THE

BRASSFOUNDER'S MANUAL;

INSTRUCTIONS FOR

MODELLING, PATTERN-MAKING, MOULDING, ALLOYING, TURNING, FILING, BURNISHING, BRONZING, ETC. ETC.;

WITH

COPIOUS RECEIPTS AND TABLES,

AND

NOTES ON PRIME COSTS AND ESTIMATES.

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With Illustrations.

SECOND EDITION, REVISED, WITH NUMEROUS ADDITIONS.

LONDON:
VIRTUE & CO., 26, IVY LANE.
NEW YORK: VIRTUE AND YORSTON.
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however, are not confined to these forms, although these are the most frequent; they consist of every form and shape, regular and irregular, plain and ornamental, of one and of several parts. It is often costly to construct core-boxes; but, as a general rule, a costly core-box can be dispensed with, by moulding the pattern in sand, and casting it solid from a composition of

1 part plaster of paris,
2 parts brickdust,
Water, q.s.,

and scraping down to the size required to form the core.

It is necessary that all cores should be vented, that is to say, have a hole through them, which is done in the process of making, by inserting a wire, and withdrawing it immediately before opening the core-box to take out the core. Without such vents the casting is sure to be bad, the gases having no way of escape. When the cores are large, core-irons are required to support the sand core. It is customary to support large and long cores in the centre by brass nails or chaplets. It is better, however, to avoid such, and balance the core by a heavy end on the core bar if possible.

To give consistency to the sand used in making cores, about one-half should be pure rock sand, which contains a certain proportion of clay, but not

generally enough; hence the addition of clay-water or British gum is necessary so give the sand the proper amount of cohesiveness.

The cores must be thoroughly dried in a stove, the temperature being between 300° and 400° Fahr. After the cores are dry, they are black-washed, or coated with a mixture of ground charcoal and water, a little clay or size being added; they are returned to the stove to have this wash dried, after which they are ready for the mould. The black wash causes the core to leave the casting readily, and renders the surface of the casting next the core smooth and free from defects.

In green-sand moulds it is better not to insert the cores till within a short time before pouring, so as to prevent their absorbing moisture.

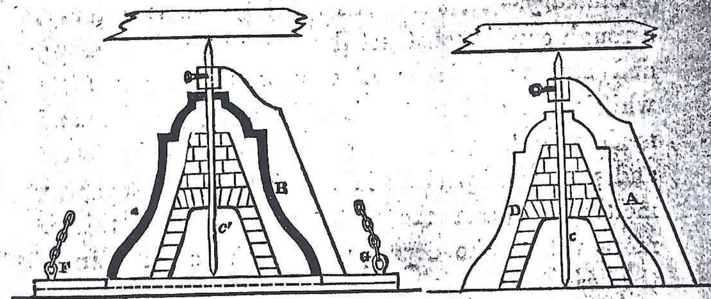

Fig. 13.—Moulding Bells in Loam.

Large and heavy castings, such as large church bells, are moulded in loam.

In Fig. 13, A and B are templets; A is made to the inside shape of the bell, B to the outside. An iron lintel is thrown across at C, supported by the under and supporting the upper brickwork. The core is left for a fire to dry the building and the coating of loam D, which is placed over the building and formed by A, which revolves round with the spindle. This is faced; a coating of fresh sand, indicated by the thick black line, and swept by B, is then applied. This is also faced; B is withdrawn, and upon an iron ring, F G, a large quantity of loam is erected. When dry, the upper loam is raised by a crane; the sand picked out; the snugs, inscription, &c., which have been separately moulded in wax or clay, are inserted; the whole dried and cast.

Statuary.—In works of Fine Art, such as statuary, a rough core is constructed of iron ribs, wire gauze, and stucco; a layer of wax, containing a little white pitch and tallow, is laid on the structure and modelled. The foregoing composition of brickdust and plaster of paris is laid on in quantity, the wax melted out, and the metal poured. But this is more within the department of the artist than of the brassfounder.

