to combustion, pressures, and numerous other kindred subjects, but very imperfectly understood by the great army of moulders, may be more generally known among them. All this will tend to sharpen the inventive faculties, and give zest and energy to minds which must otherwise remain comparatively dormant.

While it must be admitted that the general equipment for the technical school cannot possibly equal in magnitude or variety that required for large foundries, it cannot be denied that to be of any practical service whatever all such equipment should contain all the elements suitable for a practical demonstration and thorough illustration of every department of the trade by the instructor.

The cupola, for instance, should not be smaller than 24 inches inside diameter, plain in design, but provided with the best furnishings in ordinary use. The reasons for suggesting a plain cupola are that more of that kind are in use than of any other, and comparisons with improved specimens can be more readily made; also, that they are better for experimental purposes.

Instruments for ascertaining the amount of friction, pressure, etc., in blast-pipes and all the phenomena connected with melting should be provided, and their use fully explained by the instructor. The cupola would be the place where the instructor could in the most effective manner teach sound views, based upon actual practice and experiment, regarding the economy of fuel; what is meant by perfect combustion, and how it is brought about in the cupola; the importance of supplying the exact quantity of air to secure best results, and how to correctly measure the same, etc.

The reverberatory furnace need not be of greater capacity than is absolutely necessary for demonstrating its use for the purpose of melting cast iron and brass. The different principles of melting in direct contact with the fuel, as in the cupola, and of melting by exposing the metal to the action of the flame, as in the reverberatory, could be effectively illustrated and explained by actual practice. Subsequent tests, chemical and physical, would reveal differences caused by the two methods of melting, as well as furnish practice and experience in a branch of the business which has for some time been considerably undervalued and neglected.

Crucible-melting for brass, cast iron, and steel should be taught thoroughly. For brass an ordinary air-furnace of the common type should be provided, in order to clearly demonstrate the different modes of melting with a natural draught and a forced one, the latter being the style of furnace to be provided for melting cast iron and steel. The common brass-furnace with natural draught may be converted into a blast-furnace suitable for melting cast iron or steel in crucibles by simply making the ash-pit door air-tight and introducing the blast therein at a pressure of about three ounces. This would serve to illustrate the ordinary class of crucible-melting, and should be supplemented by a regenerating-furnace of the latest type, suitable for exhibiting the improved methods of obtaining extreme heats from inferior fuels, etc. The uses to which the crucible can be put for experimental purposes are too numerous to mention here, and no instructor who understands this thoroughly will fail to make good use of the opportunities they offer.

If moulding is to be taught in the technical school, castings must be made undoubtedly of such kind and dimensions as will best serve to bring out distinctly all the underlying principles which govern the art. Objections are made to this view of the matter on the ground of expense principally, but this should not be allowed to prevail if we are earnest in our desires to see this great object succeed. Here, again, we notice that no complaint reaches the surface on that score about any other department than the foundry. It cannot be that the objectors are so ignorant of affairs as to think the business of founding of minor importance in the great metal industries. Every day furnishes evidence conclusive that the foundry ranks as high, if not higher, than any other department in importance, and that under intelligent and skilful direction it may be made even more valuable than has yet been dreamed of.

Allow the foundry instruction in these schools to occupy the position it is justly entitled to, and we shall not be long in discovering that our fears were without foundation. Our young men will immediately avail themselves of the opportunities offered for obtaining information beyond that afforded in the daily routine of the shop. They will attend the night-schools, because, owing to the diversified exercises chosen, there will always be something novel and instructive to attract the attention and secure their steady attendance upon the studies enforced.

Suitable objects for the purpose of illustrating the methods of moulding in loam, green-sand, dry sand, and core-making of all descriptions could be readily obtained from the neighboring manufactories and city works of castings of a duplicate character in constant demand. Drawings could be furnished by said firms to which patterns, core-boxes, and sweeps could be made by the students in that branch under direction of their own instructor, aided by the instructor of founding. The patterns would furnish admirable practice of a genuine kind, and when complete would be moulded from in the foundry. The castings could then be bored, turned, or milled in the machine department to drawings supplied and afterwards delivered and paid for in the regular way of trade, thus furnishing serviceable practice to several branches of students, as well as being a source of revenue to the institution.

Take, for instance, an ordinary sewer-head for the city, for which castings there is always a steady demand. These castings could be made very serviceable as examples for illustration. A suitable set of flasks should be made to mould it in green-sand vertically, the core to be made in the pattern used. The same pattern could be also used as an example of bedding-in, using a cope only to cover with. Another pattern could be made in halves for the same casting with flasks to suit for casting horizontally. In this case a dry-sand core could be used, also a green-sand one on a horizontal arbor. Lastly, the centre spindle and sweep-boards could be brought into requisition for moulding this casting, exclusive of pattern or flasks, forming both the outer and inner surfaces with bricks and loam.

The above-described examples, simple as they seem, afford scope for a considerable amount of ingenuity, and almost every branch of the moulder's art is called into practice to produce these castings in the several ways described.

The instructor should be qualified to teach all the branches of moulding enumerated above; and most assuredly his sins will find him out if he is in any sense deficient, there being no one at hand able to furnish the talent wherewith to cover his own shortcomings—something of altogether too frequent occurrence in the foundries.

The importance of having men of ability and judgment as instructors will be apparent, even to the uninitiated, when they consider that all the necessary tools and their appurtenances requisite for these dissimilar operations must be devised by him in such variety and design as will not only answer present needs, but serve also as standard models of their kind, to be used for the purpose of illustration when it is desired to inculcate high-class methods of construction in the minds of the students.

Another very suitable object which might be chosen as a study in all the branches of moulding is a twenty-four-inch steam-cylinder, to be obtained from one of the large pump and engine works. This casting, in addition to the opportunities presented for moulding under altered circumstances, offers the further inducement that subsequent boring and finishing in the machine department would reveal at once any imperfections arising from either faulty moulds or unsuitable iron. The construction of such a mould entirely in green-sand, to be cast horizontally, would call forth some very excellent practice in the arrangements for pouring, in order to obtain clean castings in the bore; also to practically demonstrate the greater nicety and more delicate workmanship displayed in producing castings this way than are required for the same job in dry sand.

The latter useful and effective style of moulding can be very ably illustrated by such a cylinder. Different modes of finishing and closing, in fact all the chief operations demanded for dry-sand work of greater magnitude, may by this one illustration be made exceedingly plain.

As in dry sand so in loam: the requisite equipment for the production of such a casting in loam could be made so as to represent a facsimile of that required for moulding the largest cylinders for the government cruisers.

Firms making a specialty of ship-propellers would be willing to accept castings produced at these institutions at their market value; consequently this very interesting and highly instructive phase of the moulder's art could be learned more thoroughly in the school than in the foundry. The sizes chosen for this purpose might range from two feet to five feet in diameter, with varying pitches to accommodate the obliging firm, who would regulate them according to the stock generally carried. Here, again, we have unmistakably good practice for the pattern-making department in providing the necessary moulding-boxes with the single-wing attachment for moulding small wheels in green-sand sectionally—a method which exacts the nicest manipulation and requires considerable practice before perfection is attained. For casting wheels in dry sand the instructor would teach how to construct the requisite sets of flasks for moulding from a fixed spindle and one wing at a time, in flasks secured to a foundation-plate, using separate copes for the upper side of the blade. Practice of this class develops the constructive faculties, and expands the mind beyond the limits of an ordinary moulder's experience.

The larger wheels would make good examples for loam-work, for, in addition to the practice afforded in manipulating moulds with the spindle and sweep-board, the right use of the angle-board could be effectively explained. A 5-foot wheel would be large enough for a practical illustration of every principle involved in producing one 15 feet diameter by the same method.

The value of these instructions in propeller-moulding would be considerably enhanced by procuring an old casting about 3 feet 6 inches diameter, from which to mould one occasionally in green-sand: by bedding in the sand with the upper tips of the blades level with the floor, forming the joints at each blade, and lifting out the hanging-sand with lifters hooked on the bars of an ordinary 4-foot-square flat cope. This is a very useful class of experience, and much needed almost everywhere.

The above-described methods of moulding propeller-wheels serve as excellent illustrations of the several modes of moulding of which they are representative, the first being a specimen of sectional moulding applicable to work other than wheels; the second shows how the centre spindle may become of almost universal use in producing certain classes of castings from a simple section of the whole pattern, commonly provided. The angle-board used for forming the blade in loam is a study in itself. Since its introduction for the above purpose, very many similar objects are thus formed by the moulder, and considerable pattern-making saved, as well as cost for the mechanical contrivances formerly used. For instance, grooved drums, formerly moulded in loam by revolving two or three grooves from top to bottom of the outside cope by means of a central threaded spindle, are now formed by one revolution of a full-length sweep-board travelling on a guide corresponding to one turn of the thread desired.

A 12-inch ordinary socket-pipe 10 feet long, such as are used for city purposes, could without difficulty be obtained. By moulding these in the several ways to be described, considerable knowledge of an extraordinary kind is to be gained. By preparing a set of cylindrical flasks or casings, made purposely in three sections lengthwise, the whole system of moulding extra-long hydraulic cylinders and rams, guns, etc., may be conveniently explained. Opportunities are here presented for a nice adjustment of the sections by such effective means as will insure a true vertical mould free of seams when all are closed together. Some very good practice may be introduced here; and along with many other schemes for obtaining the mould in these flasks, let a short plug be drawn through all the sections, together and separate, forming the head and socket, with loose pieces, or in any other way which the ingenuity of the instructor may suggest. This would, of course, be a dry-sand mould, and must have a loam-core struck on a barrel made for the occasion—a class of core-making too little practised outside of the pipe-foundries nowadays. This mould, when dried and closed, must be cast vertically.

Another way is to make a full pattern in halves, with a half core-box and sweep for striking off the upper side of core. In this case half-flasks should be used for moulding in green-sand and casting horizontally; the core to be formed in the aforesaid box on a full-length cast arbor in green-sand also. This will furnish excellent practice in another class of core-making too long neglected.

The same flasks must be fitted at the ends with parallels and bearings for carrying a centre spindle horizontally with which to sweep out each half of the mould in plastic material, exclusive of the pattern. The cores in this instance may be made in dry-sand halves and jointed, to vary the method somewhat. As this mould is prepared for drying, it may be cast alternately in a horizontal and vertical position, the latter method calling for some special arrangement for hoisting into a vertical position and lowering in the pit, as well as serving to illustrate the different modes of gating and securing the core.

Some suitable specimens of hollow ware should also be introduced into these schools. There are thousands of moulders who are to day as ignorant of the processes connected with this kind of moulding as were the Dutchmen who failed in making the first pot at Coalbrookdale in the year 1709. The flasks used for this purpose are ingenious and suggestive, and the very neat manipulations of the practised hollow-ware moulder are of a kind calculated to infuse new life into the somewhat slow and slipshod ways of the ordinary workman who attempts to make this particular class of work.

The eye and hand of the ambitious loam-moulder might receive training of a high order by assiduous practice on some object similar to a Y pipe, or any other analogous surface of ever-varying dimensions and constant change of curve—something possessing a surface impossible to form except by the hand, assisted by gauges and templates. Exercises of a similar kind may be given on green-sand surfaces by the use of forming-strips and sweeps, with a final smoothing over of the tools. These exercises need not necessarily be practised on dumb moulds; the more advanced could be taught to form surfaces corresponding to sketches given, such surfaces to receive the treatment necessary for the purpose of casting metal thereon.

The changes lately brought about by the introduction of a profuse display of fine-art work in modern buildings, most of which it is now desired to produce in cast iron, has created a demand for moulders with some experience in such work; and because these castings have hitherto been chiefly made in metals other than cast iron, it has been found difficult to supply this demand, for the simple reason that fine-art work in cast iron requires to be made in material to which the ordinary worker in bronze and other alloys is unaccustomed. There is no doubt that this demand will continue, and the subject should receive immediate attention in the technical schools, where special classes could be taught the entire process of statue- and figure-founding, including the *cire-perdue* and other modes of procedure connected with taking casts in metal and plaster, confining the study as near as possible to such classes of work as would be likely to find its way into our iron and brass foundries.

It will be very evident to those who are at all interested in foundry instruction at the technical schools that no institution of the kind should be without a modern moulding-machine of acknowledged merit. This is a comparatively new study, and is claiming the attention of founders more to-day than it has ever done in the past, simply because there has been a nearer approach made to hand-manipulation by the introduction of devices which have for their object the correct ramming of the moulds within the flasks. Some of these devices are automatic and trustworthy, and the quantity as well as quality of work accomplished in a given time bears unmistakable evidence to the justice of their claims to universal recognition and adoption wherever large numbers of duplicate castings of a certain kind are in active demand.

A good machine with stripping-plate attachment would be a valuable acquisition to the school; the minds of the students could be exercised in discovering methods for overcoming difficulties presented when the joining surfaces are irregular, and in framing schemes for automatically delivering such projections as are oblique to the general surfaces of the pattern.

It is safe to say that no school of technology has been more successful than the Stevens Institute, from which place have been graduated a large number of engineers whose acknowledged ability has fully proved what can be done when competent instructors and judicious management are allowed full scope. Is it too much to ask that the moulder be allowed similar opportunities for distinguishing himself?

Teeming.—This term is synonymous with *pouring*, and is principally employed by steel-melters to signify the act of pouring metal out of the crucible. Pits in which the ingot-moulds are vertically arranged, for better convenience in casting the steel with crucibles, are by them invariably termed *teeming-holes*. Many moulders also employ this term as the equivalent of pouring.

Teetor Moulding-machine.—See MOULDING-MACHINE.

Telegraph and Telephone Wire.—These wires, when made from the ordinary bronzes, were found to be insufficiently conductive. A silicon-bronze has now been substituted, which is equal in strength to the best phosphor-bronze, much superior as a conductor of electricity, and much lighter. The alloy, when produced from the prepared compound, contains, in telephone wire, copper 99.94, tin 0.03, silicon 0.02. For telegraph wire, copper 97.12, tin 1.14, silicon 0.05, zinc 1.62, with iron a trace in each. The compound which forms the base for this mixture is obtained by fusing the copper in a lead crucible with carbonate of soda, fluorsilicate of potassium, chloride of soda, chloride of calcium, and glass. The oxides are by this means absorbed by the acid flux of the silica. Silicon-bronze thus obtained has about 70 per cent of the electrical conductivity of copper, while phosphor-bronze has but 30, and steel something over 10.

