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GOLD ALLOYS

GOLD ALLOYS

THEIR

MANUFACTURE & APPLICATION

A practical business guide to the preparation, composition, and melting of Gold Alloys of every description and caratage, for the use of Goldbeaters, Goldsmiths, Jewellers, Watchcase Makers, Enamellers, Setters, Pen Makers, Stampers, Gilders, and all kindred workers in the precious metals, showing how difficulties and failures are met with simple remedies; compounding the different colour-tinted alloys; reducing and improving the various carats of gold; metals which impair the physical properties of gold and its alloys; fluxes and their uses; recovering gold from solid waste products; imitation platinum and palladium alloys; tables of gold values; tables of weights; and sundry tables of interest to dealers in the precious metals and diamonds.

BY

GEORGE E. GEE

AUTHOR OF

"The Goldsmith's Handbook," "The Silversmith's Handbook," "The Jeweller's Assistant," "The Hall-Marking of Jewellery," "Recovering Precious Metals from Waste Liquid Residues," etc

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PREFACE

In committing to the custody of the public some particularly private and useful knowledge acquired during a lifelong experience of matters pertaining to commercial workshop practice in the precious metal-working trades of this country, I desire to impress on the mind of readers the fact that the information imparted in these pages is of the most practical and commercial utility.

As my knowledge of the intricacies of these trades is peculiarly well known, I have been requested, now that I have retired from business, to publish a book on "alloys" and other data, for the benefit of the present and future generations of society, including some of the special attributes which have helped me to achieve success in the business to which my life has been chiefly devoted, instead of having them buried in a human grave.

In assenting to this request, I simply propose to point out that, in the preparation of the different mixtures of the numerous carats of gold; of their suitability for special purposes; of the care bestowed in the melting; of the importance of obtaining good workable metal; and of keeping down the loss to the lowest possible quantity, are all high essentials to the successful practice of working in the precious metals.

Formulas for alloys of every possible description and caratage are given in the text, not merely theoretical, but those which have been well tried in every distinct branch of a business requiring such specialities as are described in this book for distinctive purposes, all of which have proved eminently satisfactory for giving full effect to the intended designs. Tables for reducing and improving the various standards, with other memorandum of a useful kind, will be found distributed throughout the pages of the book. Instructions with regard to waste products, filings, lemel, polishings, lappings, and other substances are dealt with in the most economical and appropriate manner, special

regard being given for the benefit of those entering upon the work for the first time, for there are many well-defined lines of mechanical and scientific inquiry, which may be pursued with advantage by persons engaged in business in which the precious metals are employed, but who may be unable to avail themselves of such instruction on account of the very scanty means that exist in these trades for gaining really practical and useful scientific knowledge. It is to supply the need and serve as a guide in such cases that this trade manual is written.

Full detailed descriptions and illustrations of the methods to be followed throughout the working operations are given in these pages, and also an exhaustive mass of information of an introductory nature, but essential to the knowledge required to make an experienced master goldsmith, or a skilful and expert operative. I hope this information will, therefore, add to the value and usefulness of the book.

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GOLD ALLOYS: THEIR MANUFACTURE & APPLICATION

CHAPTER I

INTRODUCTION

BEFORE entering upon the chief topics of the many attractive subjects treated of in this book, it will be advisable, by way of preliminary, to impress on the mind some important scientific principles essential to the knowledge of all workers in the industrial arts which utilise the precious metals—gold, silver, palladium, and platinum—and this will, no doubt, be found of considerable importance and of an all-absorbing interest to a very large number of my late fellow-craftsmen, with whom I have been intimately associated for the last sixty years as a practical worker. The volume is written without any pretensions to style, but in plain and simple workshop language, so that the knowledge imparted will be clearly understandable by every person engaged in business, and likewise by those employed in manipulating the precious metals for a livelihood.

From my extensive experience as a manipulator of gold, silver, and platinum, the information revealed herein cannot fail to be of service in some of the multifarious operations and processes necessary to the preparation and construction of goldsmiths' and silversmiths' work, in the many different branches of the art, extending from the melting furnace to the finished articles. It will be useful for various purposes that present themselves, both in the largest of manufactories and in the smallest of workshops—useful alike to students, to dealers, to craftsmen and to their employers—by providing a familiar guide of practical remedies for difficulties which incidentally arise in the manufacture of, and in the preparation of, miscellaneous and expert work in the precious

metal trades, by describing all the processes necessary to be followed and the apparatus to be used in the successful prosecution of the art of precious metal working. My aim, therefore, is a practical one.

Gold, taking it first as the most precious of metals, consists in its natural state almost uniformly in the metallic condition, bright, glittering, and beautiful to look upon; its colour varies from pale yellow to deep yellow of a reddish tinge, and this is a distinguishing characteristic of the condition of gold in its natural state, as it is taken out of the bowels of the earth in the different quarters of the world, which searchers after gold have clearly established as a fact. The following countries represent the different shades of gold under natural circumstances: that from California is pale yellow, that from Australia is possessed of a deeper tinge, while that from the Ural Mountains in Russia is the reddest of all natural gold. This is not altogether owing to impurity or to the kind of metal with which it is usually found associated, for there has always been observed a perceptible difference to the experienced eye, even when the gold approaches nearly 1,000 fine. Gold never occurs fine in nature. All the larger pieces are found contaminated with more or less silver and copper; iron sometimes exists, and occasionally platinum, while other metals are found mixed with it. The smallest gold pieces are usually of the purest kind. No single acid of any kind is capable of affecting gold. It is one of the heaviest known metals, and has always been considered an emblem of wealth among civilised nations. Even by savages it has always received the most pleasing recognition. Pure gold is unchangeable under all conditions, but the least admixture of any base substance so alters its condition as to make these remarks inapplicable. In its pure state, however, it is perfectly indestructible under natural circumstances. Nevertheless, it does not possess the quality of hardness, being too soft for manufacturing uses; and for this reason alone, apart from the great intrinsic value of the metal, it is a question if it could be practically worked in an absolutely pure condition. Therefore for practical purposes, as well as for purposes of economy, it has been found advisable for workers in the precious metal to alloy their gold with some other metal, not only to give the necessary hardness for working operations, but also to bring its intrinsic value within the reach of all classes of the public.

Fine gold is of a bright yellow colour, the most ductile and malleable of all the metals, and these features are of a most remarkable character. A grain of gold has been beaten so thin without disintegration that it covered 56 sq. in., and consisted of a thickness no greater than the $\frac{1}{280000}$ part of an inch, and the same may be drawn into 500 ft. of wire. History does not furnish us with a date when gold was found, but it will be sufficient for my purpose to say that it has been known from the earliest ages of the world, and has always been employed for some purpose or other, but more especially as a medium of exchange and for personal ornament.

Fine gold in tenacity is inferior to iron, platinum, silver, and copper, but it is stated that a drawn wire, the diameter being ·787, rather more than the third part of a line—a line being the twelfth part of an inch—will support a weight of 150 lb. In softness—it being nearly as soft as lead—fine gold may be readily cut with a knife; and this test, with its characteristic yellow colour and high metallic lustre, unlike any other metal, materially assists a person in detecting minerals likely to be mistaken for gold, iron and copper pyrites being the most likely substances, but their detection in this way is most easy, as they are both hard.

Fine gold melts at 1,913° F., or at 1,045° C., the English and French scale of degrees indicated by the pyrometer, a simple instrument in the form of a metallic bar, employed for measuring the various degrees of heat required in melting solid bodies above those that can be indicated by the mercurial thermometer. Gold, when in fusion in the crucible, is of a bluish white colour, and has the reflecting power of the mirror. In its fine state it is scarcely likely to become oxidised, or any portion emitted in fumes by the heat of the furnace; but jewellers' alloys, some of which are prepared for the purpose of exhibiting special tints of colour, lose considerably, without great care is exercised in the melting of them. The symbol for gold is *au*. The atomic weight is 196·20, and the specific gravity is 19·32. An explanation of the meaning of the foregoing terms will be, at the outset, advisable in case some of my readers may be without chemical knowledge. The symbol *au* (Aurum) is the name by which gold is known in chemistry; therefore it will represent nothing more significant to gold workers than its chemical name. The atomic weight represents the proportion by weight which

any element bears in comparison to the weight of any other elementary substance, a principle determined by the relative weights of the different elements as compared with *oxygen* as unity, its atomic weight being 16. These relative weights were formerly referred to *hydrogen* as unity, its atomic weight being 1. It has, however, recently been found that a more perfect system can be obtained by taking oxygen as the standard of comparison, and this system is now generally adopted for the standard of atomic weights. The atomic weight is either equal to the chemical equivalent weight or some multiple of it.

The chemical equivalent weight represents the different proportions by weight in which substances, solids, or liquids chemically combine with each other to form a chemical union, hydrogen being in these combinations taken as the unit of comparison; hydrogen being taken as the standard to work from, because it enters into combination in smaller proportion by weight than any other element. The chemical equivalent weight is not, therefore, its atomic weight always, being either that or some simple proportion of that weight, its combining proportions being referred to the atomic weight of hydrogen 1, instead of that of oxygen 16, as is the system relating to the weights of the elements, and known as their *atomic weights*.

The specific gravity is another name for density, and represents the difference existing in weight between equal bulks, or measured quantities, of liquids or solids, water in this case being taken as the unit of standard for comparison; therefore the specific gravity of gold is the greater proportion it bears in weight to that of an equal bulk of distilled water at 60° F.

The precious metals are never spoken of in any other way than as ounces, pennyweights, and grains, or as ounces and decimals of an ounce—thus, 8 lb. 6 oz. 4 dwt. would be called 102 oz. 4 dwt., or 102·200 oz. The ounce and decimal parts of the ounce being modern legislation on the subject, every dealer in gold, silver, and platinum ought to be possessed of an accurate pair of scales and weights (similar to the illustrated sketch, Fig. 1) to weigh correctly the various wares that come into their possession either for treatment or for sale. Many cases of roguery have been detected by the writer among those possessing a knowledge of goldsmiths' work with regard to some of the practices adopted by the unscrupulous, one set of weights being used for

buying and another for selling the precious metals; and I desire to point out that it is with troy weight only that you have to do in weighing any of the precious metals, and also precious stones, with the exception of diamonds and pearls, the latter being weighed by the carat, which contains 4 gr., but these grains are not the same as troy grains; $5\frac{1}{20}$ diamond grains only equal 4 troy grains; the ounce troy, therefore, would contain 606 diamond grains instead of 480 gr., the weight of an ounce of the precious metals. Anybody buying gold or silver where avoirdupois ounces are

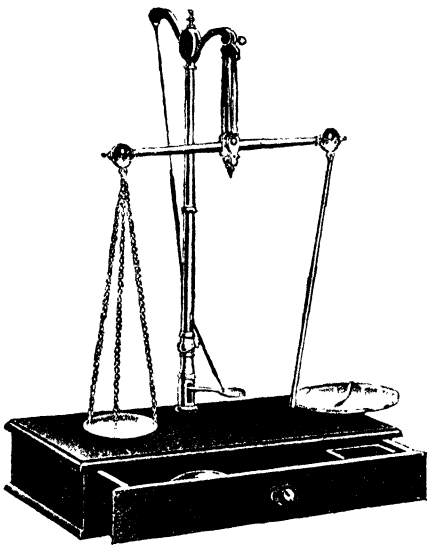

FIG. 1. Jeweller's Scales.

used would be greatly defrauded, since there would, in quantity, be a large deficiency, as compared to the quantity of ounces charged for if reweighed with troy weights, the shortage in weight being 1 oz. 1 dwt. 6 gr. with troy weights in the lb. of 12 oz. To further point out how a simple thing sometimes leads to great harm, as I often have craftsmen writing to me saying that they found after leaving the workshop they knew nothing compared to that which was necessary to success in a higher position, and when some great obstacle presented itself they were at a loss how to act for want of the requisite knowledge. It will serve a useful purpose if I give here a table of troy and avoirdupois

weights, and in addition a table by which any ware or quantity of bullion may be easily converted into the troy scale, in case the latter weights are not always available :—

Troy Weights

24 gr.= 1 dwt.
480 gr.= 20 dwt.=1 oz.
5,760 gr.=240 dwt.=12 oz.=1 lb.

Avoirdupois Weights

437½ gr.= 16 drams=1 oz.
7,000 gr.=256 drams=16 oz.=1 lb.

(The weight of the grain is the same in both cases.)