Ordnance.—Brass ordnance are cast in a manner peculiar to themselves. A wood spindle is wound with soft rope, a shade smaller than the interior

diameter of the gun; loam is applied to the rope till the proper thickness of the metal is acquired; the whole is turned to the shape or pattern of a drawing; the spindle and rope are then withdrawn; the loam dried and faced; another and thicker layer of loam is applied and dried; the first picked out; the air escape-holes, which are required for every mould, being made, the gun is cast, turned, bored, and tested.

Thickness or Reverse Moulding.—When a thin casting is required from a thick pattern, the upper half of the mould is moulded from the opposite impression, and a thin sheet of clay inserted between the two half boxes, as shown by the dotted lines in Fig. 14.

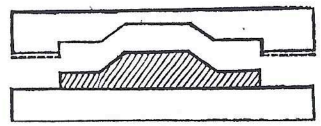

Fig. 14.—Thickness or Reverse Moulding.

Moulding Screws.—The pattern is screwed into the sand. See Fig. 8.

Odd Sides.—This term is given to the practice of taking off two impressions from the one setting of patterns, so that when the patterns are taken out, they can be placed in this third or odd side without re-arrangement.

Flowers, Insects, &c.—It is sometimes required to copy nature from natural objects, such as a butterfly, a flower, a bird, in short, anything which can be consumed by fire. The object is suspended in a box, and surrounded with a compound of brickdust and plaster of paris—two to one in water. The mould is placed in a furnace to consume the pattern, which being done, the metal is poured.

Mixing and Pouring Metals.—This is yet an open subject. The method commonly adopted for brass is to melt the least volatile metal first, and to plunge the more volatile under the liquid surface with the tongs, in small lumps and hot, in preference to large pieces, which are apt to thicken the copper and cause it to set. We say hot, for the least moisture adhering to cold metal would create danger from being driven off in all directions. We say under the surface, so as to prevent loss from

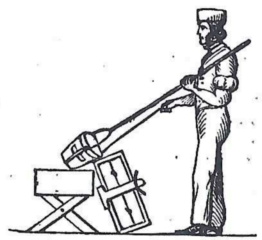

Fig. 15.—Method of Pouring Brass.

its volatile nature. To prevent such loss, charcoal and broken glass have been employed in layers above the metals.

If the metal or alloy be too hot, the casting will

be discoloured or "sand-burned." The best castings are produced when the metal is at such a heat as will cool quickly. The heavy castings take longer to cool, and, consequently, should be poured last. Care must be taken to skim the metal. Fig. 15 shows the method of pouring brass. Small work is poured vertically, large work horizontally.

ALLOYING,

AND THE PROPERTIES OF THE METALS CONSTITUTING THE ALLOYS.

THE metals form part of the elements of nature, are decompounded bodies, and distinguished from the other elements by their lustre, &c.

The *Lustre* is so characteristic as to have formed the common expression "metallic lustre."

Weight is also a rough distinguishing characteristic.

Fusibility is a property common to all metals. Before some metals are rendered fluid by heat, they become pasty; such is an indication of malleability. The following Table gives the degrees (Fahr.) of heat at which metals fuse:—

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Tin	442°
Bismuth	497°
Lead	612°
Zinc	773°
Antimony	810°
Silver	1,873°
Copper	1,996°
Gold	2,016°
Iron (Cast)	2,786°
Nickel	2,800° (about)
Manganese	3,000° (about)

Malleability, or the property of being beat out into thin plates without cracking or breaking, is common to several metals. The order of malleability is as follows, beginning at the most malleable:—

Silver,	Zinc,
Copper,	Iron,
Tin,	Nickel.
Lead,	

Ductility is also a property found in some metals. It is allied to malleability, and often confounded with it. It is the property of being drawn into wire. The following is the order in which the metals are ductile:—

Iron,	Tin,
Copper,	Lead,
Silver,	Nickel.
Zinc,	

Tenacity, or the resistance to being pulled asunder by the force of tension, varies exceedingly in metals.