Temper.—The operation of moistening and mixing sand and clay to the right consistency for moulding, is in some localities termed *tempering.*

The hardness of steel is changed by the process of tempering. See TEMPERING.

Temper is also the name of a pewterer's alloy. See PEWTERER'S TEMPER; PEWTER.

Temperature is a term that implies a definite degree of sensible heat, the thermometer being the standard of comparison. The expansion of bodies by heat furnishes the means for measuring changes of temperature. Liquids which are easily affected are used for measuring variations in moderate temperatures. Solids, which require a higher degree of heat to expand them perceptibly, are used for measuring variations in elevated temperatures; therefore we have the thermometer for the former, the pyrometer answering in the latter case. The thermometer is an instrument in which a liquid, usually mercury, is employed for ascertaining variations in moderate temperatures, and consists of a tube closed at one end, the other end terminating in a bulb. The bulb and a portion of the tube contain mercury, and, as the air is all excluded before sealing the tube, the space above the mercury is vacuum. The mercury expands by heat and rises in the tube. A fall in the temperature contracts the mercury and it falls. A graduated scale beside the tube measures the rise and fall of the mercury accurately. Fahrenheit's scale is divided thus : The space between freezing and boiling is divided into 180 degrees, but instead of starting at the freezing-point, as in *Réaumur's* and the *centigrade,* Fahrenheit determined by the aid of snow and ice to find the lowest possible cold and make that zero. By this means he got the mercury down to 32° below freezing-point, and commenced to count from there. Hence on Fahrenheit's scale freezing occurs at 32°, the boiling-point, at 212°; when, therefore, the mercury stands at 0 or zero, it is 32 degrees below the freezing-point. In Réaumur's scale the freezing-point is called 0, the boiling-point 80. In the centigrade the freezing-point is 0, the boiling-point 100. When thermometer degrees are mentioned, it is usual to indicate the scale referred to by their initial letter. Thus: 50° F. means 50 degrees on Fahrenheit's scale ; 20° R., 20 degrees on Réaumur's; and 10° C., 10 degrees centigrade.

The following are rules for mutually reducing degrees of temperature—Réaumur, Centigrade, Fahrenheit.

Réamur Degrees to Degrees Centigrade.

Divide by 4, and add product to number of degrees given.

Example: $56° \div 4 = 14°$; $56° + 14° = 70°$.

Réaumur Degrees to Degrees Fahrenheit.

Above freezing.—Multiply by 9, divide by 4, and subtract 32° from the product.

Example: $20° \times 9 \div 4 + 32° = 77°$.

Below freezing.—Multiply by 9, divide by 4, and subtract 32°.

Example: $-20° \times 9 \div 4 - 32° = -13°$.

CENTIGRADE DEGREES TO DEGREES FAHRENHEIT.

Above freezing.—Multiply by 9, divide by 5, and add 32° to product.

Example: 25° × 9 ÷ 5 + 32° = 77°.

Below freezing.—Multiply by 9, divide by 5, then take the *difference* between 32° and the result so obtained.

Example: – 30° × 9 ÷ 5 = 54°; 54° – 32° = 22°.

CENTIGRADE DEGREES TO DEGREES RÉAUMUR.

Divide by 5 and subtract product from number of degrees given.

Example: 70° ÷ 5 = 14°; 70° – 14° = 56°.

TO REDUCE FAHRENHEIT DEGREES TO DEGREES CENTIGRADE.

When temperature given is above zero.—Subtract 32°, multiply by 5, and divide the product by 9.

Example: 77° – 32° × 5 ÷ 9 = 25°.

When temperature given is below zero.—Add 32°, and proceed as above.

Example: – 22° + 32° × 5 ÷ 9 = – 30°.

FAHRENHEIT DEGREES TO DEGREES RÉAUMUR.

Above zero.—Subtract 32°, multiply by 4, and divide product by 9.

Example: 77° – 32° × 4 ÷ 9 = 20°.

Below zero.—Add 32°, and proceed as above.

Example: – 13° + 32° × 4 ÷ 9 = – 20°.

(*See table on next page.*)

Tempering.—When steel is suddenly cooled from a high temperature it becomes hard and brittle, but when slowly cooled it is very tough and pliable. The process of bringing steel to the several degrees of hardness for use in the arts and manufactures is called *tempering*. This term is usually applied to mean a combination of the hardening and annealing processes. According to the temperature to which the hardened steel has been heated before annealing, so is the diminution of the hardness affected by the process. See STEEL; RESTORING BURNT STEEL; DIES, TO HARDEN; ANNEALING.

Templet.—All formers, sweeps, strickles, etc., are in some foundries improperly called templates. The template

EQUIVALENT TEMPERATURES—RÉAUMUR, CENTIGRADE, AND FAHRENHEIT.

Réau.	Cent.	Fahr.	Réau.	Cent.	Fahr.
80	100.	212.	28	35.	95.
79	98.75	209.75	27	33.75	92.75
78	97.5	207.5	26	32.5	90.5
77	96.25	205.25	25	31.25	88.25
76	95.	203.	24	30.	86.
75	93.75	200.75	23	28.75	83.75
74	92.5	198.5	22	27.5	81.5
73	91.25	196.25	21	26.25	79.25
72	90.	194.	20	25.	77.
71	88.75	191.75	19	23.75	74.75
70	87.5	189.5	18	22.5	72.5
69	86.25	187.25	17	21.25	70.25
68	85.	185.	16	20.	68.
67	83.75	182.75	15	18.75	65.75
66	82.5	180.5	14	17.5	63.5
65	81.25	178.25	13	16.25	61.25
64	80.	176.	12	15.	59.
63	78.75	173.75	11	13.75	56.75
62	77.5	171.5	10	12.5	54.5
61	76.25	169.25	9	11.25	52.25
60	75.	167.	8	10.	50.
59	73.75	164.75	7	8.75	47.75
58	72.5	162.5	6	7.5	45.5
57	71.25	160.25	5	6.25	43.25
56	70.	158.	4	5.	41.
55	68.75	155.75	3	3.75	38.75
54	67.5	153.5	2	2.5	36.5
53	66.25	151.25	1	1.25	34.25
52	65.	149.	0	0.	32.
51	63.75	146.75	1	1.25	29.75
50	62.5	144.5	2	2.5	27.5
49	61.25	142.25	3	3.75	25.25
48	60.	140.	4	5.	23.
47	58.75	137.75	5	6.25	20.75
46	57.5	135.5	6	7.5	18.5
45	56.25	133.25	7	8.75	16.25
44	55.	131.	8	10.	14.
43	53.75	128.75	9	11.25	11.75
42	52.5	126.5	10	12.5	9.5
41	51.25	124.25	11	13.75	7.25
40	50.	122.	12	15.	5.
39	48.75	119.75	13	16.25	2.75
38	47.5	117.5	14	17.5	0.5
37	46.25	115.25	15	18 75	1.75
36	45.	113.	16	20.	4.
35	43.75	110.75	17	21.25	6.25
34	42.5	108.5	18	22.5	8.5
33	41.25	106.25	19	23.75	10.75
32	40.	104.	20	25.	13.
31	38.75	101.75			
30	37.5	99.			
29	36.25	97.25			

—See Pyrometer; Heat.

is simply an outline, in wood or iron of the whole or part of a mould or pattern in course of construction, and serves to test the accuracy of the work as it progresses. A frame or board shaped to the outline of a pipe, with lines to mark off the true position and angle of the flanges, etc., or any other similarly devised guide, is a tempaet also.

Tenacity.—It is easier to pull asunder a bar of lead than a bar of steel of equal dimensions. This proves that the molecules of some solids cohere more strongly than others. A solid is said to be *ruptured* when it is thus forcibly pulled asunder, and the power that resists this rupture is called *tenacity.* If we find how much force is required to pull asunder rods of different solids having equal dimensions, we can then determine their relative tenacity. Tenacity is also that quality of cohesiveness in bodies that causes them to adhere to other bodies, as glutinous, stickiness, etc. See COHESION; ADHESION; STRENGTH OF MATERIALS; METALS.

Tensile Strength.—See STRENGTH OF MATERIALS.

Terne Plate are thin iron plates cleaned, and coated with tin by dipping into a molten bath of the latter metal. See TINNING.

Terra-cotta.—This name is applied to figures, vases, statues, architectural decorations, etc., that have been cast or modelled in a compound of potter's-clay mixed with fine sand, pulverized potsherds, calcined flints, etc. These articles are burnt in the kiln after being dried in the air. Some of these productions resist the unfavorable influence of the weather much better than some stone. See STONE.

Testing Machines.—The great variety of testing-machines now in the market are an evidence of their growing importance. Wide-awake foundry-men everywhere realize the necessity for strict inspection of all the pig iron they purchase in order that their castings may be made to meet every requirement at the least possible cost. By means of the simplest of these machines, a sample of pig iron can be tested and its quality determined with approximate nearness in an incredibly short space of time, so that purchases need not be made blindfold as has been too frequently the case in the past. A more elaborate system of tests may be obtained by the use of Keep's test, which reveals every phase of a true test with the nicest accuracy: gradual load, impact, fluidity, tendency to curve, shrinkage, and deflection are at once determined by this machine in a manner truly astonishing. The Waterloo Transverse-testing Machine is arranged with the weighing-beam and system of multiplying levers, all tested and regulated in accord with the United States standard of weights at Washington, D.C , and delicately adjusted to weigh the strain exerted on the specimen. The power exerting the strain on test-piece is produced by a worm and gear. The best of materials are used, and the workmanship is first-class in every particular.

The specimen in process of testing has one end resting upon an A-shaped piece of metal, the other end being suspended from the lower lever of the machine.

The strain upon the test-piece is produced by turning a wheel below in front of the frame, which causes the stirrup, which is located at the centre point of specimen, to bear down upon the same, and the strain thus produced is transmitted to the weighing-beam through the intermediate lever.

The weighing-beam is kept in equipoise by shifting the poise, the power being applied simultaneously with the movement of the poise, and continuing the operation until the test is concluded. Care must be taken that the weighing-beam is balanced before the testing is begun or the test-piece in position. Additional standard weights are supplied to suspend on the small end of the weighing-beam, as occasion requires, to balance the strain up to the full strength of the test-specimen.

This machine can be arranged to test longer specimens up to four or five feet, at extra cost. An indicator to show elasticity of specimens being tested can be added. See TRIAL CAST.

Thermometer.—See TEMPERATURE.

Thicknessing is the mode of obtaining a cast in metal, or plaster, by applying a coating or thickness over one surface of mould, produced by the sweep, strickle, block, or model, from which the remaining surface is then obtained and the thickness removed. The space previously occupied by the thickness being filled with metal or plaster, constitutes the cast. See BACKING-OUT; KETTLES; STATUE-FOUNDING.

Three-high Rolls are employed for rolling light merchant-iron. They are a combination of three rolls in one pair of housings. The middle roll in the series drives the upper and lower ones in opposite directions, delivering the bar at one side, to be returned by simply changing from one side to the other of the middle roll without any reversal of motion. See ROLLS.

Three-part Flask.—See FLASKS.

Tied-core.—Two halves of dry-sand core bound together with one or more strands of wires. The wire ends are made to overlap each other sufficient to make a twisted junction. Similar fastenings are of great service on a small brick core that has no binding-rings built in it. The wires may be wrapped round before roughing up; they are then hidden by the loam. See BINDING-RINGS.

Tie-rods.—Rods of iron, used for stiffening unsupported portions of moulds and cores. Grates, or grids, make the most trustworthy supports, inasmuch as the stiffening influence is imparted in every direction. This can only be approximately accomplished by tie-rods with alternate layers at right angles to each other. See CORE-IRON; GRIDS.

Tie-wire.—Wire of different sizes, used for tying cores with. This should always be annealed and of the best quality, as the connections are invariably made by twisting the ends together. Poor wire breaks during the operation, and not unfrequently have we seen the mould completely spoiled through a rupture occurring after all was closed and considered safe. See TIED-CORE.

Tile.—Thin bricks, or plates of baked clay, differing in shape according to their use. They are employed for the roofs of buildings, also for pavements. Some finer kinds for the latter purpose are known as *encaustic* tiles.

Tilted Steel is cemented steel made stronger by hammering under the tilt. See CEMENTATION.

Tilt-hammer.—Used for shingling, and also for working finished iron. It consists of a long lever, with hammer-head attached at one end, which is operated by a cam at the other. The fulcrum is placed nearest to the cam, which is generally a wheel with about a dozen projections, called wipes. As the cam revolves, the short end of the lever is borne down by the wipes, lifting the hammer-head until the wipe on the cam has cleared, when the hammer drops upon the work on the anvil. Each wipe in succession engages the lever, causing the hammer to rise and fall with considerable force and rapidity.

Tin.—This metal has been known from very early times, but its ores have been found in a few places only; the metallic tin is not found in nature. Chief among the European sources of tin are the mines in Cornwall, where it is found as tinstone. The Phœnicians and Romans obtained from these mines all the tin employed by them in the manufacture of bronze. Malacca, Borneo, and Mexico also yield tinstone. In the preparation of this metal the tinstone is crushed and washed, and the clean ore is then put into the reverberatory furnace along with fuel and a small portion of lime. By this means the oxide is reduced, and the liquid metal, together with the slag, consisting of calcic silicate, falls to the lower part of the furnace. The blocks of tin thus obtained are still impure, and require further refining by gradually melting out the pure tin, leaving an impure alloy behind. The refined tin thus obtained is principally used for tin-plate, the remainder being the block-tin of commerce. The manner of producing grain-tin is to plunge blocks of the metal into a tin-bath, where they are caused to assume a crystallized nature, after which they are either broken up with the hammer, or allowed to fall from a great height. The long grains are caused by the latter process.