Comparative Table of Avoirdupois and Troy Weights

Avoirdupois Weight.		Troy Weight.		
Drams.	Oz.	Oz.	Dwt.	Gr.
1	1/16	...	1	3 11/32
2	1/8	...	2	6 11/16
4	1/4	...	4	13 3/8
8	1/2	...	9	2 3/4
16	1	...	18	5 1/2
32	2	1	16	11
48	3	2	14	16 1/2
64	4	3	12	22
80	5	4	11	3 1/2
96	6	5	9	9
112	7	6	7	14 1/2
128	8	7	5	20
144	9	8	4	1 1/2
160	10	9	2	7
176	11	10	0	12 1/2
192	12	10	18	18
208	13	11	16	23 1/2
224	14	12	15	5
240	15	13	13	10 1/2
256	16	14	11	16

The preceding table will be valuable for another purpose besides that mentioned in the text—viz., for indicating the exact amount required in postage stamps to be put on parcels to be sent to their destination by the parcel post. This often leads to some confusion, as the jewellers' weights are not the same as those used by the post office, but by using this table of checked weights means are provided for any uncertainty as to the amount necessary to be put on various parcels in the shape of postage.

Troy weight is the weight used by goldsmiths and jewellers for weighing the precious metals in all their business transactions ; but when diamonds and pearls are being dealt with, then an entirely separate set of scales and weights are required for the purpose of ascertaining their exactness, these being weighed by carat weights and their subdivisions. The carat, when used in connection with diamonds and pearls, is an absolute and fixed weight of 4 gr., and this differs considerably from the jewellers' and goldsmiths' carat, which is not a fixed weight, but the $\frac{1}{24}$ part of any weight. In estimating or expressing the fineness of gold, the whole bulk under consideration is understood to consist of 24 parts, which are called carats, and as many of these parts which are found to be of fine gold will be gold of that number of carats ; thus, if fine gold to the extent of 18 parts be found in the whole mass of 24 parts, it will be 18-carat gold—that is, there will be 18 parts of fine gold existing throughout the mass to every 6 parts of other metals in each and every 24 parts. The quantity of alloy is not usually considered as part of the value of metals which contain either gold or silver. The diamond carat of 4 gr. is about equal only to $3\frac{1}{6}$ gr. troy weight, or, to be more exact, to 3·1683 decimal troy grains. It therefore takes $151\frac{1}{2}$ carats or 606 diamond grains to compose the jewellery ounce of 480 gr. A diamond carat of 4 gr., if weighing it on troy scales, is equal to $5\frac{1}{20}$ gr. weight on diamond scales ; or, to be more explicit, $5\frac{1}{20}$ diamond grains are only equal to 4 gr. on troy scales. Six diamond carats equal 1 dwt. troy, or $30\frac{3}{10}$ diamond grains.

Illustration

$5\frac{1}{20} \times 6 = 30\frac{3}{10}$ gr. of diamonds to make 1 dwt. troy.
$4 \times 6 = 24$ gr. of gold to make 1 dwt. troy.
$30\frac{3}{10} \times 20 = 606$ gr. to make 1 oz. troy of diamonds.
$24 \times 20 = 480$ gr. to make 1 oz. troy of gold.

Four grains is 1 carat for diamonds and 6 carats is 1 dwt. for diamonds, but not for goldsmiths' work are they alike. For 1 oz. of gold on troy scales is equal to 1 oz. 5 dwt. 6 gr. on diamond scales.

The diamond carat is divided into 4 gr., and these are altogether different to the ordinary standard grain. A diamond grain is commonly called a $\frac{1}{4}$ carat. The diamond carat, after being divided into halves and quarters, is further

subdivided into eighths, sixteenths, thirty-seconds, and sixty-fourth parts; thus it will be at once apparent that troy and diamond grains are dissimilar, and are used for entirely separate purposes. It is frequently stated that the diamond grain equals $\frac{4}{5}$ of a troy grain. According to such a statement, it would only take 150 carats or 600 gr. to the ounce troy, whereas it really takes $151\frac{1}{2}$ carats or 606 gr. to the ounce troy weight. The following table of diamond weights, with their equivalents in decimals, and their approximation to old troy weights, will be found of service to manufacturing jewellers and precious stone dealers :—

Comparative Table of Diamond Weights

Carats.	Decimals Troy.	Old Troy Weights.		
Weights.	Gr.	Oz.	Dwt.	Gr.
$\frac{1}{64}$	0·049	0	0	$0\frac{1}{20}$
$\frac{1}{32}$	0·099	0	0	$0\frac{1}{10}$
$\frac{1}{16}$	0·198	0	0	$0\frac{1}{5}$
$\frac{1}{8}$	0·396	0	0	$0\frac{2}{5}$
$\frac{1}{4}$	0·792	0	0	$0\frac{4}{5}$
$\frac{1}{2}$	1·584	0	0	$1\frac{7}{12}$
$\frac{3}{4}$	2·376	0	0	$2\frac{3}{8}$
1	3·168	0	0	$3\frac{1}{6}$
2	6·336	0	0	$6\frac{1}{3}$
3	9·504	0	0	$9\frac{1}{2}$
4	12·672	0	0	$12\frac{2}{3}$
8	25·344	0	1	$1\frac{1}{3}$
12	38·016	0	1	14
16	50·688	0	2	$2\frac{2}{3}$
20	63·360	0	2	$15\frac{1}{3}$
24	76·032	0	3	4
32	101·376	0	4	$5\frac{1}{3}$
64	202·752	0	8	$10\frac{2}{3}$
$151\frac{1}{2}$	480·000	1	0	0

The Weights and Measures Act, 1878, 41 & 42 Vic. c. 49, s. 20, enacts that diamonds shall be sold by the ounce troy, and any decimal parts of such ounce, but its provisions can hardly be said at present to have met the requirements of those constantly dealing in precious stones; but no doubt, eventually, the effort made to supersede the old system by a uniformity of weights throughout the trade will be successful, particularly when the mode of calculation is more generally understood; but the carrying down the decimal weights to a lower degree will be requisite, as the great value of diamonds necessitates the weighing

to 10,000ths, the weights at present only extending as low as 1,000ths. This, however, is a small matter easily rectified.

The *carat* is the name of a seed of the carob tree, and known to us as *locust bean*. When dried it remains even in weight, and this caused its adoption by the negroes in Africa as the unit of weight for weighing gold and precious

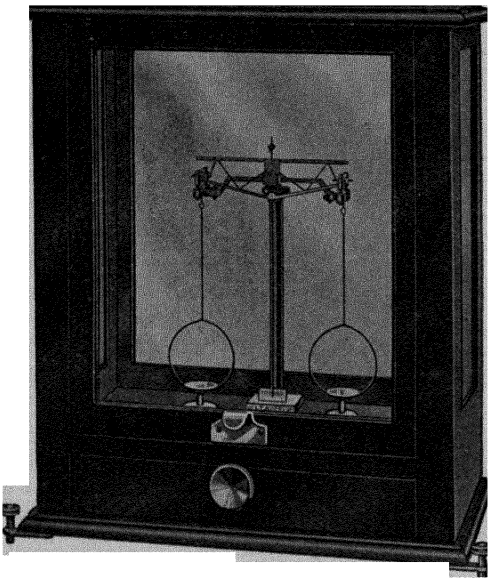

FIG. 2.—Diamond Scales.

stones. In a similar manner our grain weight was established, it being provided by taking a grain of wheat from the middle of the ear and thoroughly drying it. The carat when used in speaking of diamonds must not be adjudged the same as when speaking of the carat of the goldsmith : in the former case it is an absolute weight, in the latter it is not ; nor is it the same as the assayer's carat, it simply being the $\frac{1}{24}$ part of an imaginary weight, gold being divided into 24 parts, and when those parts consist of all gold, it is said to be fine gold of the highest state of purity, or 24 carats. The following table will explain this more fully :—

The Goldsmith's Carat of Gold

	Dwt.	Gr.
A carat of a pound is	10	0
,, grain of a pound is . . .	2	12
,, quarter grain of a pound is . .	0	15
,, of an ounce is	0	20
,, grain of an ounce is . . .	0	5
,, quarter grain of an ounce is . .	0	$1\frac{1}{4}$

By these means the proportion of pure gold contained in any alloy of gold with other metals is stated. Thus it is clear the goldsmith's carat of gold has no real fixed weight like that of the diamond, but is used by them merely to denote a ratio; therefore, to be accurate in his diamond transactions, the jeweller has to keep a separate set of diamond weights and scales to those in general use for weighing the precious metals. As regards the figures in the above table, in case the principal feature of this adoption should not be understood by some of my readers, I will further elucidate the matter by the following observations. The 10 dwt. in the first line is the $\frac{1}{24}$ part of the pound, and consequently denotes 1 carat of fine gold in the gross weight of a pound operated upon. If the pound contained 1 oz. of fine gold, it would indicate a fineness of 2 carats, and so on, and in proportion to as many extra 10 dwt. found existing in the mass, it will represent that many more carats of gold. When the ounce is the gross weight under treatment, the $\frac{1}{24}$ part is 20 gr., and that number of grains denotes 1 carat of gold in 20 dwt., and as many more 20 gr. there are in that weight of metal, the number of carats will be raised in exact proportion. It will now be quite clear to everybody that the goldsmith's carat denotes 10 dwt. of fine gold in every 12 oz. or lb.; and 20 gr. of fine gold in every 20 dwt. or oz. Therefore the goldsmith's carat is understood to mean $\frac{1}{24}$ part of the metal.

Before a person can manufacture or trade in goldsmith's work and jewellery, he will have to procure a licence, or he will be liable to a penalty of £50. The licences are now regulated by the Statute 30 & 31 Vic. c. 90, 1867, and are procurable at the Office of Inland Revenue. They apply as follows :—

Table of Gold and Silver Licences

Makers and dealers in		gold under 2 dwt. . .	Exempt.
,,	,,	silver under 5 dwt. . .	Exempt.
,,	,,	gold exceeding 2 dwt. .	£2. 6s.
,,	,,	silver exceeding 5 dwt. .	£2. 6s.
,,	,,	gold exceeding 2 oz. .	£5. 15s.
,,	,,	silver exceeding 30 oz. .	£5. 15s.

Gold and silver refiners and bullion dealers are always charged the higher rate irrespective of weight. There is now no *duty* upon the manufacture and sale of gold and silver wares of any description, that impost having been abolished on 30th April 1890. There is no licence required to deal in precious stones, which in the light of dealers in other wares connected with them has always appeared to me a strange anomaly. These licences are to be taken out yearly.

Having introduced the reader to the first essential requisites required in starting a jewellery factory or a repairing shop, combined with explanatory notices thereon for the workers' safe guidance, the next most important thing for consideration is the preparation of the material upon which the workpeople are to be engaged in the execution of their daily work; for this purpose some kind of furnace will be necessary, and as so many forms of apparatus are in constant use for melting gold and silver, I intend to give a particular description of each, pointing out what I consider their chief merits and demerits, for each form is capable of serving a useful purpose, in proportion to the surrounding circumstances of the workshop, and to the principal objects in view. The searcher after knowledge may therefore take it for granted that nothing will be omitted of an essentially necessary character to the advancement of scientific instruction and technical training; but, on the other hand, information will be communicated of an industrial and commercial nature, such as has, as a matter of fact, been thoroughly and practically put to the test in working processes with perfectly satisfactory results, from both a working and economical business standpoint. First, with regard to the procuring of the precious metals for workshop treatment, there are two ways of obtaining this: one is from the bullion dealer, already melted into *ingot form* ready for rolling; the other is by preparing your own mixtures and melting them yourself on the premises. The first method is convenient, especially with large bars of silver of

guaranteed standard to be used for hall-marking purposes, as the bullion dealer from whom the ingot was purchased takes upon himself the responsibility for loss incurred if the metal fails to pass the tests of the assay offices; and you will, as a further safeguard, have to pay him only for the actual weight of metal received, without being called upon to pay for any loss in weight which may take place in the melting of the ingot. For the purposes of large silver-plate workers and silver chain makers who use very large quantities, this arrangement is very economical and useful, a mere nominal sum only being charged above the actual value of the metal for the work entailed in providing the metal in ingot form for the use of their customers, instead of selling it to them in the fine grain. A saving of fuel in the melting, and of the workman's time in the preparation and completion of the mixture into ingot form are some of the advantages which accrue to large manufacturers, which more than compensates them for the small charge above the actual value of the metal as a condition attached to bought ingots, and the custom of purchasing ingots entirely dispenses with the risk which your own preparation involves, such as pots breaking, losses in melting, or other accidents which may happen of a nature least expected. But when gold is the subject of consideration, then mixing your own alloys is cheaper, and the mixer knows what proportion of the several metals he has used. But such knowledge is not known when gold ingots are bought from the refiner, for most probably one preparation is sold for all classes of work, and this is most unsuitable, and, in some cases, acts as a considerable drawback to successful manipulation. An experienced mixer can obtain any grade of metal, as regards colour and other workable features which are needed for rendering various alloys adaptable for any class of work.