The order of tenacity, beginning with the most tenacious, is as follows:—

Iron	549
Copper	302
Silver	137
Zinc	109
Tin	34
Lead	27

Brittleness, resulting from hardness, is a property also met with; and where the brittleness is not extreme, *hardness* is in favour where subjected to the force of compression.

All metals are conductors of heat and electricity, and on becoming liquid evolve heat.

As a general rule, the substances (elements) of nature unite together in fixed and definite atomic proportions, thereby forming new compounds. Metals unite with non-metallic bodies, and obey the same general law; but metals, when united with metals, appear to form an exception, though much doubt exists on the subject. They seem to mix in any proportion, and are thereby modified; possessing thereafter properties which fit them for many purposes in commerce and art. These compounds, being considered at present non-chemical bodies, are classed together under the French term of alloys.

The best known and most serviceable of all the alloys are those composed of copper and zinc, to which have been given the term brass. For most purposes it is better than copper, being less liable to discolour, harder, closer in grain, more workable, and fusible at a lower degree of heat. It is infinitely better than zinc, being harder, more durable, closer grained, less tarnishable, less brittle, and of better colour.

This alloy is formed by fusing together the two metals, copper and zinc, in a crucible. The copper, requiring 1996° of heat to melt, is fused first, and the zinc, which only requires 773°, is afterwards introduced. If greater heat is used, the metals will vaporise and cause loss. The zinc is introduced immediately before pouring; if allowed to remain long in the furnace, much of it will pass up the chimney. In adding the zinc in mass, care must be taken to have it warm and perfectly free from moisture, to prevent danger.

When the alloy is cast in heavy blocks, it is found that the heavy metal subsides in setting, that a greater proportion of copper is set in the under half of the casting, and thus the composition is redder below and whiter above, to prevent which some parties have recommended that the casting be fed; but it is not easy to see how feeding will affect the surface of a block, which surface is set before the interior, the interior alone being capable of being fed. The setting in accordance with specific gravity occurs with other alloys. The greater the difference between the specific gravities, the

greater is the difference between the composition of the upper and lower portions of the casting.

There are two properties which are of great value to castings, and which are easily produced in brass. The first is *sharpness*, and is obtainable by the addition of a little lead (from one quarter to two per cent.); the second is *hardness* — bushes, for example, requiring it,—and it is produced by a slight addition of tin (from point nothing to point eight per cent.; thus forming ternary alloys.

The following table of brasses presents at a glance the proportions of the composition, the colour the alloy presents, and the name under which the compound is known:—

BRASSES.—Proportions and Results.

Copper.	Zinc.	Colour.	Description.
Wire.	Fumes.	Gold	The gold wire of Lyons.
1 lb.	1 oz.	Red	The jewellers' gilding alloy.
1 ,,	2 ,,	,,	The platin.
1 ,,	3 ,,	,,	Rich sheet-brass.
1 ,,	4 ,,	Deep yellow	Pinchbeck, Bath, similar.
1 ,,	5 ,,	,,	Dutch alloy.
1 ,,	6 ,,	Bright yellow	Bristol sheet.
1 ,,	7 ,,	,,	Good brass wire.
1 ,,	8 ,,	,,	Good ordinary brass.
1 ,,	9 ,,	Full yellow	Muntz's extreme.
1 ,,	10 ,,	,,	Sheathing.
1 ,,	12 ,,	Pale yellow	Spelter solder for copper or iron.
1 ,,	14 ,,	,,	Dipping-brass.
1 ,,	1 lb.	,,	Spelter solder for brass.
1 ,,	2 ,,	Whitish	Watchmakers' brass, crystalline.
1 ,,	8 ,,	,,	Lap-alloy.

The next most serviceable class of alloys is that composed of copper and tin, to which the terms *bell-metal* and *bronze* are given. Of themselves, these metals are too soft and flexible for most purposes; when united by fusion, the compound is very hard, brittle, and sonorous.