Tin is a brilliant, silver-white metal, softer than gold, slightly ductile, and very malleable, as evidenced by the common tin-foil, which is no more than $\frac{1}{1000}$ of an inch thick. It melts at 442°. The peculiar cracking sound emitted when tin is bent is owing to the disturbance of its crystalline structure. Owing to its weak affinity for oxygen, it tarnishes but slightly on exposure to air or moisture, and is therefore valuable for domestic utensils. It is this property that renders it so useful as a coating to prevent other metals from oxidizing. The common tinware is simply thin sheets of iron coated with this metal. Tin dissolves in hydrochloric acid. If this metal be heated beyond its melting-point, with access of air, it becomes converted into the binoxide, and burns with a brilliant white light. It is certainly one of the earliest known metals, as it enters into the composition of bronze, of which alloy many of the ancient statues, weapons, and tools were made. Most metals are made harder, whiter, and more fusible by tin. It forms the principal ingredient of Britannia metal, pewter, and many solders. The finest pewter is mainly composed of tin, with some *temper*. See PEWTER.

Tin forms an amalgam with mercury, with which to silver mirrors and other objects. Tin-foil is placed on a flat slab, then covered with mercury, and the glass placed over it, when, weights being applied, the superfluous mercury escapes, leaving a film of the silvery amalgam adhering to the glass. See MERCURY.

Tin is hardened and made more silvery by alloying with antimony; zinc has the effect of cleansing it. See ANTIMONY; ZINC.

Melted pewter is prevented from oxidizing by letting a piece of zinc float upon the surface of the alloy while casting.

One ninth of tin added to copper makes gun-metal or bronze, which is tough and rigid, but can neither be rolled nor drawn—a wonderful change from the original qualities of either metal when unalloyed; and what is perhaps more remarkable, if further additions, up to about one fourth, of the soft tin be employed, the alloy is made hard and elastic. A further increase up to tin 1, copper 2, and the alloy becomes so brittle that steel tools fail to make any impression upon it, except to crumble it; its malleability is completely destroyed, a brilliant white alloy, highly crystalline, having taken its place, with no trace of the red copper in its texture. Such an alloy is susceptible of a brilliant polish owing to its extremely close and hard nature, and for this reason it is used for speculums; but special means must be employed for grinding the surfaces, as they cannot be cut. See SPECULUM-METAL; ROSSE'S TELESCOPE; COPPER; BRONZE.

Tin Enamel.—A pottery enamel consisting principally of tin oxide. The Saracens first used it to embellish their pottery-ware, but the Italians were finally successful in discovering the secret of its production, and used the enamel on their famed *Majolica* ware about the year 1600. See ENAMEL.

Tin-foil.—The best tin-foil for mirrors, etc., is made from pure tin by rolling or beating. Commoner kinds are composed of tin, zinc, and lead in varying proportions, and are made by allowing the fluid metal to flow down an inclined plane covered with canvas. See LEAD.

Tinker's-dam.—A wall, generally of clay, formed around a joint, etc., for the purpose of retaining the solder in close contact with the work to be soldered.

Tinman's Solder.—See SOLDER.

Tinning.—Brass and copper articles boiled in a solution of stannate of potassa, mixed with turnings of tin, are in a short time covered with a layer of pure tin. If the articles be boiled in caustic alkali or cream of tartar with tin-powder, the same effect is produced; the latter mixture is composed of water 2 pails, cream of tartar

$\frac{1}{2}$ lb., salt $\frac{1}{2}$ pint. Keep the article moving throughout the process.

Copper tubes may be tinned inside by a solution of salts of tin added to the solution of Rochelle salts, which forms a precipitate of stannous tartrate, which must be washed and then dissolved in caustic lye. Rinse the copper tube with sulphuric acid, and afterwards wash it well out, after which the tube must be filled with the alkaline solution, slightly warm, and a tin rod inserted; the latter will at once cause a thin coat of metallic tin to be deposited.

Iron pots and similar articles are first cleaned by immersion in sulphuric acid and water for new metal, and muriatic acid and water for old metal, with a subsequent scouring with sand, followed by washing in water. They are then put into a bath prepared with cream of tartar 1 ounce, protochloride of tin 1 ounce, water 10 quarts. This bath is kept in a wooden or stone-ware vessel at a temperature of 190°. Small pieces of zinc are distributed among the articles in the bath, which may be taken out and washed with water when the coat of tin deposited thereon is thick enough.

If iron articles are first cleaned as above, they may be made hot enough to melt tin, and then rubbed with sal-ammoniac, as well as sprinking the latter (in powder) over them; the tin can then be applied, and as it melts be spread evenly all over with a hand-cloth.

A cold process of tinning is to blend tin-foil and mercury into a soft, fusible amalgam, and, after cleaning as before directed, rub on the amalgam while the article is moist, and then apply heat to evaporate the mercury. See Tin-plate.

Tin-plate.—The thin iron plates for this purpose are usually made from the best charcoal-iron, the surface of which is made chemically clean by pickling in hot diluted hydrochloric acid. They are then washed and annealed in closed iron boxes, passed two or three times through the rolls to polish the surface and cause them to take less tin, again annealed and pickled, and subsequently washed with sand and running water, which leaves them clean and bright for tinning.

The plates are now put singly into a pot of melted grease, then into the *tin-pot,* containing the bath of molten tin, covered with grease; from this they are passed to another vessel with two compartments, called the *wash-pot,* in both of which compartments is melted tin also, well covered with grease, like the first. The tin in this pot is purer than that contained in the tin-pot. They are then lifted out of compartment No. 1, wiped with a long hempen brush on both sides, and again dipped—in compartment No. 2 this time, out of which it comes shining, to be at once transferred in an upright position to a pot of liquid grease, the temperature of which is maintained no higher than will keep the tin in contact with the oil in a liquid state, allowing the superfluous tin to run off, and spreading the remainder equally on the surface of the iron. See TIN; TINNING.

Tin-pot.—See TIN-PLATE; PANS.

Tinstone.—See TIN.

Titanium usually occurs as a gray, heavy, iron-like sand, which burns brightly in the air and is converted into titanic acid, or in prismatic crystals. In many of its reactions it closely resembles tin. Titanic acid is used for imparting a yellow tint to porcelain glazes, and for the manufacture of artificial teeth. Ores containing titanic iron are supposed to produce an excellent quality of steel.

Tobin-bronze.—See DELTA-METAL.

Tombac is a cheap gilding metal for common jewelry, and purposes where it is desired to substitute for the nobler metals a cheap imitation.

Those given in the following table are made by first fusing the copper and adding the remainder afterward in the usual way—except in the case of white tombac: in this alloy the two metals copper and arsenic are melted together in a closed crucible, and well covered with common salt to prevent oxidation.

Kinds of Tombac.	Copper.	Zinc.	Tin.	Arsenic.	Brass.	Lead.
Gold, imitation................	16	1	1			
Silver-white, for buttons, etc. ..	75			25		
Red........................	11	1				
Gilding, for common jewelry...	16	1 to 1¼				
" " " " ..	16				6	
" " " " ..	16	3 to 4				
" " " " ..	82	18	1			3
French imitation gold..........	80	17	3			
Yellow, gilt ornaments.	85.3	14.7				

Ton.—A weight, equal to 20 hundredweight (*cwt.*). The hundredweight in Britain is 112 pounds, making the ton 2240 pounds. The U. S. hundredweight is reckoned at 100 pounds, which gives a ton of 2000 pounds.

Tongs.—A metal instrument consisting of two legs joined together at one end by a pin, on which they work loose, and by means of which an object may be grasped. Used in the smithy, forge, steel and brass foundries, etc. See LIFTING-TONGS.

Tongue.—An attachment on a loam-board or sweep, by which supplementary bearings, joints, etc., are formed. See FINGER-PIECE.

Tools.—See Moulding-tools.

Top-part.—See Flasks; Cope.

Top-plate.—See Covering-plate.

Topaz.—This precious stone is found in Saxony, Bohemia, Siberia, and Brazil, mixed with other minerals in granite rocks. Its colors are yellow, bluish, greenish, lilac, and white. Electric by heat, but not by rubbing. It is composed of alumina 47.5, silex 44.5, fluoric acid 7, oxide of iron 0.5. This is for the yellow variety; their compositions vary. It occurs crystallized and in water-worn pebbles, being harder than quartz, but hardly as hard as the ruby. The yellow variety, when without flaws, is employed for jewelry. See Sapphire; Precious Stones.

Torsion.—See Strength of Materials.

Touch.—The sense of touch is perhaps more acute in the hands than in any other part of the body, and it is certain that the touch will reveal inequalities of surface which the unaided eye would fail to detect. This sense when fully developed is of infinite service when a mould surface consisting of numerous varying curves has to be formed in the sand so that all the lines may mingle one into another in such a manner as shall defy the strictest scrutiny to detect where one angle intersects the other. This nicety of touch should be cultivated among moulders more than it is: eminent sculptors have it, poor ones do not; and it is rational to say that the moulder who is deficient in this quality will never accomplish anything in his trade but what is mediocre.

The study and practice of modelling in sand and clay should by all means be encouraged in our technical schools.

Both touch and design could there be cultivated, and opportunity given for the American moulder to reach that degree of artistic superiority which has been already attained by the educated artisan in many parts of Europe. See TECHNICAL EDUCATION FOR THE MOULDER.

Touch-needles.—Used by assayers and refiners; are little bars of gold, silver, and copper combined together in all the different proportions and degrees of mixture. Their use is to discover the degree of purity of any piece of gold or silver by comparing the marks they leave on the touchstone with those of the bars. The touchstone is usually a piece of hard black basalt. See ASSAYING; BASALT.

Toughened Glass is made by plunging the glass into a bath containing an oleaginous mixture after heating almost to melting-point the articles to be toughened, the bath itself being at a high temperature, but not so high as the glass itself. Some of the articles are thus toughened without any previous annealing—simply dropping them from the workman's rod directly into the bath.

Toughness.—This quality in metals is simply the power to resist rupture—firmness, strength, compactness; not readily broken or fractured by bending, drawing, or extending. A metal possessing this quality is flexible without brittleness, yielding to force without breaking. Toughness is tested by bending, torsion, etc. See STRENGTH OF MATERIALS.

Train.—The forge-train consists of two pairs of rolls connected in one line, those on the left being the *roughing* or *puddle rolls;* the right are the *finishing-rolls.* The mill-train also consists of two pairs of rolls—*roughing* or *billeting rolls,* and *finishing-rolls.* Forge-train puddle-rolls receive the puddle-blooms from the squeezer; the mill-train billeting-rolls are for rolling merchant-iron from the puddled bar after being cut, piled, and reheated.

Trammel.—Compass-points attached to sleeves which slide on a bar or beam. They are used for describing larger circles than an ordinary compass will reach. They are held fast at any point on the bar by a set-screw on the top.

Tramping, or Treading, is a method of ramming which, when thoroughly understood, is of great value to the moulder, owing to the fact that upon an equal thickness of sand a man's weight *applied at every portion* must result in an equal depression all over, and thus produce a rammed surface of equal density at every part. Tramping is much practised by light-work moulders, who roll all their work over in frame nowels with *follow* and *bottom* boards, as well as by those employed on heavy work, when mould-beds are formed in the floor. If this operation is not performed with judgment and care, the casting will most assuredly betray the moulder's ignorance or neglect; alternate heavy and light treading being unmistakably revealed by the undulating appearance of the casting's surface. A swelled casting is an abomination, but it may always be avoided by intelligent ramming and tramping. See RAMMING; VENTING.

Tramway, Overhead.—See CRANES; IRON CARRIER.

Transverse Strength.—See STRENGTH OF MATERIALS.

Travelling-crane.—See CRANE.

Treading.—Same as Tramping. See TRAMPING.

Trestle.—A beam connected to three or four legs which spread out at the bottom to impart greater stability. Trestles are made of various sizes and shapes for supporting moulds, flasks, etc., and are commonly termed *horses* when used for this purpose. The forms of trestles, in both wood and iron, vary according to the use for which they are intended. See CORE-LATHE.

Trial-cast.—A simple and inexpensive method of obtaining a trial-cast of pig iron is to possess a gas-blast or other good crucible furnace in which to melt a small sample at quick notice, and cast a bar one inch square, twelve inches long, and another two inches wide, one-eighth inch thick, also twelve inches long. These must be moulded carefully, by the same person every time if possible, in separate flasks, and poured with metal corresponding in temperature on each occasion. If a wedge-like projection two inches long be cast on one or both ends of the square bar, the tendency to chill will be at once determined by the amount of white iron extending from the point inwards, as well as by the edges of the thin bar. The amount of shrinkage is ascertained by careful measurement of the bars; and, if the same gates be used for each cast, the thin bar will serve to show the metal's fluidity. Tensile or transverse strength can be afterwards obtained on the testing-machine. See TESTING-MACHINE; STEEL CASTINGS; GAS-BLAST FURNACE.

Trinket-metal.—See GOLD ALLOYS; TOMBAC.

Trip-hammer, or Frontal Helve, differs from the *Tilt-hammer* in that the lever, instead of being raised by depressing the tail, is lifted by projections or wipers which act by lifting the head about twenty inches. The *trip* is especially for shingling, and is made more massive than the *tilt*. See TILT-HAMMER.

Tripod.—See Spider; Ordnance.

Tripoli was originally brought from that part of Africa from whence it derives its name. It is a siliceous stone with fine particles, much like rottenstone in its nature, and like it is used extensively in polishing metals, glass, and marble. See Polishing Substances.

Trituration.—Dry grinding by special apparatus designed to make a finer powder than is possible by the ordinary means for pulverizing. When the comminution is aided by a liquid it is termed *levigation.*

Trolley.—A term of general application to all vehicles which run on a track or tracks, but more especially to the carriage of an overhead tramway. See Iron-carrier; Cranes.

Trompe.—A water-blowing machine, consisting of a cistern supported about twenty feet above the air-chamber and connected with the latter by a wooden pipe, near the top of which are several oblique holes. Another pipe connection on the lower cistern or wind-chamber leads to the tuyere. When working, the upper cistern is kept full of water, and the flow therefrom is regulated by a conical plug. As soon as opened, the water rushes down the long pipe, carrying some air, which enters through the holes along with it; the water falls on a projection inside the wind-chamber, and its height in the latter is regulated by an escape-pipe on the side; while the air carried down with the water is forced to the furnace through the discharge previously spoken of. See Catalan Forge.

Trowel.—This is unquestionably the most important of all the moulder's tools. The *square* trowels vary in size from $\frac{1}{2}$ inch $\times$ 3 inches to 2 inches $\times$ 7 inches, and are supplied with a handle similar in style to the ordinary mason's trowel, but smaller. Others, again, having handles, are heart-shaped, and vary in size from $1\frac{1}{2}$ inches to $3\frac{1}{2}$ inches across. There is, besides these, a combination tool having a square at one end and a heart at the other, which for general purposes, in skilful hands, is the most useful of all. See MOULDING-TOOLS.