The art of mixing, and the preparation of really useful alloys for commercial and industrial purposes, cannot be acquired properly without some considerable amount of workshop practice, such, for instance, as rolling, drawing, twisting, stamping, and other manipulations with the various alloys, so as to gain an experienced knowledge of one's own, apart from that of the workmen, who, as a rule, are unobservant mortals, and not always to be relied upon as to the true cause of a difficulty, and who, of course, could not be expected to supply a remedy. For instance,

to give an example as to what some people's ideas are with regard to the mixing of gold alloys, I had occasion to call attention to what I considered the unwarrantable use which had been made for pecuniary personal purposes of my own special preparations, when the accused had the audacity to make the statement that : " *There was only one* 15-*carat alloy ; everybody knew it and used it for all purposes, and every employer used the same.*" Such a statement, I think, will only require the barest of contradictions from me, for every gold worker must know how thoroughly misleading is such a statement. It, however, proves one thing, and that is how imperatively necessary it is for every master goldsmith to know something of the real practical nature of the work in which he is engaged, to enable him to meet his own difficulties in manufacturing, and thus cut short any experimental theories being indulged in to his disadvantage, which are always expensive in the jewellery trade ; and I trust, in writing these instructions, to be of some service in the above direction, by stating broad principles of fact which are the foundation of sound practice.

CHAPTER II

MELTING APPARATUS, INCLUDING WORKING DIRECTIONS

I WILL commence by describing what I consider a good and most useful kind of wind furnace for melting alloys of gold and silver. The simplest form of furnace of this nature is constructed on the following principles: The furnace can be built either on the ground floor or in the first storey

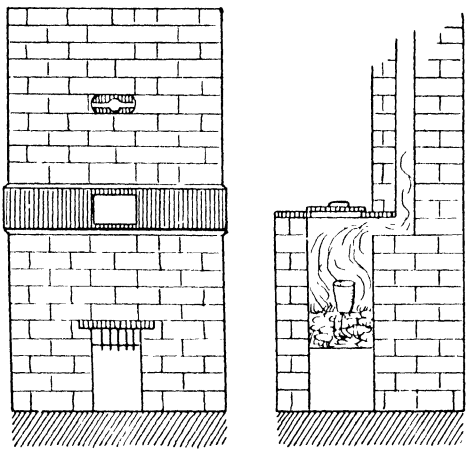

FIG. 3.— Wind Furnace.

of the workshop, in an unused fireplace, if one is conveniently situated. It will be all the better if the chimney extends to 30 or 40 ft. in height. The furnace is built of bricks, lined inside with good firebricks and cemented with fire-clay, not mortar, as the latter would not stand the great heat of the fire required for melting purposes, but would soon crumble and become destroyed, and thus be rendered incapable of retaining the necessary heat within the allotted compass. The accompanying illustrations, Figs. 3 and 4, show a frontal as well as a sectional view, together with the various

fire-tongs used in lifting and pouring both large and small quantities of metal.

The dimensions of a furnace suitable for all the ordinary purposes of the jeweller are as follows : It should stand 2 ft. 6 in. in height from the floor, be 2 ft. 5 in. in width across the front, extend 1 ft. 7 in. from the wall against which it is built at each end, and contain a fire-hole 9 in. square. The depth of the fire-hole from the top of the furnace to the fire-bars should be 1 ft. 6 in., and the depth from the fire-bars to the floor 11 in. The draught-hole in front of the furnace should be 13 in. in height from the floor and 9 in. across in width.

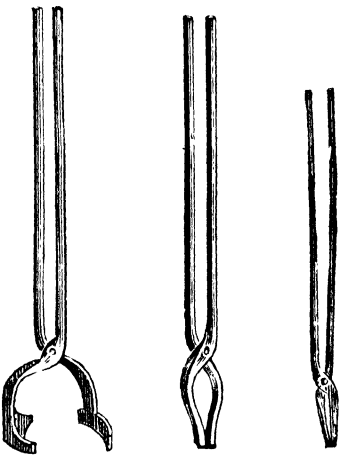

FIG. 4.—Fire-Tongs.

Such a furnace will require twelve fire-bars for supporting the fire and the crucible with the melting charge, each 18 in. long and $\frac{1}{2}$ in. thick each way. Two strong iron bars are built crosswise in the brickwork of the furnace 2 in. below the top of the draught-hole in front in order to carry the fire-bars, and this space allows for the fire-bars to be withdrawn and replaced at the will of the operator in charge of the furnace, and also provides 1 in. of air space between the bars and the brickwork in furnace. It is advisable to have a cast-iron top to the furnace, extending over its entire surface, as one constructed in this manner lasts much longer than one without it. I have had one in constant use for more than twenty years without having it rebuilt. Provision must, of course, be made for the

9-in. square hole in casting the frame. A furnace of this size is capable of rapidly melting large quantities of metal, with a good draught, and for purposes of regulating the latter, a damper, as per illustration, is provided extending right across the flue of the chimney, which enables the operator to provide a draught suitable to the work he has in hand. The passage, or draught-hole, from the top of the furnace to the chimney should not be more than 2 in. deep and about two-thirds of the breadth of the fire-hole, or too great a current of air may be set up, in which case it will act injuriously on the fused metal in the crucible. The draught-hole into the flue should be as near the top of the furnace as possible, so that it will allow of the pot, when placed in the fire, the bottom of it about 3 in. above the bars, standing high up in the furnace without the contents being cooled by the draught. The furnace when in action is covered with two firebricks, 5 in. wide and 14 in. long, bound with clamps of iron, which not only preserves them for long continual use, but also facilitates their easy removal from the mouth of the furnace when melting is proceeding, thus enabling a close watch to be kept on the contents of the crucible.

These furnaces are built in different sizes proportionate to the amount of metal to be melted therein at one operation, and to the quantity of work to be executed in the factory, and to other trade requirements. The Mint, I believe, use a furnace containing a fire-hole of 12 sq. in. in capacity. This size is large enough for every possible purpose consistent with the melting of gold and silver for industrial uses. To prevent the risk of being misunderstood, I desire to point out, in order to prevent mistakes occurring in building furnaces of various sizes, that, for every additional inch made to the square of the fire-hole, 2 in. should be added to the other dimensions of the furnace in every part, with the exception of the draught-hole in front, which of course should be increased in width only to the extent of the fire-hole at the top of the furnace, through which the fuel and melting charge is put into the body of the furnace.

A smaller furnace, one having a capacity of 8 sq. in. for the fire-hole, will be plenty large enough for all purposes which come within the scope of the majority of jewellers, and, for the uses of these craftsmen, it will be found to possess many advantages over a larger furnace, particularly where the melting charges are limited to small quantities

of metal for a single operation. This size will be found very convenient and economical, for, besides requiring less fuel surrounding the crucible to effect a proper fusion of the metal within, it will be found quite capable of melting bars of gold and silver from the smallest quantity up to 100 oz. in weight in the shortest possible time, and even the latter weight can be considerably exceeded if necessary, being in fact only checked by the incapability of the furnace to take the large crucibles used for holding greater quantities of metal. The external dimensions of this furnace need not be so large as the 9-in. one I have so fully described above. It can be reduced 2 in. in each way, with the exception of the front draught-hole, which will require to be 8 in. in breadth, in conformity with the scale of the furnace. The other details are all in reduced proportion to those I have described at length with regard to the 9-in. size, only a less number of fire-bars will be required, and the two firebricks used for covering the mouth of the furnace should not be more than $4\frac{1}{2}$ in. wide and 12 in. long. A retail jeweller doing his own repairs, and executing small orders on the premises, will not require a larger furnace than one of this size. For all crucible operations this kind of furnace is the very best for turning out good solid ingots of the precious metals, and this is a point of the highest importance, for to provide metal without flaws and blisters presenting themselves in subsequent working processes is one of the first essentials to success in a manufacturing jeweller's workshop. The actual melting of the various alloys used is not difficult, providing certain safeguards are exercised in the performance. It becomes more difficult when one or more of the alloying metals possess a low degree of fusibility to turn out an ingot possessing all the requisite advantages to be met with in ingots of more uniform degrees. For instance, it is easier to mix copper with gold than zinc, because without very great care the zinc would volatilise so rapidly that much of it would be lost in fumes, with considerable loss in the weight of the mixture, and the composition of the final product would be uncertain as regards colour and standard. But with copper and silver, gold enters into alloy with very little waste, and in most cases will yield practically certain results. To this matter I shall subsequently refer. To return to the furnace, the fuel used is always coke. The grey furnace coke—metallic coke—is the best, although gas coke may be, and is frequently, used for the purpose because it is

cheap, but it is soft and gritty, and has nothing like the heating power of the furnace coke. This coke is grey in colour, hard in substance, and heavy to the touch, while the gas coke possesses none of these characteristics. The furnace coke is comparatively free from sulphur and other to-be-avoided elements which contaminate the gas coke. The former is about three times the price of the latter, but it goes much farther, and melts the metals more rapidly and thoroughly. It is also much cleaner, and the liability of gritty particles getting into the melting charge is reduced to a minimum by the absence of shooting, which is a feature of the gas coke when heated in the furnace, by causing the retained gas to be discharged ; for the gas coke is a by-product in gas-making, while the furnace coke is not, but is specially manufactured for heating purposes.

The crucibles used by goldsmiths for melting gold and silver are plumbago, a mixture in varying proportions of fireclay and powdered graphite or coke dust, which withstand the greatest changes of temperature without cracking, and are highly infusible ; but, to enable them to better resist sudden and great changes of temperature they are now mostly coated with a mixture of borax and lime, dried, and subsequently another coating of lime and linseed oil is brushed over the outer surface. These crucibles are not the best when fluxing operations are necessary, but for melting large or small ingots of gold or silver they are unsurpassed. The crucibles formerly used were made of clay, but these are liable to crack, and plumbago, or black-lead, has now taken their place in the precious metal industries. Clay crucibles absorb moisture and are affected by frost, and it is no uncommon thing for them to fly immediately on entering a warm furnace. Plumbago crucibles are entirely free from these defects, but those commonly known to the trade as black-lead require a very careful heating before using them, for if this were not done, most probably the bottom would fly out and let the metal into the fire. I have had them fly so badly that only a mere shell of a crucible has been left behind. It is therefore absolutely necessary to carefully anneal them before melting in them. The best way to anneal a crucible is to place it mouth downwards in the furnace as soon as the fire is lighted ; in this way it becomes gradually heated all over alike, and there is not so much danger of flying taking place as there would be if put into the hot furnace. When it has become red hot

it should be withdrawn, and is then ready for use. Never submit the crucible in annealing it to the flame, for, if you do, it will be sure to fly if it is a black-lead. Clay crucibles do not require annealing, but should be warmed through before using.

The fire, on being lit in the furnace, is allowed to burn up bright and clear before the crucible with the alloyed precious metal is put in for melting. When this is done, the space left between the crucible and the walls of the furnace is filled up with small pieces of coke to a level with the top of the crucible, or nearly so ; the cover is then put on the crucible, or it may be put on before the filling-up process takes place, and this will prevent any accidental falling into the pot of loose fragments of coke, which would be injurious. In most cases, particularly where the coke is good, by the time the fire has burnt clear, the metal will have become melted. The two firebricks used as a covering for the mouth of the furnace are slid over the top immediately upon the completion of filling the furnace with coke. The brick in front, or that one nearest to the operator in charge, is occasionally withdrawn in order to watch the proceeding, as it is not so well to leave the melted mass in the fire too long after it has run down into the liquid condition. A small quantity of the finest possible vegetable charcoal powder is put in the crucible with the mixed metal at the starting-point, and this should be perfectly free from grit of any kind, for, if not, it may cause spilly gold to be the result—a thing not at all desirable in the gold and silver working trades, as much mischief is wrought by it in the varying stages of manufacturing personal ornaments, which frequently happen to be of a costly nature. The melting must be thorough, and not taken out of the fire until it is in a perfectly liquid condition- not, as some would endeavour to make us believe, of the consistency of the yolk of an egg—for, unlike iron, it does not retain its liquidity for long after being withdrawn from the furnace. On the contrary, it soon becomes thick and sets quickly, so that a uniform standard of quality would be rendered difficult of accomplishment were it not removed from the fire in a thoroughly liquid condition—such, in fact, as would enable the metal when being poured into the ingot mould to flow easily and in a thin liquid stream. Before the metal is withdrawn from the fire, it is usual to well stir it with an iron stirrer ; this should be heated to redness before allowing it to enter

the crucible. I have found a wooden stirrer to be much the best, for reasons I shall state later on, when treating on the subject of melting more exhaustively. The wood I have found best is willow. I cut the young shoots from the trees and thoroughly well dry them, selecting those of a suitable thickness for the work to be successfully performed. No flux is required in melting clean new metal, if carefully practised by an experienced and skilful operator, other than the charcoal covering I have already spoken of; but this must entirely cover the fused metal in the crucible, to protect it from the action of the air, a thin layer being all that is necessary for the purpose.