Bronze is of great antiquity. It has been used for weapons, guns, tools, gongs, and bells for time unknown. Tin improves castings of copper. A little zinc, in addition, produces better results. A little brass adds brilliancy to the colour. Lead dulls and destroys it. It is necessary to heat the tin before adding to the copper, as it is apt when cold to produce a lump at the bottom of the crucible.

The particulars of the different bronzes are set forth in the following table:—

SIMPLE BRONZES.—PROPORTIONS AND RESULTS.

Copper.	Tin.	Colour.	Description.
1 lb.	0·5 oz.	Reddish yellow	Ancient nails.
1 ,,	1· ,,	,,	Soft gun bronze.
1 ,,	1·3 ,,	,,	For mathematical instruments.
1 ,,	1·5 ,,	,,	For toothed wheels.
1 ,,	2· ,,	Yellow red	Ordnance.
1 ,,	2·3 ,,	,,	Hard weapon and tool bronze.
1 ,,	2·5 ,,	,,	,, machinery-bearing bronze.
1 ,,	3· ,,	Bluish red	Soft, for musical bells.
1 ,,	3·5 ,,	,,	,, gongs.
1 ,,	4· ,,	Ash grey	,, house-bells.
1 ,,	4·5 ,,	,,	,, larger bells.
1 ,,	5· ,,	Dark grey	,, the largest bells.
1 ,,	7· ,,	Whitish	Ancient mirrors.
1 ,,	8· ,,	Whiter	Speculum bronze.
1 ,,	32· ,,	Whiter still	Pewterers' temper.

The Japanese, who are great bronze-workers, add lead, zinc, and iron to their bell-metal, with wonderful

effect. Their name for these compounds is *kara kane.* The following are the proportions they use:—

KARA KANE.—(BELL METAL.)

Copper.	Tin.	Zinc.	Lead.	Iron.	Quality.
60	24	9	..	3	First.
60	15	3	8	..	Second.
60	18	6	12	3	Third.

For small bells they employ the first quality, and for large bells the third quality.

There is another kind of bronze, known as Fontainemoreau's Bronze, in which zinc predominates. It is said to answer well for chill moulding, that is, for pouring in metal moulds, by which method it is rendered very homogeneous. The crystalline nature of the zinc is entirely changed by the addition of a small proportion of copper, iron, &c. The alloy is hard, close-grained, and resembles steel. Moreover, it is more fileable than either zinc or copper. The following table presents the proportions in use:—

FONTAINEMOREAU'S BRONZES.

Zinc.	Copper.	Cast iron.	Lead.
90	8	1	1
91	8	0	1
92	8	0	0
92	7	1	0
97	2½	½	0
97	3	0	0
99½	0	½	0
99	1	0	0

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The union of copper with lead is usually termed "pot metal." Lead has the tendency to separate from copper, and cannot be employed in larger proportion than 8 oz. to 1 lb. of copper. Arsenic aids its fusibility. Tin, in small proportion, improves the alloy. The following are the ordinary compounds:—

Lead.	Copper.	Description.
oz.	lb.	
2	1	Red ductile alloy.
4	1	do.
6	1	Dry pot metal, or cock alloy.
7	1	do. but shorter.
8	1	Wet pot metal.

The following table presents some additional compounds for special work:—

Iron.	Brass.	Zinc.	Tin.	Lead.	Copper.	Description.
..	..	..	0·5	1	1	Mortar alloy.
..	..	1	1·6	1·6	1	Socket alloy, Stevenson's.
..	..	0·5	1·5	..	1	Pump metal.
..	..	5	2·5	..	1	Suspending metal.
..	2	..	1·5	..	1	Wheel work.
..	1·5	..	2·3	..	1	Turning work.
0·1	..	0·75	..	..	1	Keir work, forgeable.
0·02	..	0·6	..	..	1	Aich metal, resists sea-water.
00·3	..	0·5	0·02	..	1	Sterro metal, for pumps.

Of the above compounds the keir metal is capable of being made into any shape by the hammer, and is fit for propeller-blades, sheathing, and bolts.