Troy Weight.—A weight used chiefly in weighing the precious metals, gems, jewelry, etc. A standard pound Troy contains twelve ounces, each ounce twenty pennyweights, and each pennyweight twenty-four grains.

Truck.—Almost any contrivance on wheels for carrying loads is called a truck. At one time trucks were of such variety as almost to defy description, but the tram-rail and overhead conveniences have revolutionized this, leaving the foundries clear of all except the common hand-truck and wheelbarrow. See IRON-CARRIER; CRANES.

Trunnions are cylindrical projections placed on each side of a flask in a position to balance it. The trunnion forms an axis to turn in a sling, or on a suitably contrived trestle, when the cope is turned over. A depression in the middle of the trunnion prevents the sling from slipping off. See SLING.

Tub.—The rectangular wooden trough over which some brass-moulders ram their flasks is by them called a *tub*. If iron slides are fastened on the inside, lengthwise, a few inches from the top, a frame can rest thereon to hold the flasks. By this means the rammed flask may be slided across or along the tub into any convenient position without bearing up its weight—a great convenience when the work is prolonged.

Tube-vents are vent-connections made with tubes in such a manner as to make it impossible for any metal to insinuate itself therein. If the gas from one core must be made to pass off by the way of another through a connecting core, the operation is made absolutely safe by placing a tube midway at the junction; or if a vent must be led from a core remote from the outside, as in a set of steam-way cores, tubes inserted in the vents, long enough to reach the distance, make it a safe operation. See VENTING.

Tucking.—A process in moulding intended to make all parts of a mould sufficiently hard by a previous ramming or tucking with the fingers in places where under existing circumstances the rammer could not be made to reach, as under flask-bars, among gaggers, etc. The method is in many instances a reprehensible one, as the more effective and safer mode would be to do this tucking with a small hand-rammer, the latter being much easier on the fingers also. See RAMMING; VENTING.

Tula-metal.—See NIELLO-ENGRAVING.

Tumbling-barrel.—The common tumbling or cleaning barrel consists of a barrel-shaped, vessel with a side opening for introducing the work, mounted on an axis, and revolved by gears or belt.

These, however, are fast becoming scarce, owing to the numerous patented inventions of various descriptions which may be obtained from the dealers at short notice.

The Henderson oblique barrel, used for burnishing and plating small brass goods as well as iron; also an exhaust-barrel for castings; the Stover exhaust for castings, nails, forgings, etc.; friction-geared, roller-geared, and encased tumbling-barrels—are only a few of the machines designed to totally eradicate the dust and noise which have hitherto been the inevitable accompaniment of these useful devices. See EXHAUST TUMBLING-BARREL.

Tungsten, or Wolframite, forms with steel an alloy of remarkable hardness. It is a rare metal, derived chiefly from wolfram, a tungstate of iron and manganese. See WOLFRAM.

Tungsten-bronze is made by adding tungsten to the ordinary bronzes or brass containing copper, tin, zinc, and lead.

Tungsten-steel.—Wolframite aaded to steel.

Turf.—See PEAT.

Turkey-stone.—A slaty stone containing a large proportion of fine siliceous particles, which make it of great service for sharpening edge-tools. See WHETSTONE.

Turnbuckle.—A long link having tapped ends or one end swivelled; used for tightening stay-rods or chains, as in a swivel chain. See SWIVEL-CHAIN; SWIVEL.

Turning-cores.—See CORE-LATHE.

Turnover Board.—See FOLLOW-BOARD; MATCH-PLATE; MATCH-PART; BED-BOARD.

Turnover Flask is the flask used with a turnover board. See ROLLING-OVER; TURNOVER BOARD; FLASKS.

Turpentine.—Oil of turpentine is obtained by distilling with water the pitchy matter that exudes from pine-trees; what remains after distillation is called common rosin. Boils at 320°; is highly inflammable; specific gravity 0.86. See PITCH; RESIN.

Tutania.—A beautiful table-ware alloy of silvery brightness. One mixture is tin 2 pounds, antimony 4 ounces, arsenic 1 ounce. The Engestroom tutania is copper 4, regulus of antimony 8, bismuth 1, melted together and added to 100 parts of tin. A German alloy is tin 48, copper 1, antimony 4. See SPANISH TUTANIA; SILVER; GERMAN-SILVER; BRITANNIA METAL.

Tutenag.—An Indian name for zinc. It is sometimes applied to denote a white alloy brought from China and called *Chinese copper*. Analysis discovers copper, zinc, and iron in some specimens, while others are said to be merely copper and arsenic. It is used chiefly for table-ware, and is generally composed of copper 50, nickel 19, and zinc 31, although it is common to mix lead or iron in small quantities along with these ingredients. See WHITE ALLOYS.

Tutty.—A polishing powder consisting of an impure oxide of zinc, gathered from the chimneys, etc., of the zinc furnaces. See POLISHING SUBSTANCES.

Tuyere.—A tube to direct and regulate a current of air to the inside of a cupola or other blast-furnace. For description, see CUPOLA; for number required in different-sized cupolas, see CHARGING THE COMMON CUPOLA. See also BLAST-PIPES; BLAST-GATE; EYEPIECE; BLAST-PRESSURE; GREINER PATENT CUPOLA.

Twister.—See HAY-ROPE TWISTER.

Tymp.—An opening in the masonry of a blast-furnace hearth, across the top of which is laid either a block of refractory stone, or a hollow iron block, through which a current of water is kept constantly flowing to prevent it from melting. The *dam-plate* stands a little below and supports the *dam-stone,* which forms the front of the *fore-hearth.* The slag flows over the tymp, while the reduced iron collects in the hearth below. See Cast Iron.

Type-founding.—Typography means writing by types. Movable types were used for printing in China and Japan long before the art was practised in Europe; blocks were used there as far back as the sixth century, but it was not till the tenth century that books were produced. The Chinese employed movable types of clay about the eleventh century, and in the fifteenth century the Coreans invented types of copper. The book trade was established in Europe about the thirteenth century, and it was about the year 1457 that Faust and Schoeffer printed with movable wooden types. Some think that the earliest types were cast in sand, and followed later by plaster moulds; but whatever process of casting was then employed, their form corresponds with those now in use—lead, iron, copper, tin, steel, and brass being all employed in their production at that time.

The earliest printers cast their own types, but the modern type-founder has usurped that part of the business. To make a type in the ordinary way, the letter is first cut on the end of a soft steel punch and then hardened, after which the impression is obtained on a piece of polished copper. This impression is the matrix, on which the face of the type is cast after it has been enclosed within a metal mould. The metal is poured into the mould by the workman, who gives it a quick jerk, after it has been filled, to solidify it.

The above is the hand-mould method practised until about 1838, when a type-casting machine was invented by

David Bruce of New York, followed by many others of a similar description, most of which kept the metal fluid by gas-jets, and forced it into the moulds with a pump, making an average of 100 types per minute. Johnson's English patent consists of a furnace covered by a shallow pot of fused metal, in which the pump and mould are placed, opposite its nozzle. After adjustment the metal is injected and solidifies, forming a type, with jet or gate attached. This letter is thrust out, and the mould closes for another cast, all of which takes place at one revolution of the axis. As they are thus cast and delivered, the letters are guided to the dressing-machine, and by a subsequent series of automatically performed operations they are finally delivered ready for the printer. See TYPE-METAL; STEREOTYPE.

Type-metal.—Lead is the principal ingredient of type-metal, with varying proportions of antimony, ranging from 17 to 20 per cent of the latter, with small proportions of other metals to harden it, as tin, bismuth, nickel, and copper. Ductility, hardness, and toughness being the prime requisites of a type-metal, these alloys must vary according to the quality and nature of the work for which they are intended.

A less proportion of antimony is used for large than for small type. Small type must be harder, to resist the wear and make it rigid.

In 1855 Besley's patent type-metal came into use, consisting of lead 100, antimony 30, tin 20, copper 8, bismuth 2, nickel 8.

The common type-metal compound for mixtures consists of lead 80, antimony 20, with from 5 to 6 of bismuth.

Lead 3, antimony 1 makes the hard alloy for the smallest type; if required softer, add one part more to the lead.

Medium-sized types require lead 5, antimony 1. Large types, lead 6, antimony 1; or lead 7, antimony 1 for a softer grade.

Stereotype plates, 4 to 8 of lead to 1 of antimony, according to hardness required.

About five per cent of tin may be used on the small type, or a small proportion of copper.

The antimony is very serviceable in type-founding: being a metal that expands in cooling, it counteracts the high shrinkage of the lead, and thus preserves the original size of the cast—a very important feature in stereotype-casting. See Type-founding.

U.

Uchatius Bronze.—See Telegraph-wire.

Uchatius Steel.—This steel is produced from iron which has been granulated by plunging into water and then melted along with brown hematite ores, etc.

Umber.—A variety of hematite ore, composed of oxide of iron 48, oxide of manganese 20, silex 13, alumina 5, water 14. It is found in Cyprus; occurs massive; has no lustre; is brown and yellow in color; becomes a reddish brown when burnt, and in that state is used as an artist's color.

Undercut.—A pattern or model is said to be undercut when its lower dimensions are largest—exactly opposite to taper or draught. Such patterns may in some cases be rammed within a flask and withdrawn after reversing the whole, or the projecting parts may be made loose on the main block and drawn inward after the latter has been taken out. Another method is to proceed contrary to the usual custom and draw the mould from the pattern in as many sections or *drawbacks* as will allow the pattern to be lifted away from the remainder. See STATUE-FOUNDING; TAPER; DRAWBACK; FALSE CORE.

Universal Rolling-mill.—A compound rolling-mill consists of a pair of vertical rolls working in combination with another pair of horizontal ones, which act to compress the pile edgeways and flatways at once.

Unsoundness of Steel.—See SILICON; HONEYCOMBING; STEEL CASTINGS; PRESSING FLUID STEEL.

Upright Runner.—See GATE-PIN.

Uranium.—A metal found in a few minerals, as *pitchblende,* which is an oxide, and *uranite,* which is a phosphate. The former is its principal ore. The metal, according to the process by which it is obtained, is either in fused white malleable globules or in a black powder. It is used for imparting a yellow tint to glass. See METALS.

V.

Vacuum denotes a space empty or devoid of all matter. When air is removed from a vessel with an air-pump a vacuum is said to be produced. Sometimes a vacuum occurs from natural causes, but it is only for an instant, as the surrounding air rushes in to fill them. The most perfect vacuum until recently was the space above the mercury in a barometric tube. See TEMPERATURE.

Vapor.—Heat converts liquids into vapors, and the process is called *vaporization.* Heat applied to a solid first expands it, then melts it, and finally turns it into vapor. When vapor is formed sensible heat is absorbed and cold is produced. Hence when the skin is moistened with a volatile liquid (one that passes readily into vapor), like alcohol, a sensation of cold is produced; the heat has been consumed.

Varnishes.—The solutions of the various resins in alcohol, the drying-oils, or the essential oils. *Transparent varnish for patterns:* Alcohol 1 gallon, best shellac 2½ pounds; to be kept *warm,* not hot nor cold. *Common oil-varnish:* Resin 4 pounds, beeswax ½ pound, boiled oil 1 gallon; mix when warm; then add spirits of turpentine 2 quarts. *Mastic varnish:* Mastic 1 pound, white wax 1 ounce, spirits of turpentine 1 gallon; reduce the gums small, then digest with heat in a closed vessel till dissolved. *Turpentine-varnish:* Resin 1 pound, boiled oil 1 pound; melt; then add turpentine 2 lbs.; mix well. *Gold-varnish:* Digest shellac 16, sandarac, mastic, of each 3, crocus 1, gamboge 2, all bruised, with alcohol 144. *Chinese quick-drying:* Sandarac 2 ounces, mastic 2 ounces, alcohol 1 pint. *Copal varnish:* Pale hard copal 2 pounds; fuse; boil with one pint drying-oil and thin with turpentine. See Black Varnish; etc.

Vegetable Casts in Metal.—See Insect Casts in Metal.

Vegetable Wax.—This wax is found as exudations on leaves and fruits, where they form a *glaucous* surface, which repels water. The bayberry, for instance, is thickly coated with it.

Veins.—See Ores.

Venting.—The word "venting," as understood in foundry nomenclature, is a significant one, and means any or all of the various schemes which are being daily invented and practised to safely dispose of the gases produced in the moulds and cores, when brought in contact with the molten metal. It is unquestionably the most important phase of the moulder's art, and would likewise be the most interesting if the workmen fully understood all its niceties from the standpoint of the chemist. So far this advantage has been denied the average moulder, and there is every indication that he must for some time longer keep moulding castings the manipulation of which involves processes which are common only in the laboratory of the chemist. How he acquits himself of the task is an unsolved problem to every one at all conversant with the work.

All moulds and cores contain various proportions of organic and volatile matters, consisting of portions of roots, horse-dung, coal, straw, etc., all of which when decomposed by the hot metal generate inflammable gases; in addition to which must be added steam from the moist sand, which when decomposed gives rise to hydrogen, while its oxygen combines with whatever carbon may be present in the material to form carbonic oxides. These inflammable gases when mixed with atmospheric air produce a dangerously explosive compound, and it is in dealing with this objectionable substance that the moulder's judgment and skill are frequently taxed to the utmost in order to avoid the terrific explosions which would be sure to follow, in some instances, if it should be ignited prematurely.

The methods employed for venting are various—from the simple operation of making a small hole through the centre of an inch core, or perforating the sand in the top and bottom parts of a bench-flask, to the more complicated systems necessary for the successful production of high-grade castings. Nevertheless they all aim at the one object, viz., to convey the gas safely away as soon as it generates in the sand, and thus prevent it from forcing its way into the interior of the mould by breaking down such portions as are not of sufficient strength to resist the pressure. It is largely due to imperfect venting when the mould surface is destroyed in this manner, and what are technically called "scabs," "blisters," "blowheads," etc., may also be traced to this source, which in extreme cases may result in total disruption of the mould by explosion.