The proper construction of a furnace is of the highest importance, and I here give a table of the most useful sizes:—

Bricked Draught Melting Furnaces

	Dimensions and Sizes.				
	1	2	3	4	5
Height of furnaces	28 in.	30 in.	32½ in.	34½ in.	36½ in.
Breadth of fronts	26 ,,	29 ,,	32 ,,	35 ,,	38 ,,
Width of ends	17 ,,	19 ,,	21 ,,	23 ,,	25 ,,
Square of fire-hole	8 ,,	9 ,,	10 ,,	11 ,,	12 ,,
Thickness of walls surrounding fire-hole	9 ,,	10 ,,	11 ,,	12 ,,	13 ,,
Size of flue leading from fire-hole to chimney	2×8 ,,	2×9 ,,	2×10 ,,	2×11 ,,	2×12 ,,
Depth of fire-hole to fire-bars	17 ,,	18 ,,	19 ,,	20 ,,	21 ,,
Air space between bars and top of draught-hole in front	1 ,,	1 ,,	1 ,,	1 ,,	1 ,,
Height of draught-hole in front to brickwork	12 ,,	13 ,,	14½ ,,	15½ ,,	16½ ,,
Height of draught-hole in front to cross-bars	10 ,,	11 ,,	12 ,,	13 ,,	14 ,,
Thickness of square fire-bars	½ ,,	½ ,,	¾ ,,	¾ ,,	¾ ,,
Thickness and breadth of cross-bars	½×1 ,,	½×1 ,,	¾×1½ ,,	¾×1½ ,,	¾×1½ ,,
Number of fire-bars	11	12	10	11	12
Length of fire-bars	16 in.	18 in.	20 in.	22 in.	24 in.
Length of cross-bars	12 ,,	13 ,,	14 ,,	15 ,,	6 ,,
Distance cross-bars are fixed from front	5 ,,	6 ,,	7 ,,	8 ,,	
Distance cross-bars are fixed from back	1 ,,	1 ,,	1½ ,,	1½ ,,	1½ ,,

In most cases, varying differences exist in the arrangement of the flues and in the height of the chimney, and these have great influence on the working. If out of proportion to the conditions which constitute a good furnace, the draught will be considerably affected—it may even be too strong or too sluggish ; if the latter, it would prevent the requisitely high temperature from being attained in the furnace which is essential to complete success in melting some of the alloys of jewellers ; if the former, it would be equally detrimental, for a current of air would be set up which would not only sweep off the charcoal powder used as a protective covering to the metal, but would oxidise the metal itself, and thus cause considerable loss, besides producing very indifferent working bars of gold and silver. The dimensions of a good wind furnace will be found in those I have so amply described, they having proved in every way eminently satisfactory through long practice. The draught is principally regulated by the flues ; if these are too narrow, the draught would be too slow ; and if too wide, it would be too great. The dimensions of the flues have, therefore, great influence on the working of the furnace. Attempts have from time to time been made to improve upon this kind of furnace, but not with that measure of success it was at first contemplated would follow their introduction into the precious metal trades. The illustration (Fig. 5) represents Carr's patent melting furnace. It is somewhat arranged on the principle of the old wind furnace, and is a convenient arrangement. It is well adapted for many of the uses of jewellers, and may be set up as a permanent fixture or not, according to circumstances and conditions of tenancy.

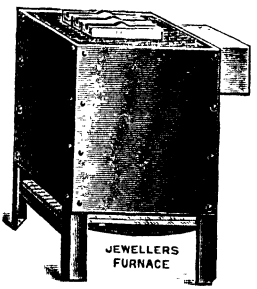

Fig. 5.—Carr's Patent Melting Furnace.

It consists of a frame of wrought iron bolted together by means of four rods, and lined inside with firebricks, after the principle of the old wind furnace ; but in this furnace there is no outside brickwork required—the iron frame replaces that. It will thus be seen it can be easily fixed in any desirable place when once completed as a furnace. It does not require to be taken right down when out of repair, relining with firebricks being all that is necessary to restore

the furnace to its normal condition again. Cast-iron frames are also used in the making of this furnace, but they are much heavier, and are also liable to crack in use ; for these reasons alone the wrought-iron frames are to be much preferred. These are some of the advantages that can justly be claimed for this ingenious furnace. But there are attendant drawbacks attached to it, which does not make it quite equal to its predecessor for crucible operations, for which purpose it was designed to wholly supersede. Fire-bars for supporting the crucible containing the melting charge are, as in the older form, a necessary adjunct to this kind of furnace, a space being provided above the bars in front to enable the air to pass into the furnace above the bars, as well as from underneath between them. These furnaces are in use by many Birmingham jewellers and silversmiths.

They are built in five different sizes, large or small, to suit the various trade requirements ; but for melting large quantities of metal the walls of the furnace should be thick, especially where a continuous and sustained heat is an important factor to the satisfactory performance of the work. As for the iron casing, through being a good conductor of heat, it has a tendency to withdraw some of the heat from the interior of the furnace, and thus cause the process to be prolonged. In some of these furnaces the air is admitted by means of tubes, and these are so arranged that additional air can be blown into the openings by means of foot-bellows. This device increases the more rapid working of the furnace ; but the advantage gained has proved to be not of permanent service, for in cases where fluxing operations have to take place, any flowing over of the fluxes will cause the tubes to become stopped beyond the power of the operator at the furnace to correct, a new inside in most cases being necessary to remedy the defect, and that makes the furnace expensive ; and for this reason alone they are not so good as the furnace I have illustrated, when it is required for the general work of a jewellery establishment. This kind of furnace requires a brick chimney, sufficiently straight, and of good height, to ensure a proper draught being created to successfully cope with the work it is called upon to perform. The furnace should be placed at the bottom of the chimney in front of it, and fixed to the wall in a manner which causes the draught to be set up in a steady equable current. For small operations,

the flue of an ordinary house will be sufficient for melting gold and silver with this furnace. The ashpit is on the floor level, which should therefore be laid with stone or bricks to prevent injury to it; but where large quantities of metal are being melted and heavy pots have to be lifted out of the furnace, it is preferable, as in the case of the old brick furnace, to sink it somewhat below the floor, for besides being more easy to withdraw the pots from the fire, by not having to raise them so high, the ashes which accumulate fall direct into the so formed pit beneath the furnace, and are thus prevented from falling out and rolling under the feet of the operator in charge of the melting.

The different dimensions of the five sizes of this furnace are as follows :—

A size—	12	in.	square,	22	in.	deep,	6	in.	fire-hole.
B ,, —	15	,,	,,	22	,,	,,	7	,,	,,
C ,, —	18	,,	,,	22	,,	,,	8	,,	,,
D ,,	21	,,	,,	22	,,	,,	9	,,	,,
E ,, —	24	,,	,,	22	,,	,,	10	,,	,,

A defect in these furnaces as the sizes increase is that there is not quite enough body in them in proportion to the size of the fire-hole for rapid and effective work, when large quantities of metal have to be melted in a given time; nor are they so effective, when a large quantity has to be melted at one charge, as the bricked wind furnaces consisting of greater thickness in the body surrounding the fire-hole, which retains the heat much better and in a higher degree. Also, in proportion as the fire-hole is increased in the square of these furnaces, so also should be the depth from the mouth to the bars, to enhance their utility to the full, and with a corresponding reduction for a diminished fire-hole; for, unless the latter was provided for, great and unnecessary waste of both fuel and heat would certainly take place. There is no reason why these furnaces should not be made available for the sundry uses of jewellers, silversmiths, and all other workers in the precious metals if they were provided on the lines I have indicated, one of the effects of which would be to prevent them getting so hot outwardly as to enable the workman to continue his operations in large work under more pleasant circumstances.

The suggestions which occur to my mind are embodied

in the accompanying table, which contains all the most useful sizes :—

	Measurements of Furnaces.				
	A Size.	B Size.	C Size.	D Size.	E Size.
	In.	In.	In.	In.	In.
Height of furnace . . .	26	28	30½	32½	34½
Square of furnace . . .	20	23	26	29	32
Fire-hole	8	9	10	11	12
Thickness of walls each side of fire-hole	6	7	8	9	10
Depth to bars	16	17	18	19	20
Depth below bars . . .	9	10	11	12	13
Height of draught-hole outside .	11	12	13½	14½	15½

These measurements allow of an air space of 1 in. between the bars and the top of the draught-hole, and ¼ in. should be allowed for between the closeness of the bars to each other, to enable the air to enter the furnace from underneath between them as well as above them.

July 1920.—These furnaces have now, since these suggestions were made, been improved by increasing the thickness of body, and the inside is made of solid fireclay in place of firebricks, formerly used. The fireclay is moulded to the shape of the furnace and let into the iron frame. They last much longer, and the heat is much more condensed also, so that the man in charge can now stand in front at his work, more comfortably protected from the heat cast outwards.

A very convenient furnace for the melting of small bars of gold and silver suitable for small workshops and for jobbing jewellers is that devised by Mr Fletcher, of Warrington. It is of very simple construction and fairly durable in use, being built entirely of fireclay and strengthened with three hoop-iron bands, which support the casing, as it is subject to wear from the powerful blast thrown in from foot-bellows or blowing machines. It is heated by gas, and is made in five sizes to suit the general purposes of jewellers and others, for whom such a furnace is likely to be of service for particular operations. The following illustrations represent this kind of melting apparatus. Fig. 6 shows the furnace, and Fig. 7 the

foot-blower to be used for the purpose of giving the air pressure to the gas which is to be injected into the furnace.

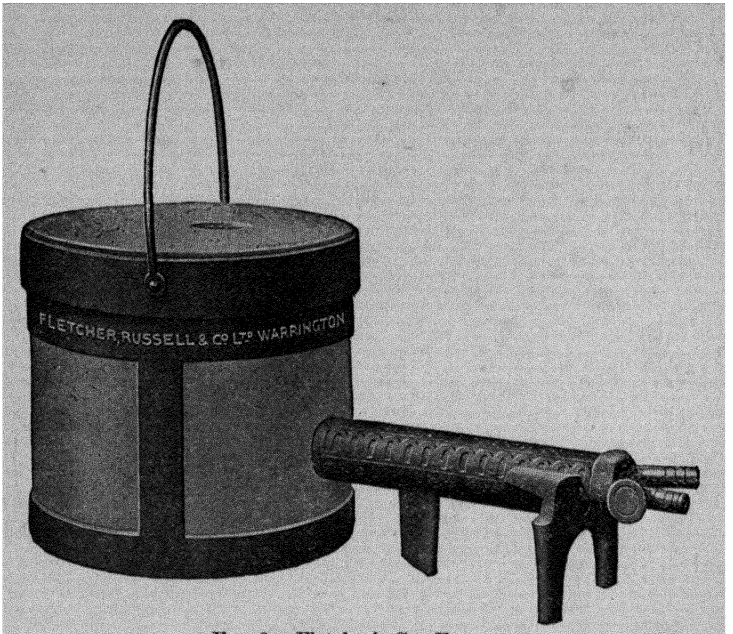

Fig. 6.—Fletcher's Gas Furnace.

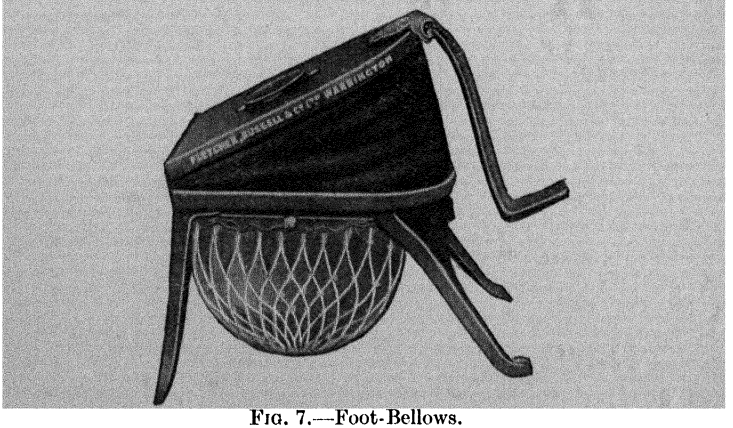

Fig. 7.—Foot-Bellows.