The aich metal is said to be stronger than copper. Sterro metal is said to stand 75,000 lbs. to the square inch.

In using iron filings employ a little corrosive sublimate for fixing it.

Of all the alloys, perhaps no class has occupied more attention than the *white alloys*. First, as a substitute for silver, and secondly, as a source of solder, these compounds have been very successful, and have added very much to the industry of our country. The following table presents the most important:—

TABLE OF WHITE ALLOYS.

Silver.	Nickel.	Brass.	Zinc.	Tin.	Lead.	Copper.	Animony.	Bismuth.	Description.
	dwts	lb.	dwts	lb.	lb.	lb.	lb.	lb.	
...	3	...	16	...	...	1	...	...	Nickel, or German silver.
...	15	...	13	...	...	1	...	...	White copper of China.
...	...	...		9	2	...	1	2	Queen's metal.
...	...	1	lbs.	49	...	1	3·5	...	Britannia metal.
...	...	16	2	1	...	...	...	...	White button metal.
...	...	2	...	1·5	...	1	...	...	Solder for bell metal.
...	...	1	...	0·6	...	0·15	...	...	Do. brass.
...	...	...	...	1·	0·5	...	...	...	Do. tin.
1	...	0·5	...	...	...	...	...	...	Do. silver.
1	...	0·3	...	...	...	...	...	...	Do. do.
4	...	...	...	...	...	1·	...	...	Do. do.
1	...	0·15	...	...	...	...	...	...	Do. Mokume.
835	...	...	...	...	...	165	...	...	French coin.
950	...	...	50	...	...	...	...	...	M. Piligot's coin alloy.
900	...	...	100	...	...	...	...	...	Do. do.
800	...	...	200	...	...	...	...	...	Do. do.
900	...	...	50	...	...	50	...	...	Do. do.
800	...	...	100	...	...	100	...	...	Do. do.
835	..	...	72	...	...	93	...	...	Do. do.
100	...	...	...	...	...	30 to 50	...	...	Gin shi bu ichi.

The substituting of zinc for copper in silver alloys

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gives greater fusibility to the alloy. Some small Swiss coins contain zinc in their composition.

Another very interesting alloy has lately come to us from Japan, called *shakdo.* It is composed of copper, with from one to ten per cent. of gold. On being polished it is boiled in a bronze, which we shall describe among the artificial bronzes, presenting a bluish-black colour of great beauty.

There is another interesting alloy being tried in America, but which little concerns the brassfounder, being the introduction of a richer metal with iron, which is said to render cast iron doubly strong.

The employment of *arsenic* into alloys requires the use of a good flux to unite it well with the other metals; that flux is commonly *nitre,* or one part nitre and two of tartar. The alloys made with arsenic are chiefly for speculums—that is, telescope mirrors.

Table of Speculum Alloys.

Silver.	Brass.	Copper.	Tin.	Arsenic.
..	..	32	14	2
..	..	32	13½	1½
..	..	6	2	1
..	..	32	2	1
..	..	3	1¼	
..	..	64	29	
1	1	32	15	

In using arsenic, it must be introduced into the crucible when the mixture is in a melting state.

Being in a coarsely-pounded state, it is tied up into a paper bag, and let into the crucible by a pair of tongs. The whole mixture requires to be stirred with a birch rod till vapours cease to rise. Avoid breathing or inhaling while the vapours appear; as soon as they are over the alloy is ready for pouring. Arsenic renders alloys white and hard.

The alloys containing arsenic should be taken out of the flask as soon as properly set, and placed in hot ashes, and in a proper place for protracted annealing.

It is said that speculums are sometimes made from *platina.* It is also on record that platina, plus iron, forms the composition of some Spanish gun-barrels, which never rust, and that iron and copper may be coated with the composition.

LATHE WORK.

The Lathe.—Lathes are almost endless in variety; yet one principle pervades all ordinary lathes, whether propelled by foot or steam. For brassfounders' purposes, the common ordinary lathe, of a somewhat light make, will be found most useful. The following woodcut represents, typically, an ordinary