Very much of the venting practised on ordinary green-sand work might, however, be dispensed with if those interested in the business were better informed with regard to the sand employed for moulding purposes. The worth of sands for foundry use are almost entirely dependent on their possessing certain chemical and physical properties; by the chemist's aid it is reasonable to anticipate a time in the near future when many of the evils we now attempt to obviate by increased venting will be more effectually remedied by a change in the materials employed.

While we admit that careful venting is a prime requisite in some cases, it is a fact beyond question that very much valuable time is wasted in venting some moulds which, if intelligently rammed with suitable material, would be

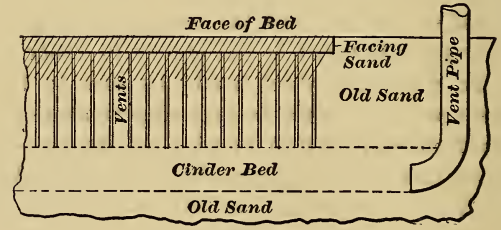

Fig. 1

equally good, or perhaps better, without a vent. Some moulders mix sea-coal with sand, believing that it imparts a quality thereto which makes venting unnecessary; whereas the sea-coal only serves to separate the clayey portions of sand, and introduces particles of refractory carbon, which prevent in some measure the partial fusing of the sand—to be noticed on castings that have been made in new sand. The coal burns and emits its smoke, forming a film of gas betwixt the sand and the metal; but this gas, like the rest, must be conveyed away as fast as it generates, otherwise it will seek an entrance to the mould, with the result above described.

To ascertain the effect of coal upon sand, and obtain a true estimate of the materials employed for making mould surfaces, prepare two open sand-plates on the floor, about 3 feet square and $\frac{1}{2}$ inch thick, one bed to be made with ordinary coal facing-sand, the other in floor-sand free from coal; both to be equal in density and moisture, but neither one vented. The free-sand mould will permit the metal to spread uninterruptedly over its surface, because there is comparatively no gas-producing substances in the sand used for forming it. How different in the other case! The instant you begin to pour, gas is generated from the coal-sand surface, which cannot make its escape outwards because there are no vents provided: it must therefore force its way inwards; the result being that the whole surface of molten metal is converted into a mass of eruptive jets, which continue to bubble forth the imprisoned gases as long as the metal remains fluid. The solidified plate will show a honeycombed surface all over, and be worthless as a casting. If such a plate be prepared 2 inches thick instead of $\frac{1}{2}$ inch, the metal will remain in a fluid condition for a longer space of time, and the quantity of gas generated will be augmented correspondingly; this naturally adds force to the gas, which in its effort to escape will carry along with it the sand crust, throwing it upwards through the metal with considerable force until the violent action is arrested by solidification of the mass.

The water contained in green-sand mould surfaces is at once converted to steam when the molten metal covers them; if this steam is not adequately drained off by venting, the result will be similar to that described for coal. Ordinarily this steam is pressed backwards into the porous mass of sand behind, but when this sand must necessarily be rammed so hard as to make it impossible for the steam to circulate through it, then recourse must be had to venting. Masses of green-sand almost entirely surrounded with metal require the most accurate venting, as there is no possibility of the steam and gas circulating; it must pass through a limited space, and special means are provided for guiding it out at that aperture, wherever it may be located.

All green-sand surfaces—which for obvious reasons must be made very hard—require special treatment; such, for instance, as the bottom of bed-plates, lathe and planer beds, and all similar moulds. For work of this class the ordinary wire venting must be supplemented by the use of a

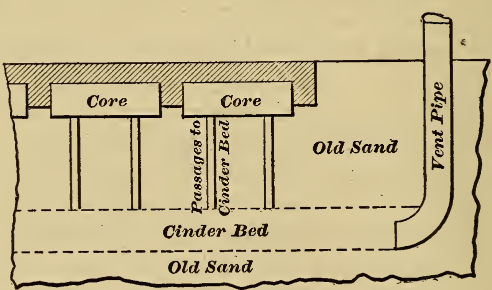

Fig. 2

cinder-bed, which acts as a general receiver of all the gases generated on the outside walls and bottom surfaces of the mould, and for the inside too in some instances. This consists of digging down from 12 to 16 inches below the bottom surface of the pattern and placing a layer of coarse cinders down on the bottom from 6 to 8 inches deep, the interstices to be filled with finer ones. Over this a thin layer of hay or straw serves to prevent the sand from entering. Pipes must be set at convenient places, to which the cinder-bed is connected, and through which the collected gases will escape to the surface. Over this a layer of old sand is firmly rammed to within one inch of the intended surface, when the whole is vented with a ⅜-inch wire down through the sand to the cinders; after which the facing-sand is spread over in sufficient quantity to admit of treading or ramming down enough to leave the surface somewhat above the straight-edges by which the bed is formed. Before striking off the superfluous sand, it is requisite in some particular cases to supplement the previous venting with the large wire to the cinders by another course of very fine vents, giving them a little slant in order to make sure of striking the large vents. The large vents may be 2 inches apart, but the smaller ones should be much closer. By using an extremely fine wire in the latter venting, there will be no open vents by the time the bed has been strickled off and made smooth. Fig. 1 illustrates the processes herein explained.

Cinder-beds offer many inducements for their more general adoption, as by this means all venting required on the sides and elsewhere may be effectually done by either pushing a wire down to the cinders or ramming up rods from thence. This enables the moulder to make his mould free of vent-holes at the joint—"a consummation most devoutly to be wished," as every intelligent moulder knows. While it is freely admitted that gas will rise easier than it will descend, there is no question about the efficiency of down venting when the passageways are kept clear.

All large areas, especially such as must receive cores, etc., over which the metal will rest, can be easily and most effectually vented by means of the cinder-bed when any of the other methods usually employed might render the operation more than doubtful. See Fig. 2.

Deep green-sand work, such as tanks, cisterns, etc., round or square, offer very few difficulties when the cinder-bed is employed as a basis for venting. If such castings be plain, and are moulded bottom up, the open

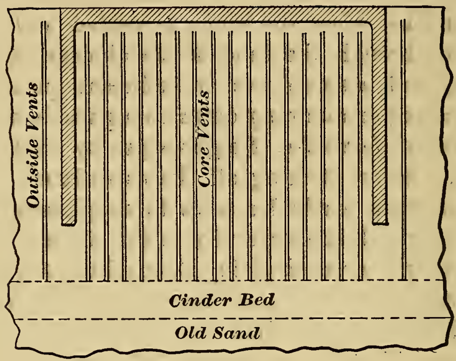

Fig. 3

bed below will readily receive the vents from the wire direct; but should there be branches or other attachments, which make it necessary to lift out the core, an intermediate layer of cinders inside the core will intercept the vent, and a convenient hole in the lifting-plate serves to convey the gas downward to the original bed. See Figs. 3 and 4.

There are, however, a large number of moulds that can be very readily vented by the wire alone. Thin flat work is particularly adapted for direct wire-venting. A shallow channel cut in the joint some distance from the pattern serves as a starting-point for the wire, which when bent a little may be thrust in under the pattern (see Fig. 5); or, should the pattern be more complicated, as a beam or lintel, the sand below the casting may be perforated by means of a bent wire thrust in from the outside, after the ramming has reached some distance from the bottom, and these again pierced by vertical vents from the joint. It only remains to vent down the lower vents through the core and a somewhat imperfect communication is made.

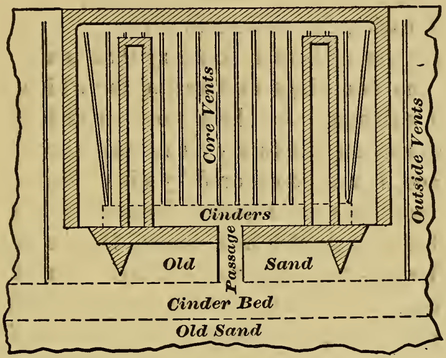

Fig. 4

The success of this method depends largely on the sand under and around the pattern being evenly tempered, and sufficiently porous to permit the gases to circulate freely. See Fig. 6.

The value of working green-sands with the least possible amount of water is forcibly demonstrated by the following illustrations: When making cast-iron flasks with an upper and lower web on the sides, it invariably happens that more or less repairing needs to be done at the edges after the pattern has been drawn out of the sand. Should it happen that a careless or ignorant moulder attempts this, he will try to facilitate the operation by a plentiful application of water, the steam generated from which, when the metal rises to that part, no ordinary venting is able to carry away. Now there are very few moulders of any experience whatever who have not seen more than one flask utterly spoiled on this account, and yet they insist upon a free use of water, for the same reason, on other important moulds, evidently persuading themselves that because it is hidden under a flask no such harm can ensue. It most assuredly does; and only the added pressure in the covered moulds prevents a complete disaster always, but even that fails in eradicating the scabs and dirt.

The writer remembers a foundry that made a specialty of pistons, the two rings and spring for which were made as separate castings. As these were turned all over, and ought to present an absolutely clean face throughout their entire surface, it was considered by all to be a critical job, and many castings were rejected because of the pin-holes and dirt which, no matter how careful the moulding, would be revealed when the skin was broken. One man in the shop, by some considered a crank, kept reminding them that they were using too much water and coal-facing, and that as long as they did this they would never make a permanent success of the job. How he was answered by the indignant failures around him need not be related here. The foreman, fearing that this crank's boast of being able to make them clean might reach the ears of his superiors, thought to silence him forever by giving him one of the largest springs to make, fully expecting that he would fail in making good his boast, and intending to use that as a means for ridding himself of an intolerable nuisance. In this, however, he was deceived. The crank dug his hole deep and wide, and filled it to within a few inches of the pattern with dry old sand from the scrap-pile, after which he prepared his facing-sand, which consisted of finely sifted old sand just moist enough to bind together. With the exception of that portion immediate to the runner, the whole was faced with the dry mixture, and as the gate which he used was a very fine drop-gate, very little of the coal-facing sufficed. With a sharp, fine vent-wire he pricked through the cope to the pattern, and with a larger one round and under it. After finishing clean with absolutely no water, he returned the cope and made his runner-basin, which held almost all the iron required for the casting. He flooded this basin instantly with the hottest iron procurable, in a manner which made it impossible for any dirt to enter the small gate he had made. In went the iron at its leisure, and out through every little hole rushed the hot air and gas, until the mould filled, when the iron spurted upward in a hundred tiny sprays. Result: The first large spring ever made at that place without a flaw. It is needless to say that the crank remained. Fig. 7 illustrates the crank's mode of procedure.

There can be no question that copes need venting to permit the escape of steam and gas; otherwise, if not led upward, they may force an entrance into the mould below, carrying a crust of sand along. The holes should be small. Large holes act too much like open risers, and rob the mould of that steady pressure so desirable to maintain for the support of other surfaces besides the cope. When copes that have been vented buckle, the true cause will be found in the sand.

It is criminal to suppose that a core or piece of mould, because it is far removed from the upper surface, may be left unvented, and trust to the pressure above preventing future trouble from that source. If the certain commotion created at that precise part by such neglect be not immediately apparent, it is probable that more or less of this gas which has entered the mould, instead of passing outside by a suitably provided vent, is held imprisoned in some part of the casting, and is likely at some time or other to reveal itself unpleasantly.

One reason why large surfaces in open-sand moulds can, as a rule, be made without any other venting than a moderately soft bed affords, arises from the fact that most castings, including foundry-plates made after this manner, are not required to be very correct, a slight swell or scab not materially affecting their usefulness. Nearly all beds for open-sand castings can be made moderately soft, as before stated, and without any admixture of coal. The latter condition limits the gas present to whatever gas-producing elements are contained in the old sand, which is very little; the former condition is favorable to a free absorption of the little that is made.

It must be remembered also that such beds are not called upon to resist the same amount of pressure that is common in covered work. A plate 2 inches thick in open sand exerts a pressure downward equal to $\frac{1}{2}$ pound per square inch; the same plate covered, with head-pressure of 2 feet, would be $6\frac{1}{2}$ pounds per square inch.

Relieving moulds of expanded atmospheric air and accumulated gases is sometimes as difficult an operation as any that are connected with venting the sands and loam used for making them. Leaving risers open in order to free the moulds of these accumulations is not to be thought

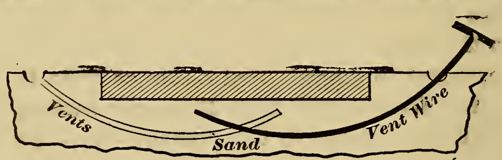

Fig. 5

of where the materials are in any sense deficient; and some adequate means must otherwise be provided for the expulsion of these offending gases. One manner of accomplishing this is to make large basin riser-heads at the highest point of the mould, fill the basin with soft hay well pressed down, and place thereon a riddle, with weights to keep it there; or make good-sized plug-risers, and place over each a piece of fine wire-cloth, securing it in such a manner as that nothing shall pass out except through the netting. By either of these means the mould is effectually relieved without any of the roar and friction which usually attend open pouring when the riser area is limited.

When large volumes of gas must necessarily be relieved by a very limited passageway, either from cores or moulds, extra precautions should be taken, and one great help is to make sure that the atmosphere in the immediate neighborhood of the vent be as hot as possible. A considerable body of molten iron poured down under the mouth of the vent is better than lighted shavings, as it insures a steady heat which precludes the possibility of cold air interfering with the easy egress of the outcoming gas.

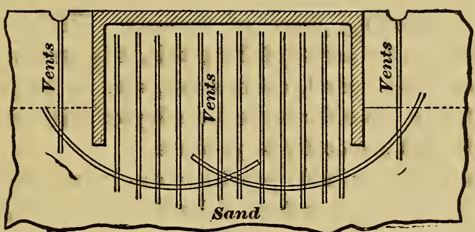

Fig. 6

When the gas from one core must necessarily pass through another core to reach its place of exit there should be no hesitation about making such connections as will convert the two cores into one practically. This may be easily accomplished by making pipe-connections, and, whether the final exit be through the side, top, or bottom, if the mould be an important one, the pipe method of securing vents should be strictly adhered to. See Fig. 8.

Not unfrequently large core-barrels in horizontal moulds will explode with disastrous effect during the process of casting. This is an instance where the dangerous accumulations spoken of at the outset are made possible within the hollow barrel. There are several ways of preventing these explosions: a few shavings scattered along the bottom and ignited when pouring commences serve to burn off the gases as they exude; but if by any means the light should cease suddenly before the casting is well poured, the danger is not removed. Where practicable, it is advisable to fill the barrel with straw or shavings, and thus exclude the atmosphere, or place a netting of wire-cloth at each end that will exactly fill the space: this acts like a Davy-lamp, prevents the flame from entering the barrel, and allows the gas to burn harmlessly away at each end.