The most efficient blowers are those with the air valve at the top and the wind bag enclosed in strong netting underneath ; if the valve was at the bottom, or underneath

the blower, it would pick up dirt from the floor, and not act so well, besides being more liable to damage through injury to the valve, which would soon put it out of perfect working order. There are several sizes of these foot-blowers in use, and No. 5 size will be the most suitable for the furnace I next describe.

The gas furnace usually employed by jewellers is only a very small arrangement, as the following dimensions will show. Its total height is only $8\frac{1}{4}$ in. outside measurement; it is made in the form of a cylinder with a lid at the top, both the top and the bottom being flat. The height from the bottom up to the lid, outside measurement, is only $6\frac{3}{4}$ in., and the lid has a thickness of $1\frac{1}{2}$ in., which completes the total height of $8\frac{1}{4}$ in. The thickness of the bottom of the furnace is 2 in.; the depth inside the furnace from the lid is $4\frac{3}{4}$ in., the lid being quite flat inside and $1\frac{1}{2}$ in. thick. Thus, it will be seen, it again works out at $8\frac{1}{4}$ in. for its full height.

The thickness of the fireclay casing which forms the body of the furnace is 2 in. The interior of the furnace has a diameter of $5\frac{1}{4}$ in., the diameter of the complete furnace being $9\frac{1}{4}$ in., with an outside circumference of 28 in. The length of the burner or blow-pipe—supplied with furnace—which conveys the mixed gas and wind into the furnace is $7\frac{1}{2}$ in. from the nozzle to where the gas enters it, and $9\frac{1}{2}$ in. to where the wind enters. The burner, when the apparatus is working, contains mixed gas and wind, and it has at the discharge end a diameter of about 1 in., and this end is not open, but perforated, the perforation arrangement being slightly concave. The lid of the furnace is one clear, flat piece of fireclay containing a slanting hole to convey gas and fumes away in the opposite direction to that of the workman in charge of the process. The gas supply pipe should not be less than $\frac{1}{2}$ in. for use with this furnace, which may perhaps be correctly described as No. 3 of the five sizes manufactured by Messrs Fletcher, Russell, & Co. Ltd., of Warrington.

The largest-size crucible the furnace described above will take is $4\frac{1}{4}$ in. in height and $3\frac{1}{2}$ in. in external diameter. About 30 oz. of 9-carat gold will fill this crucible to the brim at the beginning, and 25 oz. of sterling silver will fill it in silver at the starting-point; but it is not advisable to crowd too much metal of either kind into a crucible for melting as to cause it to be too near the top when melted,

on the grounds of both safety and economy. A larger pot cannot be put in this sized furnace, because it would leave no room for the fire-tongs to grip it when ready for withdrawal with the melted metal in it ; and by having the pot too full would cause the tongs to have to be dipped into the fused mass to enable a firm grip to be taken, in order to support it with safety from the furnace, and also during the process of pouring the metal from the crucible to the ingot mould, which is a trying circumstance and tests the security of the grip to the utmost, and, further, it is of the utmost importance for many reasons to keep the tongs quite free of the gold. A free supply of gas is required for these furnaces to enable a high temperature to be achieved for rapid and effective working. All gas pipes and taps should have a clear way right through them, and it will be necessary to blow down the burner occasionally, blowing from the perforated nozzle in the direction of the open end, so as to remove all grit or other substance which accumulates in the burner, and which is prevented from being blown through by the gauze or perforated end of the burner. As this accumulation will after a time check the supply of air and gas to the furnace, thus causing the process to be much prolonged and even made difficult of attainment, it is necessary to be often cleaned out.

To work this furnace to the best advantage, it is absolutely necessary to fit the nozzle of the burner tightly in the hole provided for it in the casing of the furnace, very near the bottom, but not quite. When this is properly fixed, turn on the gas supply, light the gas inside the furnace, but do not put on the lid until the furnace is thoroughly heated, or you will cause the gas to explode through being confined in a damp atmosphere. When you have lighted the gas, commence blowing with the foot-bellows, previously opening the air check ; and when the furnace has become sufficiently heated, put in the crucible with its contents, and place on the cover of the furnace, and if the gas flame comes through the hole in the cover and extends upwards about 2 in., the proper proportions of gas and wind are right, and the blowing may be continued until complete fusion of the metals in the crucible takes place. If the gas flame extends more than 2 in., more wind is required, and you must enlarge the hole in the air jet until enough wind is injected to control the gas flame ; or, on the other hand, reduce the gas flame by turning a little of the gas off, after the principle adopted

when soldering with the gas jet and mouth blow-pipe and the mode of regulating the gas, as practised by goldsmiths and jewellers when working at the board. If the gas flame is small and almost invisible, screw in the check which conveys and regulates the wind until the gas flame appears in the proper form. The larger the hole in the wind tube, the greater is the power of the furnace for rapid working, always, of course, providing the gas supply is sufficient to cause it to act as aforesaid. When using the foot-bellows for these furnaces you must keep up a continuous supply of wind, and never cease treadling until complete fusion has taken place, or the gas will reverse and light back through the gap provided in the burner for taking in oxygen from the air apart from that provided by the bellows, and

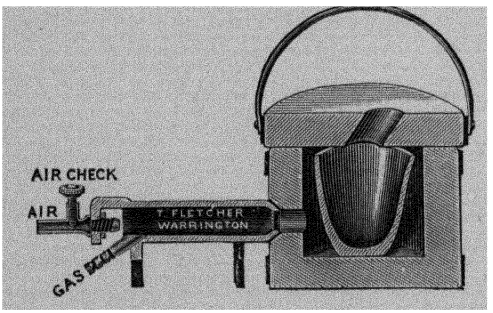

FIG. 8.—Fletcher's Gas Furnace in Section.

sometimes a series of small explosions takes place with the gas if this action is allowed. It will also cause the melting to remain stationary at a certain stage, and when this does happen, it is much more difficult to afterwards melt the mass completely. The liability of the gauze to get choked may with care and attention be guarded against, providing the necessary safeguards are occasionally exercised. The burner does not appear to work to advantage without the perforated nozzle. Before stopping the blower, draw the burner back from the hole, turn off the gas, and then cease blowing. The blow-hole is not quite at the bottom of the furnace inside, being about $\frac{1}{4}$ in. above the level (see Fig. 8). A little silver sand strewed on the bottom of the furnace for the pot to stand on will prevent it sticking to the bottom in case fluxes may have overflown, or other extraneous matter exists likely to cause adhesion.

The largest sizes in these furnaces will require two foot-blowers to accomplish the extra work for which they are designed, or a blower worked by motor power is preferable, in which case the air tube must be much larger than that used with foot-blowers. The following are the dimensions of the large size :—

10½ in.=Total height, including lid.
8½ ,, =Height outside, up to lid.
6½ ,, =Depth inside, from lid to bottom of furnace.
2 ,, =Thickness of lid of furnace.
2 ,, =Thickness of bottom of furnace.
2 ,, =Thickness of casing which forms body of furnace.
5½ ,, =Diameter inside furnace.
9½ ,, =Total diameter of furnace, including the casing.
29 ,, =Circumference of furnace.

An extra gas supply is required with this furnace, probably double that of the one I have already described ; but I notice the gas receive pipe on burner is small, as supplied by Messrs Fletcher. No doubt this acts as a drawback, and explains why so much time and gas is consumed in melting a bar of gold of little more than the average size. All these furnaces crack in using, and almost at the first time ; but they may still continue to be used, as they do not appear to get much worse. Various devices have been resorted to by those using them for the purpose of repair, with more or less success. Plaster of Paris mixed with water, and in some cases with alum and with borax, have been tried, but they all chip and fall out after a short time. Fireclay mixed with water makes a good cement, and is fairly durable. A freshly mixed paste prepared from ordinary fireclay and liquid silicate of soda, and applied to the surfaces of the fracture, will join them together fit for future use. The edges of the crack must be first wetted with the silicate solution, which causes the paste to adhere more tenaciously. No more of the solution should be used than is just necessary to effect the desired purpose, when, after repair, the furnace may be at once used if required. An excellent cement for repairing these furnaces consists of asbestos powder made into a thick paste with liquid silicate of soda. This preparation is pressed into the cracks of the furnace, and very well serves the purpose for which it is intended. It hardens very quickly, stands any heat, and is steam and air tight. All these furnaces take considerably

longer to melt either gold or silver, are much more expensive in use, and not so many heats can be got through in a stated time as with a good old-fashioned bricked wind furnace; and when the foot-bellows are used, the process is both trying and tedious. The advantages in their favour are that they are clean and quickly put into action, and no doubt prove a boon to jobbing jewellers and small manufacturers, where only small lots of metal have occasionally to be melted, for there is no fire to be lighted, no cokes required, and therefore no ash is made and no refuse left to be cleaned away before another melt can be made on a subsequent occasion. They are fairly durable in wear, and the most wasteful action appears to take place on the lid underneath, around the hole through which the flame and fumes escape. Fig. 8 shows a sectional view of this furnace with the crucible in position, as arranged for the operation of melting. It also shows how the fume-hole is made in the lid, and fully illustrates the manner in which both the gas and air are injected into the burner. The air check on the topmost tube regulates the wind by either screwing or unscrewing. By unscrewing the check a larger volume of wind is driven into the furnace than would be the case if the reverse operation was adopted. The slanting tube below is that from which the gas is drawn.

The rubber tube made use of for connecting the burner with the gas main, and especially that which connects the burner with the bellows, should be strong. It is better without the wire spiral inside, as this has a tendency to obstruct the volume of air from being forced freely through it. A canvas lining is far more serviceable as a support for the tube when under great pressure, as is the case when in use with the foot-bellows. When it is used in connection with a fan worked by an electric motor, it is absolutely necessary for it to be supported by a strong outside wire casing to prevent bursting. There is no advantage in using an air-hole in the burner as large as that of the gas supply; in fact, it answers much better smaller. There are many difficulties experienced in using these furnaces in the gold and silver trades, and, in consequence thereof, they are becoming less used. The conditions bestowed upon them in regard to the rapid performance of the work of which they are said to be capable, has not been verified in actual practice from a commercial point of view. Fifty ounces of gold is the limit which the larger furnace I have described will melt at one

time, and about 30 oz. is the limit with the smaller one. These operations take quite half an hour each to melt the above quantities under the most favourable condition, and smaller quantities, in single melts, take almost as long. Experiments have frequently been made to endeavour to shorten the time by introducing various devices for that purpose, but without much avail. By starting with the furnace and crucible cold, it takes from twenty to thirty minutes to melt small quantities; and by heating the furnace first, and then putting in the pot with its contents, it takes about the same time to attain the object in view. In melting *lemel* with these furnaces only a few ounces can be melted at one time, and if you make additions to the mass in the crucible as it sinks down, you endanger the safety of the crucible, for it would be sure to crack and run the metal out. And then another evil presents itself besides the breakage of the crucible: the flux, by coming in contact with the sides and bottom of the furnace, would cause its partial destruction, as it unites with the fireclay —the material forming its construction—and this causes its removal more difficult of accomplishment without injury to the furnace. The force of the volume of gas and wind injected into these furnaces operates with great destruction on the crucibles. Not half the quantity of heats can be got out of a crucible when it is submitted to a blast, as there can be by using it in a coke fire. Clay crucibles always crack, no matter how carefully they may have been annealed first. Plumbago, although they may be used a number of times, always chips at the place where the gas first strikes them; and though the crucible is invariably set to face the gas in different places, the action is the same. This, of course, soon renders the crucibles unsafe to use for continuous operations. Holes are frequently blown into them by the strong force of the mixed gas and air blown against their sides. It is recommended to put some silver sand at the bottom of the furnace for the crucible to stand on, in order to prevent its adhesion to the furnace when great heat is required; but unless this substance is used in a most sparing manner, it will fly about inside the furnace, strike the lid at the top, and rebound into the crucible in sand-blast fashion, unless protected from so doing by the cover of the crucible. The crucible should always be provided with a cover in this form of melting gold and silver alloys, for this, and for other reasons which I shall

subsequently describe in the treatment of a form of melting which has always been eminently successful.

Another source of constant trouble associated with this furnace is the splitting of the rubber bladders which form a part of the foot-bellows, and this happens so frequently that it is no uncommon thing for an extra pair of bellows to be kept in readiness to replace those suddenly ceasing to act. But the greatest objection to the use of this furnace is that it produces blistery gold. I have seen rolled bars presenting one mass of air bubbles from end to end. This is caused by the oxygen created by the blast being taken up by the fused gold alloy in the crucible, and as the bars of gold after being cast are reduced in thickness by rolling, this defect shows itself upon annealing; the expansion of air within the metal causes the latter to rise up in the form of little blisters when rolled near enough to the enclosed air as to cause it to exercise pressure on the gold when heated. All goldsmiths know the irritation and annoyance these blisters produce when they show themselves on a piece of plain work of large surface, such as a locket or a cross, especially after the process of colouring and frosting, without my referring further to the subject now.

It has been stated that one of the special advantages which this furnace possesses is its great heating properties. It is claimed for it that it is capable of melting $\frac{1}{2}$ lb. of cast iron in twelve minutes, starting with all cold, with $\frac{1}{2}$-in. gas pipe, and the smallest foot-blower. I am not prepared to accept this statement myself, but can testify to some of the advantages it undoubtedly possesses for the use of small workers in the gold and silver trades. I would suggest, however, that it be made much stronger, probably to double the strength, as it would prevent radiation all the better. The casing, bottom, and lid should be at least 4 in. thick, and the hole provided in the lid for the escape of the fumes created in working the furnace should be dispensed with, and a small outlet provided in a slanting upward fashion on the edge in place of it. This would tend to increase the heat inside, and the extra thickness of the fireclay would condense the heat and cause less radiation. The furnaces should also have a larger interior, so that the crucibles could be set further away from the discharge end of the burner, for, by these means, a greater heat would be attained in and around the crucibles, and that, too, with less consumption of gas. When several melts have to take place at the same

time, and these consist of various quantities, it is much the best plan to melt the smallest quantity first, then the next, and so on, reserving the largest quantity till the last melt, for, by so doing, each melt is performed more quickly by the heat of the furnace having been raised to a proportionately higher degree to meet each quantity.

By adopting this plan more heats can be got out of these furnaces, and a larger quantity of work performed in less time than would otherwise be the case; but, notwithstanding the many ingenious devices which skill and experience has suggested for the melting of the precious metals by means of illuminating gas, on the whole the metal is not so good as that prepared with a good coke fire. Gas melting and gas annealing are both inferior substitutes to fire, in consequence of the deleterious vapours which arise through its use, and these are injurious to some of the alloys of gold, causing them to be hard and brittle, and thus they become much more difficult of manipulation in the various stages of working, for a piece of work is not so rapidly executed as when a thoroughly malleable, ductile, and tenacious metal is being under treatment. The handy craftsman can easily verify this fact for himself by taking two strips of a refractory alloy and subjecting one of them to annealing by gas, and the other to a clear fire, as often as this is required during the working stages; and observe how much softer and easier to work is the one which has been annealed by fire to the one which has been annealed by gas, also how much further you can advance the work on the fire-annealed one over the other, each time between the annealings. Something of the same principle is involved, and is equally distinguishing in bars of gold and silver separately prepared by fire and gas, as that found under the distinctive processes of annealing above mentioned.

Another melting arrangement has been devised by Messrs Fletcher for melting small quantities of gold and silver without the use of a furnace. The apparatus consists of a shallow-formed crucible, and this is attached to the mouth of the ingot mould. The metal is melted in the shallow crucible, and, by gently tilting the instrument, it runs into the ingot mould. The ingot mould is composed of two parts, and these slide on each other, so that ingots of different widths may be cast, suitable to the work in hand. The part which may perhaps be correctly described as the blowpipe is affixed to the ingot mould, and the whole works

upon a rocking stand, so that the instrument can be tilted when the metal is melted, and this enables the latter to run easily into the prepared mould. Fig. 9 illustrates the largest size of this kind of melting apparatus. It is claimed for it that with a $\frac{1}{2}$-in. gas supply, and a foot-blower, such as I have previously described, it is capable of melting 14 oz. of silver, or 20 oz. of 18-carat gold, in five or six minutes. In melting with this arrangement you must connect the rubber tube from the foot-blower to the upper tube of the melting apparatus, and the rubber tube from the gas main

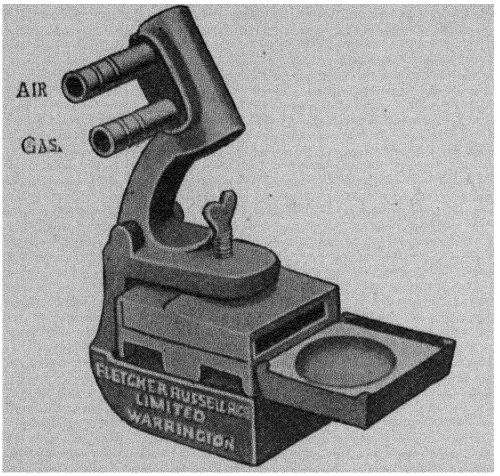

Fig. 9.—Tilting Apparatus for Use in Melting.

to the lower tube of the melting apparatus before commencing the operation. The rubber tubes must be clear and smooth inside, and without wire. It has been stated that a sound 3-oz. ingot can be obtained in two minutes, and a 20-oz. one in six minutes by means of this apparatus, but the kind of metal is not given; probably it was lead.

In the trade this kind of apparatus for melting is called a "tilter," and small tilters are manufactured for the use of jobbing goldsmiths and others, who, on the spur of the moment, require a bit of metal for a special purpose, and for this object they are useful, as they can be brought into immediate action. They are manufactured on the same plan as the above, with the exception that a heavy swivel stand is here introduced, to prevent the possible risk of the crucible and its contents being pulled over by the weight

of the rubber tubes when not held by the hand. (See illustration (Fig. 10), which shows this little instrument at work, with the swivel action clearly visible to the reader.)

The mould is warmed and very slightly greased to prevent the metal spitting up when being poured in, and from sticking to it in the case of a new mould being used for the first time. If too much grease is used, the spitting will still take place, notwithstanding the heating of the mould, and loss of metal would take place; therefore this

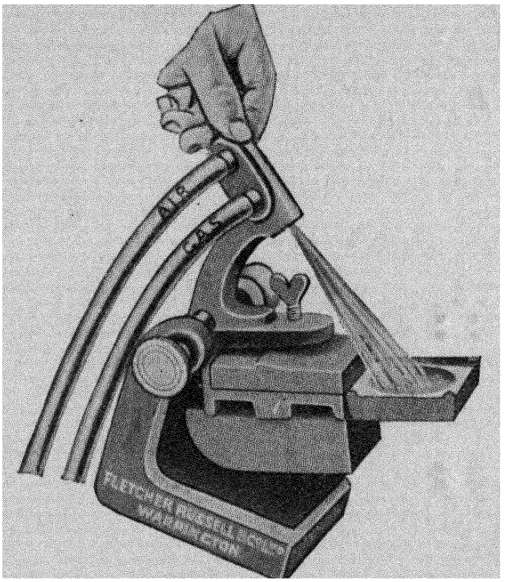

FIG. 10.—Tilting Apparatus shown in Action.

is an important point to consider. It is an advantage to slightly dust the surface with some very fine charcoal powder and to blow off the surplus before closing the ingot mould. This will enable the operator to overcome all difficulties of that kind, if the advice is carefully followed. The smallest size of this apparatus is only capable of melting 3-oz. ingots, and by sliding the two parts of the mould on each other, any smaller quantities can be melted and cast to the width desired. When the ingot mould is fixed to the width required, it is secured firmly in position by the screw on the top (see illustrations). The india-rubber tubes are then

connected in the manner stated, the mixed metals placed in the open crucible, the gas turned on at the stopcock, and you at once commence blowing the wind against the volume of gas with the foot-bellows by treadling with the foot. A little powdered borax is strewn on the metal during the melting, as occasion requires. This assists the fusion, and also tends to prevent the production of dry alloys, through the oxidation of the copper which this kind of melting is apt to produce. When perfectly melted, the metal will revolve from side to side of the shallow vessel containing the fused mass ; the heat should be continued until no thin-pointed bits of metal are seen projecting out of the mass. As the copper takes longer to melt than either the silver or the gold, it is absolutely essential that the heating should be continued until the whole of the fine threads of copper have become absorbed by the gold and silver, so as to form a thoroughly intimate mixture of gold, silver, and copper. No stirring is required in melting small quantities with this apparatus, the revolving of the metal by means of the force of gas employed being sufficient, providing proper fusion has taken place of the copper, the more refractory metal composing the alloy. When the metal is ready for pouring, that part of the arrangement containing the crucible and mould is gently raised by means of the swivel action, and carefully tilted forward towards the operator, when the fused metal runs, in a thin liquid stream, into the ingot mould, and the bar is formed of the width to which the ingot has been set. After a few seconds, to allow of the metal becoming firm, the mould is opened by unscrewing with a pair of strong pliers, the top of the mould removed, and the bar of metal is exposed to view. This is then rolled to the size required for working purposes by means of heavy steel rollers. This melting arrangement is said to be constructed to melt a bar of gold weighing from 2 to 3 oz. in two minutes.

The person in charge of the operation must not feel deceived if he fails to accomplish his work in the time stated, as it will all depend upon the nature of the alloy, and the quality of the gold to a considerable extent, as well as on the heating power of the blast, for a rapid performance to be effected. The apparatus is a very ingenious arrangement, and is useful for small country jobbers and others, who desire to melt small quantities of either gold or silver with very little trouble to themselves, and when the melting is required to be done on the spur of the moment. But,

under the most favourable circumstances, neither the amateur, the scientist, nor even the practical man will succeed in melting the alloys of gold of the weight named in the time stated. Nevertheless, the little instrument is useful in the workshop, and with one or two alternatives may be made more so. I am continually being consulted in reference to one or other of the "difficulties" of goldsmiths, and I have invariably been successful in supplying "simple remedies," which have proved of great assistance to workers in the precious metals. Difficulty is experienced in getting out gold wire from these small "tilters," having very often to remelt the alloy several times on account of the wire turning out brittle and cracky on the surface, even when all new metals have been employed. The smallest of these melters is only arranged to melt 3 oz. of metal, and this quantity can be melted at one time when it is required to be rolled into "flat stuff," and usually with successful results; but when wire is the object aimed at, you either have to cut the bar into strips with the shears at a certain stage in the rolling, or have to resort to several melts, where one should do, by sliding and fixing the ingot mould to the width of the required strips; and this, of course, takes time unnecessarily employed in preparing a quantity of strips, as only one strip could be cast at a time. With 18-carat gold this crackiness on the surface is a particularly prominent feature in converting it into wire, whilst it may be rolled into flat without exhibiting any signs of disintegration whatever. Now the question is, can this defect, which brings with it so many subsequent evils, be obviated? I think it can, and that, too, in a very simple manner, as it has all to do with the shape of the ingot mould. Make the mould deeper, so that a thicker bar can be cast when wire is the objective. Subject the bar to very heavy pressure in its passage through the rolls the first and second time, so as to make its molecular system equal, and you will be successful in your endeavours to procure wire in small quantities, even when the melting has taken place, with the smallest of these tilting arrangements. With lower qualities of gold this crackiness is not so strong a feature as is the case with the quality I have just named; but other difficulties altogether different are set up occasionally, particularly with 9-carat gold, an alloy which takes much longer to melt than most qualities, the chief of which is the liability to oxidation of the copper by the absorption of oxygen gas,

and to the perishable condition of the copper if exposed too long in melting to the influences of the gas jet and to the action of the air; for this metal rapidly becomes oxidised if exposed for any length of time at a red heat to the oxygen of the air, and very indifferent working gold is thus produced. The remedy is, in the absence of any other oxygen absorber, to sprinkle the mass in the crucible with powdered borax (this repeatedly), and to always keep a plentiful supply ready to hand for this purpose. When you observe the mass in melting to assume a rough, dry appearance, it requires a sprinkling of borax; this will reduce the oxide forming into bright fluid metal, and if you can continue it in this state until thoroughly melted, you will be sure to have good metal. But I am not in favour of open melting, although I occasionally resort to it, but in a different way. It is a disheartening proceeding to have to remelt over and over again, to say nothing of wasting the gold, and also the time, which in these days of break-neck speed is an equally valuable item. Therefore, any assistance, however little, in the form of useful information and practical knowledge which is brought to bear, is a step in the right direction, and may, besides leading to commercial successes, be the means of reducing the time of worry and anxiety of persevering craftsmen to one of more pleasant surroundings. I have stated that, by the use of gas furnaces and gas melting, spilly gold is more apt to be produced, but this must be taken in the figurative sense; and it is only just to state that in the manufacture of some kinds of wares those difficulties which are irremediable in some work without remelting the gold, in other work are easily surmounted, and I am now experimenting with a view to the removal of the existing defects from those wares to which I have called attention, and ultimately hope to be successful.