Large round or flat bottomed tanks and compound cylinders cast with their open ends down, making it necessary to convey the gas from the bottom of the mould, furnish an interesting phase of venting. While there are many methods for accomplishing this, it is certain that filling the core with sand, coke, straw, etc., is by all means the safest, and should always be adopted with castings of magnitude that are costly to produce.

By this means suitable provision can be made for carrying off what little gas is formed by the brick core, etc., and all danger from admixture with atmospheric air successfully avoided.

For ordinary pan-castings, however, much quicker methods must be devised, even if some risks are taken. It is therefore no uncommon thing to see such castings made without any particular attention to the vent other than to cut a single gutter from the middle, underneath, and connect with a pipe which leads it to the floor-level. An explosion once in a while prompts the moulder to observe greater care, but it is for a short time only. A bad feature at some foundries is to place large quantities of shavings and wood in the interior, and set them on fire before casting commences: this creates an instant expansion of the core, and very often loosens the loam from the bricks. A little iron run down a sloping gutter to the middle will heat the atmosphere within to create a draught which, if there be two opposite pipes, will convey the gas harmlessly away. By leading a good-sized pipe up to the surface, and covering it with wire-cloth, all communication with the inside is shut off, and the gas may be lighted as any ordinary vent. The same result is obtained when the gutter leading from the middle is filled with cinders or straw. A dumb-vent is a channel constructed from the pit through the wall of the foundry, or to some part within that is remote from the possibility of sparks igniting the gas, and thus causing an explosion.

A remarkable incident occurred at a foundry in England, where the writer was engaged moulding a large purifier in loam. The foreman, a self-willed fellow, with little knowledge or experience in that class of work, strenuously opposed any special measures being taken for carrying off the vent, and the mould, rammed within iron curbs which rested on the plate lugs outside the slings, was duly prepared for casting, leaving the vent-hole to take care of itself down at the bottom between the pit-wall and the curbs. As I had a decided objection to pouring a piece so

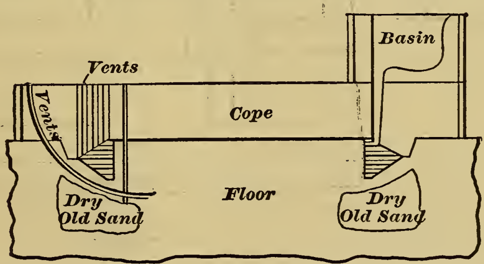

Fig. 7

inadequately vented, the foreman took the ladle and poured it with great pomp, exclaiming, as he passed on his way to the cupola, "I told you so!" The words had hardly escaped his lips when a most terrific explosion occurred. The mould and fastenings, being contained within the curbs, were lifted entirely from the floor and fell back again in a leaning position, scattering the runner in all directions. But, strange to relate, the casting was com-

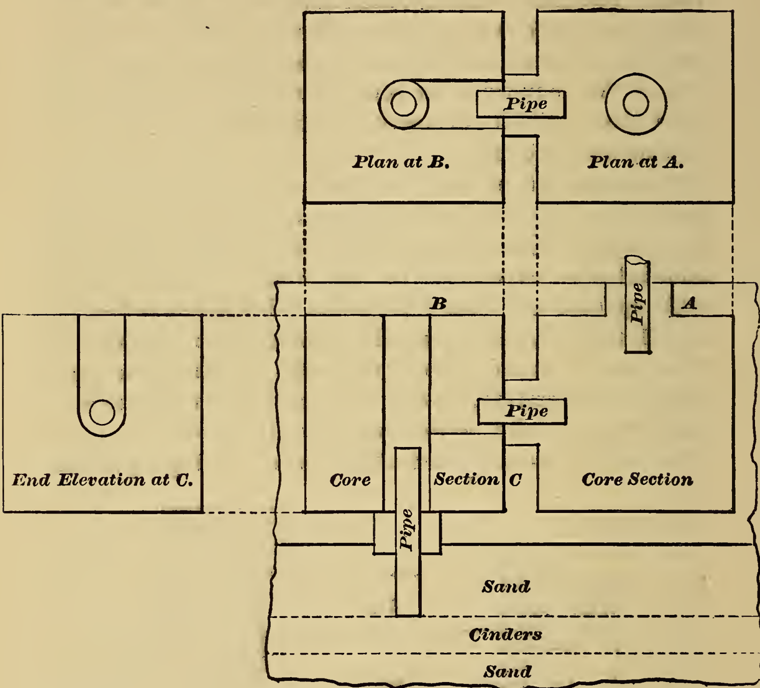

Fig. 8

paratively uninjured, the fine gates having congealed in the interval. The foreman was very much surprised.

When shallow pans are cast in casings or moulds supported above the floor level no special venting is required, as the free circulation of air prevents any accumulation of gases. A few shavings will serve to light at once the vents of deeper close-moulds cast after this manner, and the gas will burn away freely in the air.

Brick walls of loam-work are best vented by choosing such material for the loam as will be sufficiently porous when dry to permit a free circulation of the gases outwards, and this is why as much care should be practised in making the building-loam porous as there is for the facing-loam; otherwise, the gas must enter the mould and be forcibly ejected at the riser and runners. This is why there is such a rush of air at the moment vertically cast moulds are filled where no attention is given to this particular. All connections, such as branches, flanges, brackets, etc., should be vented direct with wires or straws, and these be carefully connected with the upright vents, which should in all cases be set at intervals around the mould when it is rammed in the pit. Gases generated in loam covering-plates may either pass through holes in the plate or be led to the edge by layers of straw set down at the bottom of the prickers before it is covered with loam. Core covering-plates for cylinders, condensers, cisterns, etc., are vented by means of holes cast therein to lead the gases inside the core. Flat brick surfaces need only to be openly built and the spaces filled with fine cinders, connecting them with whatever means for outlet may be provided.

Dry-sand moulds, if they are made in suitable materials and well dried, require little or no venting, except in confined parts that are remote from the ordinary means of exit for escaping gas. Projections of sand that are almost surrounded with metal, and such portions of the mould as are least likely to be dry, need some special venting—the former for the escape of gases, the latter for steam. If the ordinary coal-facing is used to make dry-sand moulds, then the venting needs to be in every respect as particular as for green-sand. But if the facing be simply a refractory sharp sand with just sufficient clay and flour to make it cohesive, venting, as before stated, may be almost dispensed with.

Venting-cores might be very much simplified if the sands used for making them were chosen with the view of meeting the necessities of every case; but too frequently they are chosen at haphazard, and every core is made from the same pile of sand, no matter what it may be required for. Cores that are difficult to vent on account of their diminutiveness may sometimes be used successfully without vents if they are made from washed sand stiffened with a little glue-water. The reason for this is that the gas-producing substances are eradicated from the sand by washing, and the small quantity of glue required to make it cohesive is too slight to seriously affect it.

While cores, generally speaking, may be considered as a kind of dry-sand mould, there must be every attention given to core-venting, as in the majority of cases they are surrounded with the molten metal, which drives the gases to the centre from all directions, and if instant egress is not given to this constant flow, the core is shattered and an eruption occurs within the mould.

Vent-wire.—The wire with which a moulder pierces sand, in order to form passageways for the escape of gases. Large ones should be made fast to a crutch-handle, and the entering end for an inch high increased about $\frac{1}{16}$ inch in diameter and pointed. The point then pierces the sand easily, and forms a passage slightly larger than the wire; which follows with little effort, there being comparatively no friction. Smaller wires will enter very freely if the end be simply cut off square across and perceptibly enlarged by a slight jumping. See VENTING.

Verdigris.—A very poisonous diacetate of copper, which forms in a green crust on its surface if exposed to a damp atmosphere. It is useful in the arts as a pigment. See COPPER.

Vermilion, or *mercuric sulphide,* occurs native as cinnabar, a dull red mineral, which is the most important ore of mercury; bright red in color; has a good body, and is useful as a pigment for paints. See MERCURY.

Vertical Casting.—See ORDNANCE; CAST-IRON PIPES; HORIZONTAL CASTING.

Vinegar Bronze.—This is for brass goods, and consists of vinegar 10 galls., blue vitriol 3 lbs., muriatic acid 3 lbs., corrosive sublimate 4 grains, sal-ammoniac 2 lbs., alum 8 ozs. See BRONZE.

Vitreous.—Resembling glass; pertaining to or consisting of glass. See GLASSY; SLAG.

Vitrifiable.—Capable of being converted into glass by heat and fusion. See FLUX; SLAG.

Vitriol.—See SULPHURIC ACID.

Volatile.—A body is termed volatile when it is capable of evaporating, or passing easily into an aëriform state, as alcohol, ether, etc. See VAPOR; ALCOHOL.

Vulcanite, or *ebonite,* is caoutchouc mixed with half its weight of sulphur and hardened by pressure and heating. It is very hard, takes a high polish, and is used extensively for the manufacture of buttons, knife-handles, and combs. See INDIA-RUBBER.

W.

Wages Table.

CALCULATED ON A SCALE OF TEN HOURS' LABOR PER DAY; THE TIME, IN HOURS AND DAYS, IS NOTED IN THE LEFT-HAND COLUMN, AND THE AMOUNT OF WAGES UNDER THE RESPECTIVE HEADINGS AS NOTED BELOW.

Hours.	$1.00	$1.50	$2 00	$2.50	$3.00	$3.50	$4.00	$4.50	$5.00	$5.50	$6.00
½	.01	.01¼	.01⅔	.2	.02½	.03	.03½	.03¾	.04½	.04½	.05
1	.01⅔	.02½	.03⅓	.4⅙	.05	.06	.06⅔	.07½	.08⅓	.09⅙	.10
2	.03⅓	.05	.06⅔	.8⅓	.10	.11⅔	.13⅓	.15	.16⅔	.18⅓	.20
3	.05	.07½	.10	.12½	.15	.17½	.20	.22½	.25	.27½	.30
4	.06⅔	.10	.13½	.16⅔	.20	.23⅓	.26⅔	.30	.33⅓	.36⅔	.40
5	.08⅓	.12½	.16⅔	.21	.25	.29⅙	.33⅓	.37½	.41⅔	.46	.50
6	.10	.15	.20	.25	.30	.35	.40	.45	.50	.55	.60
7	.11⅔	.17½	.23⅓	.29½	.35	.41	.46⅔	.52½	.58⅓	.64⅙	.70
8	.13⅓	.20	.26⅔	.33⅓	.40	.46⅔	.53⅓	.60	.66⅔	.73⅓	.80
9	.15	.22½	.30	.37½	.45	.52½	.60	.67½	.75	.82½	.90
Days.											
1	.16⅔	.25	.33⅓	.41⅔	.50	.58⅓	.66⅔	.75	.83⅓	.91⅔	1.00
2	.33⅓	.50	.66⅔	.83⅓	1.00	1.16⅔	1.33⅓	1.50	1.66⅔	1.83⅓	2.00
3	.50	.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00
4	.66⅔	1.00	1.33⅓	1.66⅔	2.00	2.33⅓	2.66⅔	3.00	3.33⅓	3.66⅔	4.00
5	.83⅓	1.25	1.66⅔	2.08⅓	2.50	2.91⅔	3.33⅓	3.75	4.16⅔	4.58⅓	5.00
6	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00	5.50	6.00

Hours.	$6.50	$7.00	$7.50	$8.00	$9.00	$10.00	$11.00	$12.00	$13.00	$14.00	$15.00
½	.05½	.06	.06¼	.06⅔	.07½	.08⅓	.09	.10	.11	.12	.12½
1	.11	.11⅔	.12½	.13⅓	.15	.16⅔	.18⅓	.20	.22	.23½	.25
2	.21⅔	.23⅓	.25	.26⅔	.30	.33⅓	.36⅔	.40	.43⅓	.46⅔	.50
3	.32½	.35	.37½	.40	.45	.50	.55	.60	.65	.70	.75
4	.43⅓	.46⅔	.50	.53⅓	.60	.66⅔	.73⅓	.80	.86⅔	.93⅓	1 00
5	.54⅙	.58⅓	.62½	.66⅔	.75	.83⅓	.91⅔	1.00	1.08⅓	1.16⅔	1.25
6	.65	.70	.75	.80	.90	1.00	1.10	1.20	1.30	1.40	1.50
7	.76	.81⅔	.87½	.93⅓	1.05	1.16⅔	1.28⅓	1.40	1.52	1.63⅓	1.75
8	.86⅔	.93⅓	1.00	1.06⅔	1.20	1.33⅓	1.46⅔	1.60	1.73⅓	1.86⅔	2.00
9	.97½	1.05	1.12½	1.20	1.35	1.50	1.65	1.80	1.95	2.10	2.25
Days.											
1	1.08⅓	1.16⅔	1.25	1.33⅓	1.50	1.66⅔	1.83⅓	2.00	2.17	2.33⅓	2.50
2	2.16⅔	2 33⅓	2.50	2.66⅔	3.00	3.33⅓	3.66⅔	4 00	4.34	4.66⅔	5.00
3	3.25	3.50	3.75	4.00	4.50	5.00	5 50	6.00	6.51	6.99⅔	7.50
4	4.33⅓	4.66⅔	5.00	5.33⅓	6.00	6.66⅔	7.33⅓	8.00	8.68	9.33	10.00
5	5.41⅔	5.83⅓	6.25	6.66⅔	7.00	8.33⅓	9.16⅔	10.00	10.85	11.66⅓	12.50
6	6.50	7.00	7.50	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00

If the desired number of days or amount of wages is not in the table, double or treble any suitable number of days or amount of money, as the case may be, until you obtain the desired number of days and the wages to correspond.

Walker's Converter.—This converter differs from the Bessemer and others in having a straight neck, so that it can be charged or poured from either side. This equalizes the wear on the lining. See BESSEMER STEEL.

Wall-cranes are a very handy and important addition to the foundry or the forge. They can be arranged so that the large jib or traveller will pass over them in the performance of the heaviest work, leaving the moulders engaged on the light and medium classes of moulding to continue their operations uninterruptedly. See CRANES.

Warping of Castings.—See STRAIGHTENING CASTINGS.

Wash for Cores.—See CORE-WASH.

Washing.—When a loam-moulder moistens the hardened surface of his mould with water, preparatory to chinsing and finishing with the tools, the process is termed *washing*. If some portion of a mould is carried away by a current of metal running violently over it, it is said to be *washed* off. See FOUNTAIN RUNNER.

Waste Gases.—The most efficient mode of utilizing the waste heat from puddling and other furnaces is the regenerative-gas furnace, where it is applied to raise both the gas fuel and the air for burning it to a high temperature previous to their meeting at the point of combustion. See REGENERATIVE FURNACE.

Waster.—A bad casting, so called, in some localities.

Waste-wax Process.—Making statuary, figures, etc., by melting out a wax model of the object, which has been previously encased in loam or composition, and filling the space with molten metal. See CIRE PERDUE; STATUE-FOUNDING.

Water is a compound of 8 parts by weight of oxygen with one of hydrogen; by bulk it is 1 of oxygen to 2 of hydrogen, and is present in nature in three forms—solid, liquid, and gaseous. It is transparent, tasteless, and inodorous. It evaporates at all temperatures, boils at 212°, and freezes at 32°. At 60° a cubic inch of pure water weighs 252.45 grains—exactly 815 times the weight of an equal bulk of air. The American standard gallon weighs 58,970 grains of pure distilled water at the maximum density of 484. The weight of an imperial gallon is 70,000 grains, or 10 pounds.

A cubic foot of water is taken at 1000 ounces, and 62.5 pounds for convenience in reckoning; but the actual weight is 998.068 ounces, or 62.37925 pounds avoirdupois.

Water expands $\frac{1}{1124}$ of its bulk in freezing.

The height of a column of water at 60°, equivalent to the pressure of 1 pound per square inch, is 2.30 feet, and the height of atmosphere is 33.94 feet. The number of cubic feet in a ton of water is 35.84, and a cubic foot of sea-water weighs 64.31 pounds. See HYDROGEN.

Water-bellows.—A blast-machine consisting of two cisterns partly filled with water, in which are placed the induction and eduction pipes, both standing a little above the water. Inverted chambers suspended on the ends of a working-beam inclose the pipes within the cisterns, and as each chamber is made to rise alternately the air is drawn up through the induction-pipe into the chamber, and expelled at the eduction-pipe by means of suitable valves; the valve being at the top for induction, at the bottom for eduction.

Water-boshes.—Hollow cast-iron boshes or chambers, through which a constant supply of water is made to circulate, to prevent overheating and consequent fusion. See FINERY FURNACE; TYMP.

Water-core Barrel.—See ORDNANCE.

Waterfall Blower.—See TROMP.

Water-gas is gas produced by passing steam over red-hot coke, which changes it to carbonic oxide and hydrogen, in which state it is made to absorb as much carbon as is necessary, by passing through a retort in which rosin is being subjected to the process of decomposition. See GAS.

Water-glass is usually prepared by boiling silica with caustic alkali under pressure. It is soluble only in boiling water, and has the appearance of glass when pure and solid. See SOLUBLE GLASS.

Water-jacketed Cupola.—The Keims cupola is jacketed, and is described by the inventor as follows: In this new cupola there is no burning out at or about the tuyeres; there are no clinkers to be chipped off daily, and repairs to be made before another heat can be run; and the bottom need not be dropped for months, if you so desire. To accomplish these results the inventor uses a three-foot water-jacket, with the tuyeres placed as near the bottom of the jacket as possible; the blast being upward, and the jacket not allowing anything to adhere to it, prevents burning out or clinking. The lower portion is part and parcel of the jacket (but not water-jacketed), and is lined with fire-brick, so as to retain the heat in the metal well and to prevent chilling. This improved bottom and jacket may be used in connection with the old cupolas now in use by simply taking off enough of the bottom of the old in which to insert the new, thus avoiding any great expense in making the change. As there is no hanging or clogging in this cupola, the blast has perfect circulation throughout the entire mass that is to be melted, and so is a great fuel-saver, as every particle of fuel is used to the best advantage. As the heat of the jacket cannot be raised above 240° Fahrenheit, it will readily be seen that there will be no burning out, and that with ordinary care a jacket will last as long as a steel boiler; for the whole arrangement is made of ¼-inch steel plate, and as the overflow is higher than the jacket, it would be only through gross negligence if it should burn. In fact, the jacket would be the coldest point as long as any water remained. The metal produced is of the best quality, and has a ring almost equal to bell-metal.

Water-pipes.—See CAST-IRON PIPES.

Water-proof Cement.—See CEMENT.

Water-proof Glue.—Melt common glue with the smallest quantity of water possible; add by degrees drying or boiled linseed oil. The ingredients must be well stirred while the oil is being added. See GLUE; CEMENT.

Water-proof Polish.—Alcohol 1 pint, gum-benzoin 2 oz., gum-sandarach ¼ oz., gum-anime ¼ oz.; put these in a stoppered bottle, and set in a hot-water or sand-bath until dissolved; then strain and add $\frac{1}{4}$ gill of best poppy-oil, and shake well together.

Water-sprinkler.—See SPRINKLING-POT.

Water-tuyere.—This class of tuyere is used at the blast-furnaces to protect the walls of the hearth from the intense heat that is generated by the hot blast in the neighborhood of the tuyeres. They are of various kinds; some being rectangular in section and made of either cast or wrought iron or bronze, while others are simply a spiral tube, used alone or cast within a solid block. This tuyere is kept cool by a circulating current of water.

Wax.—Beeswax is a secretion of the honey-bee. In its ordinary state it is yellow, but is bleached white by exposing it for some time in thin slices to the joint action of air and moisture.

Modellers' wax consists of beeswax 13, rosin 12, paraffin-wax 26, linseed-oil 4; the rosin and oil to be well boiled together before adding the other ingredients.

Sculptors' wax is composed of one part each of tallow, turpentine, and pitch to ten parts of beeswax. See VEGETABLE WAX.

Wax-modelling.—See STATUE-FOUNDING.

Weathering Ore.—Such ores of iron as contain pyrites or shale in a large proportion are subjected, before calcination, to the action of the atmosphere and moisture, by which means the sulphur is oxidized and dissolved out by the rains. Being spread on the ground in the open air the process is called *weathering*. See CALCINATION; CAST IRON; KILN.

Web-smoother.—See SLICKER.

Wedge is one of the mechanical powers which, in principle, is simply a modification of the inclined plane. This implement, simple as it is, constitutes one of the most important tools in foundry practice. It is made of wood and cast iron, but the latter kind is to be deprecated, because of its liability to snap. Wrought-iron wedges, *well taken care of*, are a good investment in any foundry.

Wedgwood-ware.—Porcelain made by the firm of Wedgwood at Burslum, Staffordshire, England. Josiah Wedgwood created the art in Britain. See POTTERY-MOULDING.

Weighing-scales.—A more active and intelligent practice in foundry operations has made weighing-scales a prime necessity on the charging-platform. Without accuracy in charging-material it is useless to expect uniformity of mixture, and the result is invariably a marked failure wherever the quantities of materials introduced are left to the furnaceman's judgment; the latter word being, in this instance, a misnomer, as the fact of being without scales evidences a lack of sound judgment. See RATIO OF FUEL TO IRON; CHARGE; CUPOLA.

Weighting Copes.—This operation consists in placing as much weight upon copes as will hold them down securely, independent of any other means, such as bolting, binding, clamping, etc., when the pressure of molten metal tends to lift or force them upwards, such pressure (per square inch) being always proportionate to the depth from the metal's surface in the runner-basin to the cope's surface below. The total pressure is the amount per square inch multiplied into the area. For example, a cope covering a plate 4 feet square is 9 inches deep, and the runner-basin adds 9 inches more, making 18 inches in all. Now, as 18 inches pressure is exerted on every inch of the plate while the metal remains liquid, it only remains to ascertain what pressure a vertical column 1 inch square and 18 inches high exerts,—*in other words, to find the weight of such a column,* and multiply it into the area,—to discover what weight is required to hold the cope down; as, 18 × .26 (*the weight of a cubic inch of cast iron*) equals 4.68 pounds pressure on each inch, which, when multiplied into the total area, 48 × 48, equals 2304 inches; which, again, multiplied by 4.68 pounds, gives 10,782 pounds as the total pressure. Hence exactly that amount of weight, including the cope's weight, would be required to balance the pressure exerted against it, unless the head of pressure be *cut off* by a system of risers, to relieve it at some antecedent point below. When the full head of pressure is imposed some *extra* weight is needed, as fins, gate-surfaces, etc., act in proportion to their area, and the possibility of shock is a contingency that will always be adequately provided for by the wise moulder. See CUT-OFF; RISERS; PRESSURE OF MOLTEN METAL; HYDRAULICS; HYDROSTATIC BELLOWS.

Weights of Castings.—To ascertain the weight of a casting in any of the various metals, obtain, first, the number of cubic inches contained in the casting, and then multiply that number by the weight of a cubic inch of the metal employed. For the weights of various metals, cubic inch and cubic foot, see WEIGHTS OF METALS.

Weights of Metals.—The following table shows the weight of a cubic inch and cubic foot of different metals; also specific gravity:

Metals.	Weight of One Cubic Inch.	Weight of One Cubic Foot.	Specific Gravity.
	Pounds.	Pounds.	
Cast iron	.263	450	7.207
Wrought iron	.281	486	7.788
Steel	.283	490	7.833
Gold, cast	.696	1,210	19.258
Silver, cast	.378	654	10.474
Copper, cast	.317	540	8.788
Tin, block	.263	455	7.291
Zinc, cast	.248	437	6.861
Brass { copper 3, zinc 1 }	.282	525	7.820
Lead, cast	.410	710	11.352
Aluminum	.092	160	2.560
Bronze { copper 10, aluminum 1 }	.272	480	7.680
Bronze { copper 10, tin 1 }	.309	535	8.560

Welding is the union produced between the surfaces of two malleable metals when they have been heated to fushion and rolled, pressed, or hammered. Few metals are susceptible to this process; but iron is the principal weldable metal. To prevent oxidation of the surfaces, when the pieces to be welded are taken from the fire they they are sometimes sprinkled with sand or some other substance, which fuses and spreads over the heated surface. Borax alone is employed for steel at times, but preference is given to certain compositions which are considered to favor a more intimate joining of the pieces. One composition for either iron or steel, or both together, is to calcine and pulverize together 100 parts iron or steel filings, 10 sal-ammoniac, 6 borax, 5 balsam of copaiba. One of the pieces is to be heated red, carefully cleaned of scale, the composition is to be spread upon it, and the other piece applied at a white heat and welded with the hammer. Another: Fuse borax with one sixteenth its weight of sal-ammoniac; cool, pulverize, and mix with an equal weight of quicklime, when it is to be sprinkled on the red-hot iron and the latter placed in the fire. A German powder is: Iron-turnings 4, borax 3, borate of iron 2, water 1. See SOLDERING; BRAZING; BURNING.

Wet-blacking is composed of water mixed with clay in varying proportions, along with one or more of the carbon-facings. See BLACK-WASH.

Wheelbarrows.—There is now an almost infinite variety of wheelbarrows, manufactured and ready to hand, including steel foundry-barrows, steel square trays, pig-iron barrows with one or two wheels, charging-barrows for blast-furnaces and gas-retorts, etc., always in stock at the foundry-supply dealers.

Wheel-moulding Machines.—See MOULDING-MACHINES.

Wheel-pits.—See CAR-WHEELS.

Whetstone.—A hone or smooth flat stone for sharpening edge-tools. See TURKEY-STONE.

Whip-hoist.—A small single block-and-tackle for quick hoisting of light loads. See CRANES.

Whirling-runner.—See SKIM-GATE.

White Alloys are all such alloys as tutenag, packfong, British-plate, German-silver, etc., which are usually compounded with the view of imitating the more costly metal—

silver. They differ in quality and price, according to their composition. Nickel is the whitening as well as the hardening metal used in these alloys, and the amount entering into their composition varies according to quality. The lower grades of nickel alloys contain about nickel 4, copper 20, zinc 16, while the better qualities may have nickel 6, copper 20, zinc 8. Such alloys are suitable for plated ware, mathematical instruments, parts of musical instruments, saddlery, etc.

The white copper of the Chinese, which bears a close resemblance to some German-silver, contains nickel 31.6, copper 40.4, zinc 25.4, iron 2.6. It may be surmised that the iron sometimes found in these white alloys has been accidentally introduced with the nickel, but when the quantity is small it is not prejudicial. Frick's silver is an imitation composed of nickel 17.48, copper 53.39, zinc 13.

When tin is used for hardening and whitening alloys, we obtain inferior white alloys, as Britannia metal, pewter, solders, etc. The best pewter is mostly composed of tin with a small percentage of copper, yet if not more than one sixth of lead be added the alloy will be white, hard, and sonorous, but without gloss. A little antimony adds both to the whiteness and the hardness of the tin alloys.

For a description of the principal white alloys now in use, see MOCK SILVER; SPECULUM METAL; GERMAN-SILVER; GERMAN WHITE COPPER; PACKFONG; IMITATION SILVER; WHITE ARGENTAN; TUTENAG; PARISIAN WHITE METAL; QUEEN'S METAL ; SPANISH TUTANIA ; GERMAN TUTANIA ; PEWTER; BRITANNIA METAL; PEWTERER'S TEMPER; SOLDERS ; BABBITT-METAL; TYPE-METAL; SHOT; POT-METAL; FUSIBLE ALLOYS.

White Argentan.—A beautiful silver imitation ; nickel 3, copper 8, zinc 35. See SILVER ; GERMAN-SILVER ; BRITANNIA METAL.

White Arsenic.—Arsenious acid, or oxide of arsenic. See ARSENIC.

White Brass.—A term used for white alloys. See WHITE ALLOYS.

White Copper.—For this mixture see WHITE ALLOYS.

White Copperas.—Copperas of sulphate of iron, found in Chili.

White-flux.—See FLUX; BLACK-FLUX.

White Iron.—See HARD CAST IRON; CAST IRON.