For practical purposes tilters may be used for melting small quantities of gold or silver up to 3 oz.; gas furnaces with foot-bellows, from 3 oz. up to 10 oz.; small gas furnaces with fan, driven by an electric motor, up to 30 oz., and with the largest furnace, 50 oz. with the fan and electric motor. Although any of these quantities can be melted by using the foot-bellows, the time occupied is much longer and the process most tedious in the extreme. The noise caused by the machinery when driven by a motor is most deafening, being plainly heard in the street when near to it. The roar caused by the use of the foot-bellows is not one whit more

pleasant to the ear. Any quantity of metal can be melted at one time with a good wind furnace, but it is usual to build one of a size to accord with the volume of work turned out of the workshop. No noise is created in working with these furnaces, and, when properly built, they are most effective and rapid in working out a number of heats.

A method of melting, and one which I have often had to resort to when a customer has wanted some old keepsakes converted into a special article, and has desired his own gold back again, is of much merit, as all doubt on that head can be at once set at rest, for the customer could see the melting take place; and this could be accomplished by any country jeweller readily enough, though he may be limited to very few jewellers' tools. The plan is as follows: Procure two pieces of stick charcoal—all jewellers should keep these by them; see that they are sound and straight; rub the best of each side down quite flat on a stone. A

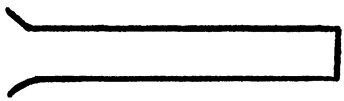

Fig. 11.—A Mould for Melting Bits of Scrap Metal.

file will do if you have not a stone, but it must not be too rough. One of the pieces of charcoal should be longer than the other, for the reason I shall presently state. On the longest piece get cut out a shallow cup-like cavity to lay in the scraps of gold. Then get a piece of thin, flat iron about the thickness of a shilling, and cut a strip off, and bend it to the width and depth you want the small bar of gold to be, as this is to form the ingot mould (see illustration, Fig. 11). The cutting of the strip of iron will depend, as to size, on the thickness and length of the bar of metal required. If it is to be a plain ring, bend the strip of iron to the width of the required ring; turn the ends outward, like sketch, to form a mouth for the melted gold to easily run in without spilling any of it. When the iron is bent into the right shape, make the edges quite flat with a file, so that it fits close to the charcoal: when this is done, draw the sharp edge of a penknife across each piece of charcoal in several places to form air lines, so as to enable the air to be expelled when the melted gold is being poured in, or it would probably shoot up again, and some of it may be lost. In fixing the

ingot together, all you have to do is to put the iron ingot on to the piece of charcoal that has the shallow cup cut in it, keeping the mouth of the iron ingot close up to the shallow cup; then take the other piece of charcoal and place it on the top of the iron ingot, bind the lot together with binding wire, and the ingot mould is complete. Having proceeded so far, hold the ingot up between yourself and the light and look down it, when, if you perceive no light through it, it is right; if you see light here and there, it is not perfect, and may run the gold out. But, to save any further trouble and loss of time, you can put a little wet whiting on the places where the light is perceived. Now put the gold into the shallow cavity you have cut in the lower piece of charcoal, and direct the gas jet thereon by means of a mouth blow-pipe, and continue this operation until the gold melts, sprinkling at intervals a little borax powder on the gold to exclude the air; when the gold has melted, slightly raise the mouth of the ingot, and let the gold run gently in, and you will have a strip of gold available for the purpose you desire.

CHAPTER III

TABLES OF THE CARATS OF GOLD, INCLUDING THEIR WEIGHTS AND VALUES

I HAVE now presented the reader with a descriptive outline of all the principal melting arrangements and the necessary apparatus to be used in the melting of gold and silver beneficial to the trade, and I need scarcely mention that throughout the matter treated of, it has been considered an object of paramount importance to direct attention to those details which are apt to be overlooked, but which ofttimes prove an absolute necessity to the fullest economic results being achieved.

Before directing special attention to the actual melting of gold and silver and their alloys, and to their treatment in the crucible, I must not omit to express by way of the following tables, carefully selected, the valuation of gold alloys, and the divisions into which they are divided, for I regret to state this essential knowledge is not so generally known as practical experience in the craft would assume it to be. The following tables will, therefore, be useful :—

Table showing the goldsmith's carats and their equivalents in decimals of an ounce :—

Carats.	Decimals.	Carats.	Decimals.
24 =	1·000	12 =	0·500
23 =	0·959	11 =	0·459
22 =	0·917	10 =	0·417
21 =	0·875	9 =	0·375
20 =	0·834	8 =	0·334
19 =	0·792	7 =	0·292
18 =	0·750	6 =	0·250
17 =	0·709	5 =	0·209
16 =	0·667	4 =	0·167
15 =	0·625	3 =	0·125
14 =	0·584	2 =	0·084
13 =	0·542	1 =	0·042

Note.—It sometimes happens that fractional parts of a decimal number work out in this table; these have purposely been replaced by the higher numerals.

Table showing the old troy weights and their equivalents in decimals of an ounce :—

Dwt.	Decimals.
20	1·000
19	0·950
18	0·900
17	0·850
16	0·800
15	0·750
14	0·700
13	0·650
12	0·600
11	0·550
10	0·500
9	0·450
8	0·400
7	0·350
6	0·300
5	0·250
4	0·200
3	0·150
2	0·100
1	0·050

Grains.	Decimals.
24	0·050
23	0·048
22	0·046
21	0·044
20	0·042
19	0·040
18	0·037
17	0·035
16	0·033
15	0·031
14	0·029
13	0·027
12	0·025
11	0·023
10	0·021
9	0·019
8	0·017
7	0·015
6	0·012
5	0·010
4	0·008
3	0·006
2	0·004
1	0·002
½	0·001

Example.

Decimals.	Oz.	Dwt.	Gr.
12·000	12	0	0
·550		11	0
·031			15
12·581	12	11	15

Table showing the amount of fine gold contained in a standard pound of any of the following qualities, with their money values :—

Lb.	Carats.	Oz.	Dwt.	Grains.	£	s.	d.
1	24	12	240	5,760	51	0	0[1]
1	23	11½	230	5,520	48	17	6
1	22	11	220	5,280	46	15	0
1	21	10½	210	5,040	44	12	6
1	20	10	200	4,800	42	10	0
1	19	9½	190	4,560	40	7	6
1	18	9	180	4,320	38	5	0
1	17	8½	170	4,080	36	2	6
1	16	8	160	3,840	34	0	0
1	15	7½	150	3,600	31	17	6
1	14	7	140	3,360	29	15	0
1	13	6½	130	3,120	27	12	6
1	12	6	120	2,880	25	10	0
1	11	5½	110	2,640	23	7	6
1	10	5	100	2,400	21	5	0
1	9	4½	90	2,160	19	2	6
1	8	4	80	1,920	17	0	0
1	7	3½	70	1,680	14	17	6
1	6	3	60	1,440	12	15	0
1	5	2½	50	1,200	10	12	6
1	4	2	40	960	8	10	0
1	3	1½	30	720	6	7	6
1	2	1	20	480	4	5	0
1	1	½	10	240	2	2	6

[1] Pre-war prices, at 85s. per oz.

Table showing the amount of fine gold contained in an ounce of any of the following qualities, with their money values :—

Oz.	Carats.	Oz.	Dwt.	Gr.	Gr.	£ s. d.
1	24	1	20	0	480	4 5 0[1]
1	23	...	19	4	460	4 1 5½
1	22	...	18	8	440	3 17 11
1	21	...	17	12	420	3 14 4½
1	20	...	16	16	400	3 10 10
1	19	...	15	20	380	3 6 3½
1	18	...	15	0	360	3 3 9
1	17	...	14	4	340	3 0 2½
1	16	. .	13	8	320	2 16 8
1	15	...	12	12	300	2 13 1½
1	14	...	11	16	280	2 9 7
1	13	...	10	20	260	2 6 0½
1	12	...	10	0	240	2 2 6
1	11	...	9	4	220	1 18 11½
1	10	...	8	8	200	1 15 5
1	9	...	7	12	180	1 11 10½
1	8	...	6	16	160	1 8 4
1	7	...	5	20	140	1 4 9½
1	6	...	5	0	120	1 1 3
1	5	...	4	4	100	0 17 8½
1	4	...	3	8	80	0 14 2
1	3	. .	2	12	60	0 10 7½
1	2	...	1	16	40	0 7 1
1	1	...	...	20	20	0 3 6½

[1] Pre-war prices, at 85s. per oz.

Table showing the amount of fine gold contained in a pennyweight of any of the following qualities, with their money values :—

Dwt.	Carats.	Gr.	£ s. d.
1	24	24	0 4 3[1]
1	23	23	0 4 0$\frac{7}{8}$
1	22	22	0 3 10$\frac{3}{4}$
1	21	21	0 3 8$\frac{5}{8}$
1	20	20	0 3 6$\frac{1}{2}$
1	19	19	0 3 4$\frac{3}{8}$
1	18	18	0 3 2$\frac{1}{4}$
1	17	17	0 3 0$\frac{1}{8}$
1	16	16	0 2 10
1	15	15	0 2 7$\frac{7}{8}$
1	14	14	0 2 5$\frac{3}{4}$
1	13	13	0 2 3$\frac{5}{8}$
1	12	12	0 2 1$\frac{1}{2}$
1	11	11	0 1 11$\frac{3}{8}$
1	10	10	0 1 9$\frac{1}{4}$
1	9	9	0 1 7$\frac{1}{8}$
1	8	8	0 1 5
1	7	7	0 1 2$\frac{7}{8}$
1	6	6	0 1 0$\frac{3}{4}$
1	5	5	0 0 10$\frac{5}{8}$
1	4	4	0 0 8$\frac{1}{2}$
1	3	3	0 0 6$\frac{3}{8}$
1	2	2	0 0 4$\frac{1}{4}$
1	1	1	0 0 2$\frac{1}{8}$

[1] Pre-war prices, at 85s. per oz.

These are the Mint values of the various divisions of gold, and the tables will no doubt be found useful for many little purposes that come within the scope of the goldsmith and jeweller, and also others who have dealings in the precious metal. The table herewith appended expresses the relation existing between the pound and its subdivisions as regards value, thus :—

	£	s.	d.
A pound of fine gold is worth . . .	51	0	0[1]
An ounce of fine gold is worth . . .	4	5	0
A pennyweight of fine gold is worth . .	0	4	3
A carat of fine gold is worth . . .	0	3	$6\frac{1}{2}$
A grain of fine gold is worth	0	0	$2\frac{1}{8}$

With regard to the alloys of gold, they are as various as they are numerous, and endless suggestions have been made by persons having very little practical experience as to the method that should be adopted in the melting for the production of good workable metal. Now, there is not much difficulty about the operation, providing certain rules are followed; and if the manipulations are carried out with a cool action, steady nerves, and a little practice to give the necessary confidence to the person in charge, then there is no reason why the work should not be performed satisfactorily enough as to the point raised. It has been said that experience is the father of invention, and the more experience one has had in this matter, the more able will he be to work in a safe manner and to guard against the difficulties and failures that may otherwise be involved in the process.

[1] Pre-war prices, at 85s. per oz.

CHAPTER IV

MELTING ALLOYED GOLD MIXTURES

THE principal substance used for alloying gold is copper, and this metal is prepared and sold to the workers in the jewellery trades in various states, such as bean shot copper, refined grain copper, pure deposited copper, and Swedish double refined copper in wire coils; with the exception of the first-named, any of the others may be purchased in wire coils, grain, flat, and shotted, in whichever form preferred. The other chief metals used for alloying purposes are silver, composition—a mixture of copper and zinc—and zinc. But it is not advisable to use too much of either of the latter metals for adulterating gold, as an immoderate quantity makes the gold brittle, and, with the higher qualities of gold, they cannot safely be used at all, for the more gold there is in an alloy, the more brittle does it become with these metals as an admixture. Never use impure base metals for alloying gold, more especially in the higher qualities, for, if you do, indifferent working gold will be the result. See that each metal is quite clean before putting them into the crucible. You will soon prove the advantage that will be gained by adopting this plan by the time saved in the subsequent working of the metal. Copper showing oxide on its surface should not be used until thoroughly cleaned, and from my investigations into this subject, which have been somewhat extensive, I am led to the conclusion that the state of the copper is a most important object for consideration in preparing the alloys of gold. The particular oxide which I more especially refer to now is that caused by acids acting upon it in the workshop. Copper used in this state causes what I term dry alloys, and although they may roll into *flat*, they become inductible on being drawn into *wire*. A well-known firm of Birmingham manufacturers consulted me with regard to a difficulty which had been puzzling them for more than twelve months. The trouble was this. They could not melt the gold into a condition which made it suitable for drawing into wire.