White Lead.—The carbonate of lead. It is produced by several methods, and extensively employed as a paint. The Dutch method, usually considered a good one, is to place thin sheets of lead rolled into scrolls into earthen pots with weak vinegar or acetic acid. These are fitted with lead covers and closely packed, and buried in spent tan-bark. The acid corrodes the metal, forming a coating of acetate of lead. The carbonic acid set free by the decomposing vegetable matter displaces the acetic acid, combines with the lead, and the carbonate is formed. The acetic acid thus released attacks more metal, which is again carbonized, and thus, with occasional charges of vinegar, the operation is continued and the lead keeps constantly changing. See LEAD.

White Metals.—See WHITE ALLOYS.

White Rubber.—White vulcanite, made by adding white pigments to the sulphur and caoutchouc during the manufacture of vulcanite. See INDIA-RUBBER.

White Sand.—The silver-sand is a white sand, and results from the disintegration of soft, pure, siliceous sandstone. Beach-sand in some localities is also a white sand, but not so pure as silver-sand, as it invariably contains more or less of other substances, besides being somewhat calcareous from the presence of carbonate of lime, rendering it inferior to silver-sand in refractoriness. See SAND; FACING-SAND; CORE-SAND.

White Tombac.—See TOMBAC.

Whitewash.—Slake the lime in boiling water, and to 3 gallons of whitewash add 1 pint of molasses and 1 pint of salt, well stirred when adding the ingredients. Good for fences and out-door buildings. An excellent fire-proof whitewash is made by adding to every 5 parts of whitewash 1 part of potash. Soak glue, $\frac{1}{4}$ pound, over night in tepid water; on the next day place it in a tin vessel with water 1 quart; boil, and stir till the glue dissolves. Next put 7 pounds Paris white (sulphate of baryta) into another vessel, add hot water, and stir until it becomes milky. Add the sizing, stir well, and apply with a kalsominer's fine brush. This is nearly equal to kalsomine made from zinc-white. See LIME; ZINC-WHITE.

Whiting.—Chalk levigated and cleaned from all foreign substances; then made into cakes and dried. See LIME; CHALK.

Whiting Cupola.—A patented cupola manufactured by the Detroit Foundry Equipment Company, Detroit, Mich. Among many special excellences claimed for this cupola are the following: (the special features over other cupolas are largely in the arrangement and construction of the patent tuyeres): "There are two rows of tuyeres.

The lower ones are arranged to form what is practically an annular air inlet, thus distributing the blast almost continuously around the entire inner circumference of the cupola. These tuyeres are constructed in such a way that the blast is admitted through the small end, which is expanded into a large horizontal opening. This allows the blast to reach the iron through an opening nearly double the area of that through which it enters, thereby admitting the same volume of blast, but softening its force. The result is a better, softer, and more fluid iron, even in quality and easy to work. A sharp, uneven blast destroys the best qualities of iron. The cupola has an upper row of smaller tuyeres of similar construction, and of sufficient size to furnish air to utilize the escaping carbon gas. As we employ a slag-hole, the melting in our cupola may be continued indefinitely."

Whitworth's Compressed Steel.—See PRESSING-FLUID STEEL.

Winch.—The common winch for well purposes is simply an axle on which the rope is wound by means of a crank at one or both ends. For heavier purposes, gearing is employed in their construction, to obtain an increased power. See STEAM-WINCH.

Wind-box.—The encircling belt of a cupola which incloses all the tuyeres. See CUPOLA.

Wind-furnaces are air-furnaces which, instead of being urged by a blast-machine, blower, or fan, depend on a natural draft, which is usually induced by connecting the flue with a long chimney, as in brass and reverberatory furnaces. See BRASS-FURNACE; REVERBERATORY FURNACE.

Wiped Joint.—So called by plumbers when the solder is left in a mass around a lead joint and smoothed, tapering each way, with a cloth pad.

Wipes.—See TILT-HAMMER; TRIP-HAMMER.

Wire.—In order that a wire may be drawn, it is necessary that the metal should be ductile. Gold, silver, steel, iron, copper, and their several compounds have this property. Iron is prepared by heating the rods and re-rolling down to a size suitable for the draw-plate, consisting of an oblong piece of hard steel pierced with conical holes, progressively smaller and smaller. The pointed end of the metal, being passed through one of them, is forcibly withdrawn by strong pincers, or by means of a reel which contains the wire to be drawn, from which it is forcibly unwound by a conical drum having a hook to receive the previously reduced end of the wire after it has been passed through the draw-plate. The drum is made to revolve by suitable machinery. For some very fine and accurate purposes jewelled holes are prepared in the plates consisting of rubies and similar hard stones. See TELEGRAPH AND TELEPHONE WIRE.

Wire Cloth.—The business is now so well perfected as to make it a matter of the least difficulty to obtain from manufacturers every conceivable variety of this fabric. They weave all the grades of iron and steel wire cloths, from the finest and lightest hardware grade to the coarsest and heaviest coal and mining grades; also, all the different kinds of brass, copper, and galvanized cloths for any of the various purposes for which wire cloths are used.

Wire Rope is steel or iron wire twisted into ropes. When great pliability is required it is customary to make the centre of hemp, especially the smaller-sized ropes. A reel should always be used for stowing wire rope, and as a protection against rust the rope should be occasionally tarred or painted. Short bends should be carefully avoided; and, while wire rope of similar strength to hemp will run on sheaves of the same diameter, it is always preferable to have larger ones, as the rope will wear longer. The relative dimensions of hemp cable and of wire rope are as follows, the figures denoting circumference in inches:

Hemp....	3,	4,	5,	5½,	6,	6¾,	7¼,	8,	9,	10,	10½,	11,	12.
Wire.....	1⅝,	2⅛,	2¾,	3,	3¼,	3⅝,	4,	4⅜,	4⅞,	5½,	5¾,	6,	6½.

Wolfram.—Tungstate of protoxide of iron; occurs in Cornwall, in the Bohemian tin-mines, and in Siberia. Its composition is tungstic acid 78.77, protoxide of iron 18.32, protoxide of manganese 6.22, silex 1.25. See Tungsten.

Wood-flasks.—See Flasks.

Wood-screw.—A moulder's device for making fast to a pattern, consisting of an ordinary screw connected by welding to a stem, with an eye turned and welded to the body. A small hole is bored, which admits the screw without splitting the pattern, and the eye serves as a handle by which to turn the screw and lift the pattern. See Spike.

Wood-spirit.—Wood naphtha; is a product of the distillation of wood. Chiefly used for dissolving the rosins in making varnish. It is also called methylic alcohol. See Naphtha.

Wootz-steel.—See India Cast Steel.

Worm-geared Ladle.—A crane-ladle geared with an endless screw and a spiral toothed wheel. The screw or worm being made to turn in a fixing attached to the bail, transmits motion to the axis of the ladle by means of a spiral toothed wheel keyed thereon. See CRANE-LADLES; LADLES.

Wrench.—A tool having jaws, adjustable or fixed, for gripping nuts or the heads of bolts, to turn them. There is a great variety of these implements, but those made from a piece of round twisted steel, with fixed and loose jaws and nut, are perhaps the best for general purposes, especially in the foundry. The *Acme Wrench* is of this description, and is defined as follows:

1st. Being made of only four pieces of steel, where other wrenches are composed of from seven to nine pieces, the wearing qualities are obvious.

2d. It has no handle to get loose or soak with oil.

3d. Having two slides, it is very much stronger.

4th. The thread in the nut is about twice as long as in the ordinary wrench; consequently there will never be the same amount of play in the slides, or stripping of thread.

5th. The jaws open one eighth wider than any other wrench of corresponding size.

6th. It is steel, and the jaws are hardened.

Written Impressions on Cast Iron.—See HANDWRITING IMPRESSIONS ON CAST IRON.

Wrought Iron.—See MALLEABLE IRON.

Y.

Yard.—The standard measure of linear dimension. It is subdivided into feet and inches. Three feet are contained in one yard, and each foot = 12 inches.

Yellow Brass.—*Bright-yellow* brass or Bristol-sheet is composed of copper 16, zinc 6. Copper 16 and zinc 5 is Dutch alloy, which is a deeper yellow; and a very *deep yellow*, called *pinchbeck, semilor,* and *bath-metal,* is composed of copper 16, zinc 4. Good yellow-brass wire is copper 16, zinc 7; and good ordinary brass, *bright yellow,* is copper 16, zinc 8. Copper 16, zinc 9 makes a *full yellow* brass, usually called *Muntz's extreme.* Sheathing is composed of copper 16, zinc 10; and a *paler yellow* is copper 16, zinc 12, which is a good solder for copper or iron. *Pale-yellow dipping-brass* is composed of copper 16, zinc 14. Yellow brass is made sensibly harder by adding from $\frac{1}{4}$ to $\frac{1}{2}$ oz. of tin, and from $\frac{1}{4}$ to $\frac{1}{2}$ oz. of lead increases its malleability and makes it more fluid. These proportions are to the pound of mixed brass.

Yellow Dipping-metal.—Copper 32 pounds, zinc 2 pounds, soft solder $2\frac{1}{3}$ ounces. For soft-solder mixture, See Solder. See Dipping.

Yellow Iron Pyrites, or Sulphuret of Iron, is brass-yellow in color; occurs crystallized, capillary, massive, disseminated, and cellular; it is hard, brittle, and lustrous. This sulphuret is often very beautiful, having crystals, resembling burnished gold, from the size of a small grain up to two inches diameter. Fusible, with a strong odor of sulphur, into a magnetic globule. Composition: iron 47.85, sulphur 52.15; specific gravity 4.8. See Sulphur.

Yielding-platen Moulding-machine.—See Moulding-machines.

Yoke.—A name in some localities for the bail of a crane-ladle. See Bail.

Yttrium.—This metal was discovered by Wöhler in 1828. It is a very rare metal, dark gray in color, and very brittle. See METALS.

Z.

Zinc.—A brilliant bluish-white metal, found in nature in combination with sulphur as *zinc blende,* and with oxygen and carbonic acid as *calamine.* Great quantities of red oxide are found in New Jersey. It is a brittle metal at common temperatures, but when heated from 212° to 300° it may be rolled out into thin sheets, and retains its malleability when cold. It again becomes brittle at 400°, and melts at 741°; taking fire if exposed to the air, and emitting a whitish-green flame as it burns, forming the oxide of zinc. This metal tarnishes readily in a moist atmosphere, and forms a film of oxide which resists further change. This property is what makes this metal so valuable for gas-pipes, roofing, and for galvanizing iron. It prevents oxidation of the metals on which it is applied. See GALVANIZED IRON.

The native carbonate, or *calamine,* is the most valuable of the zinc ores. It is first roasted to expel water and carbonic acid, then mixed with fragments of coke or charcoal, and distilled at a full red heat in an earthen retort; carbonic acid escapes, while the reduced metal volatilizes, and is condensed, generally mixed with minute portions of arsenic.

When zinc forms a component part of any alloy, a better mixture is obtained by melting the zinc separately, and pouring it into a ladle containing the melted copper, through a hole in the cover. This is done to prevent the rapid oxidation of the zinc; for if this is done without excluding the air, the zinc volatilizes very quickly and with violence, throwing off vapors which burn and produce an immense quantity of oxide, which falls down in flakes.

When zinc is not more than from 35 to 40 per cent of a mixture with copper, the alloy retains its malleability and ductility. Beyond this proportion it assumes the crystalline state, until at zinc 2, copper 1 the alloy may be crumbled in a mortar.

Bronze alloys are improved by the addition of a small proportion of zinc: their malleability is increased, with little or no diminution in the hardness; besides which it assists materially in the mixing.

It is certain that zinc and copper alloys form a more perfect chemical union than the alloys of lead with copper or tin with copper.

Zinc is caused to combine with lead by the admixture of a third alloy, arsenic; but, like other alloys with arsenic, it becomes very brittle, and almost useless.

Zinc combines with tin to form a hard brittle alloy, not of much use commercially.

Old zinc plate, etc., assumes the crystalline state again when remelted.

A small proportion of zinc will render gold brittle; zinc vapors alone sensibly affect gold in fusion. Gold 10, zinc 1 makes a brittle alloy, the color of brass; and gold 10, zinc 5 makes a white, hard alloy, susceptible of a high degree of polish.

Very few of the zinc alloys, except those with copper to form brass alloys, are of much service; and the maximum of strength in the latter is obtained when the alloy contains about 44 per cent of zinc. See COPPER; FONTAINEMOREAU'S BRONZES.

Zinc-coating.—Copper and brass articles may be permanently coated with a layer of pure zinc by boiling them in a solution of chloride of zinc, with an excess of zinc-turnings present in the solution.

Gray-iron castings may be coated or galvanized by first cleaning them by abrasion with sand in a tumbling-barrel, then heating and plunging them separately, while hot, in a liquid composed of hydrochloric acid 10 lbs., and sufficient sheet lead to make a saturated solution. In making this solution, add sulphate of ammonia 1 lb., when the evolution of gas has ceased. If the castings are hot enough after dipping them in this solution they will dry almost instantly, leaving a crystallized surface of zinc. They must now be placed in a bath of melted zinc over which, after skimming, some powdered sal-ammoniac has been thrown to prevent further oxidation. Small articles can be lowered into the bath in a wire basket, lifted out, the superfluous metal shaken off, and then cast into water.

Zinc-plating.—See Galvanized Iron.

Zinc, Reducing the Oxide of.—Have a large pot that will hold about five hundred pounds of the oxide; place it over the fire and fill it with the dross, etc.; then pour sufficient muriatic acid over the top to act as a flux. The action of the fire will melt the dross, and the pure metal will fall to the bottom.

Zinc, To Purify.—Granulate zinc by melting, and while very hot, pouring it into a deep vessel filled with water. Put the granulated zinc in alternate layers with one fourth its weight of nitre in a Hessian crucible, and with an excess of nitre on the top. The crucible must be covered and the lid secured; then apply the heat. When deflagration takes place the crucible can be taken out, the metal freed from slag, and poured. Zinc treated thus is freed from arsenic and other impurities.

Zinc-white, or *zincic oxide,* is a strong base, forming salts isomorphous with the magnesian salts. It is prepared either by burning zinc in atmospheric air or by heating the carbonate to redness. Under the name of *zinc-white* it is frequently substituted for white lead as a pigment for paints. It is prepared on a large scale by volatilizing metallic zinc in earthen muffles, the vapor from thence passing into a receiver, where, coming in contact with a current of air, it is oxidized. The oxide, being a light woolly substance, is carried along tubes to the condensing-chamber, where it falls as a fine powder, or zinc-white.