For, whilst it rolled into flat, and could be manipulated into the various articles manufactured by the firm from that state, it could not be drawn into wire, breaking short at every attempt to pull it through the draw-plate. At last, in despair of matters ever improving, I was asked to melt a bar of the metal, the opinion being that the fault lay in the melting and not in the materials. The materials were brought to my workshop, together with a new crucible, for me to try my skill. I inspected the alloying metals, rejected the copper—on the ground above stated—and provided some more in its place ; I then proceeded to melt the mixture and cast it into a bar of metal, which, when completed, I duly handed over to the member of the firm who had been watching me. Later on I had the satisfaction of knowing that the remedy had been supplied, and the firm are not now troubled with bars of gold that will not draw into wire. The fault lay entirely with the copper, which my experience enabled me to detect at the outset.

Common bean shot copper, when alloyed with gold, produces hard metal, and it cannot be recommended to goldsmiths on account of the impurities it contains. It sometimes has incorporated with it a little lead, and even antimony ; a grain of either is sufficient to entirely destroy an ounce of 18-carat gold. Their destructive properties are greater the higher is the standard of the gold, and lesser in the lower qualities ; thus, in 9-carat gold, if existing only in infinitesimal quantities, their injurious effects are not quite so pronounced. It may be used for alloying silver.

The pure deposited copper I have not found so suitable as is the Swedish copper drawn into wire, for general purposes, in the formation of the various gold standards. The mode of preparation of deposited copper is of such a nature as to cause the production of dry alloys when it is associated with gold. This defect is nowhere more experienced than in the art of wire-drawing. I have found the best of all copper for alloying gold is that which has been prepared as free as possible from its association with acids, and this is the double refined Swedish copper, sold in wire coils.

I will now proceed to describe the preparation and the melting of the alloys of gold. An alloy is a combination by fusion of two or more metals, as gold and silver ; gold, silver, and copper ; gold, silver, and brass, etc., etc., but when one of the metals entering into combination is mercury,

the resulting mass is termed an amalgam and not an alloy. The term "alloy" will be understood to mean the baser metals with which the gold is combined: thus, silver will be an alloy to gold, as well as copper, brass, composition, zinc, or any other metal that may be used for the purpose of lowering the standard of gold. Many alloys are composed of definite chemical proportions of their component metals, and these are called compounds because they combine chemically. In the majority of alloys, however, the various metals unite in any proportions, and these would consist of compound *mixtures* because they only combine mechanically. The alloys of goldsmiths and jewellers are prepared from a definite proportion of fine gold and of indefinite proportions of silver and copper, or, in conjunction with these, some portions of the other metals I have named, as the case may be, in accordance to the mechanical properties it is desired the alloy should possess, or to the effects they have in producing the several distinctive shades of gold, for there are many variations in this respect. Copper is used to heighten the colour, whilst silver makes it pale. A very slight addition of either of these metals to gold produces a great change, both as regards colour and mechanical properties, and these qualities are only ascertained by long and careful attention to the subject as well as being a practical worker in the precious metal. As the production and utilisation of the precious metals is intimately allied with chemistry in the goldsmith's art, it must be obvious to all acquainted with the craft how important it is that the principles of chemical science should be understood by practical men, and how full of advantages would this knowledge be to them by the furnishing of many a useful idea which must prove of great assistance in the daily routine of the workshop. Having got together the materials for melting, and the proper proportions of the various metals having been correctly weighed, they are put into a plumbago crucible (Fig. 12) and placed inside the melting apparatus for fusion into one homogeneous mass. Some firms always melt sovereigns when they can get them, others prefer the fine gold in grains. Melting sovereigns produces the cheapest alloy on account of the standard being guaranteed by the Mint assayers. The silver used for alloying is almost always in the grain, and the copper, when used from the wire coils, is cut up into short pieces of such a length as would cause them to drop easily towards the bottom of the crucible as

the fusion of the metals takes place therein. When grain copper is used there is no more preparation required than there is with either the silver or the gold, being, in fact, purchased in the same form from the dealers in bullion. The person in charge of the melting usually has fixed quantities of metal to melt at each operation, and it is a very good plan, after having weighed each base separately, to put the whole subsequently into the scales to check the correctness of the first weighing, for by that means fewer mistakes occur, and it is known wherein lies the mistake when an irregularity exists in the total weight, on re-weighing the bar of gold after the casting process has been performed, whether it exists in the gold or in the alloy. I have often correctly decided the point by these means in

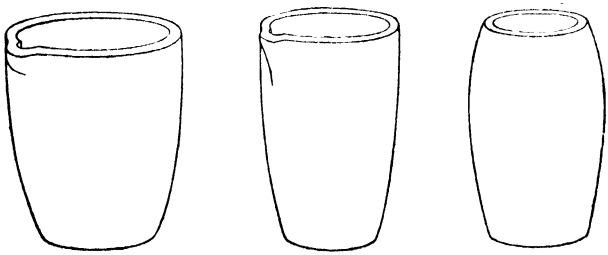

FIG. 12.—Plumbago Crucibles.

errors of my own. In the case of melting sovereigns, these can be counted both before and after weighing, the last count taking place just prior to placing them in the crucible. Black-lead crucibles are used by some persons for melting gold and silver, but they are not so good as plumbago, for they do not stand the fire so well, nor last so long, as the latter. The very best crucibles are the "Salamander" brand of plumbago. These pots will stand fifty melts with ease in the hands of a careful and experienced craftsman. Copper takes a higher degree of heat to melt it than does gold, and gold takes a higher degree of heat than does silver—that is, when each metal is in its elementary state. The explanation of the latter appellation is that each metal in its pure state is an "element," which means it to be a simple substance not compounded with anything else, and from which nothing further can be extracted either by chemical or mechanical means; an element is, therefore, a chemically indivisible body which cannot further be

decomposed or separated into two or more dissimilar substances; it is, in fact, a whole substance complete in itself, and found to be incapable of further analysis, and all bodies of this class are called *elements*. I intend, at a later period, to provide the reader with a table of the most important elements, with their symbols and atomic weights, taking into consideration their chemical and physical properties so far as they are concerned in the work of those who are constantly manipulating and constructing articles in the precious metals.

To proceed with the subject from the point at which the metals are placed in the crucible. The copper should be placed in the pot first, so that it comes at the bottom, the silver next, and the gold on the top. When composition metal, or brass, is used along with the other metals, the latter should be placed first in the pot, then the copper, silver, gold, in the order named. I shall now proceed to explain my reasons for adopting this course. Most metals unite with oxygen, but gold and silver do not in their pure state so readily combine with it as do the inferior metals, and for this reason it is a decided advantage to have them at the top in the crucible. The action of oxygen on inferior metals is such that a considerable amount of oxide is formed on copper, brass, composition, and all similar metals which are capable of rapid oxidation. When these metals are used in large quantities the oxidation appears greater, and increases under the influence of heat in the furnace unless certain safeguards are introduced to prevent it from taking place. The inferior metals should therefore be free from all oxide before putting them into the crucible at the commencement of the melting operation, as they are liable to become strongly affected by the action of the air and the fumes of the workshop if not protected against these influences during the time they are being kept unused. The presence of such an oxide in melting is most objectionable, as the particles of oxide do not actually combine with the fused mass in the crucible, but continue floating on the surface after the melting has been effected, and, after stirring the compound mixture, are liable to become spread throughout the mass in infusible particles; and, though in comparatively minute portions, they offer a decided resistance to the ductility of the alloy, while as regards its malleability, although the effect may be not quite so pronounced, they cause cracks and fissures to appear at regular intervals in the working,

as well as causing the gold to scale at every one of the places where these small particles have embedded themselves in the compound mixture. If in using a kind of melting apparatus wherein an undue proportion of oxygen is created, and if this enters into combination with the fused mass in the crucible, it not infrequently renders it necessary that the repeated operation of melting should be resorted to, and this is always at the sacrifice of both time and metal. To obviate the above troublesome perplexities, various devices have been suggested and tried with the view to their eradication, and although none of these have proved eminently successful, they have thrown much light on the subject, and a greater amount of knowledge has been disseminated throughout the gold-working trades which cannot fail to leave behind some beneficial results. It has been recommended to slightly silver or gild the copper or brass by the electro-process as a precaution against oxidation, having first removed any previous oxide from the metals by a momentary dip in weak nitric acid, the film of the more unoxidisable metal deposited being so trifling as to cause no expense, yet effective enough to prevent the oxidation referred to, and to render the operation of melting more successful in its results. This plan of operations is not likely to be adopted by manufacturers on account of the extra time and trouble involved; besides, it is not so effectual in actual practice as it apparently appears in theory; the deposited metal becomes decomposed during the heating in the furnace, and the inferior metal is again exposed to the fumes of the melting apparatus, unless some other substitute is there for protection. Painting the inferior materials with a thick solution of borax is another device which has been recommended, and then heating them so hot on a clear fire, or, if in small quantity, with the blowpipe and gas flame on a charcoal support until the borax fuses and attaches itself to the surface of the metal. This coating of flux effectually protects the metal from the action of the air and its oxidising influences, and in the case where brass is used, it also prevents in a large degree the volatility of the zinc during the time of fusion in the crucible, for the latter metal is subject to rapid sublimation by fire, and, unless protected in some way, is soon brought into a state of vapour by heat; and, as a resulting consequence, both the colour of the alloy when formed and the weight of the bar of metal when poured out of the crucible would suffer con-

siderably were the evolving of the zinc allowed to proceed by discharging bluish white flakes of zinc oxide for any length of time after fusion has taken place. The physical properties of the metal would also undergo a change for the worse, the metal becoming much harder and more brittle. Writing from an industrial and commercial standpoint, this process, like the one before mentioned, is not satisfactory, for it takes up too much time in the preparation of the metal for melting, and is also a most tedious performance. For that reason alone it is not likely to become adaptable for the use of manufacturers, and further, another objection can be advanced which, I fear, is fatal to its being acceptable to the trade. It loads the crucible with borax, which so covers the fused metals as to prevent the oxygen gas from escaping, and thereby causes it to become mixed with the other constituents of the crucible.

Liquid metal in this condition, upon being poured into an ingot mould, will present blow-holes on the outer surface of the bar of gold or silver. These are caused by the breaking of the air bladders of gaseous oxygen nearest to the outside of the casting through the contraction of the metal in cooling; while those existing in the interior will break out in blisters, as the metal is reduced by rolling to their proximity upon its being subjected to heat in annealing; and in this manner spilly or scaly gold is produced. The craftsman will have observed how dirty looking is the undersurface of the metal upon the breakage of these blisters, and this is metallic rust, produced by the above-named oxygen gas acting on, and combining with, the mixed metal to form oxide. In the production of good metal, this form of oxidation should be most strongly guarded against, and I shall show as I proceed with my teaching how this can be successfully accomplished.

Gold alloys, when prepared with a small quantity of zinc in addition to the other ingredients, or with an admixture of any other substance containing it, are much more liable to these defects than are those gold alloys prepared according to the regular rule with silver and copper only. Zinc, or other metals alloyed with it, if heated much above their melting points for any length of time, absorbs oxygen greedily, and in the presence of air the zinc will burn with a bluish-green flame, and will ultimately become converted into a whitish oxide; in this state it forms the well-known *zinc-white* used in house painting. Most wild speculations

are frequently indulged in by workmen in the workshop when inferior metal comes before them for treatment as to the cause of it, and according to the varying forms in which the oxygen has affected the metal, such expressions as "over-heating," "not half-melted," "full of dirt," "incapacity for correctly performing the work," etc., etc., are often heard, yet very few of these persons have had the least experience in the matter of which they so freely complain to their fellow-workmen. The object of these remarks is to make a more intelligent and better craftsman of the man who never reasons, but simply imitates, by the diffusion of real practical information fit for immediate application, either in the melting shop or in the ordinary workshop, so that it may reach the men, and instruct any intelligent workman to explain the "why" of all the operations he performs; but to do this he must first make himself acquainted with the laws that govern them, and in support of this I shall afford the trade all the facilities and assistance which my capacity and experience suggests in aid of that result, by sober reasoning with the attractive principles of practical craftsmanship compatible with business enterprise.

Unless the mixed metals are protected when melted in the crucible with some kind of covering against the action of the air, they rapidly become oxidised on the surface, and in the presence of a strong draught this action is much intensified. A thick film of apparent dross appears as soon as the metals are melted, and this is oxide, a compound of oxygen with the other elements of the crucible. Now, although borax prevents the *oxygen gas* from escaping if intermingled with the liquid metal, it will, if spread over the surface to act as an entire covering, effectually prevent the oxidation of the metals by the exclusion of the air, and will also dissolve any oxide that may have formed there before the borax is added by withdrawing the oxygen from the oxidised metal, leaving the latter isolated and quite free again to unite with the fused mixture in the crucible in a perfect manner. Borax is a reducing agent, and rapidly dissolves metallic oxides by liberating the metals from their oxygen, and restoring them to their natural state. Borax is a compound of boracic acid and carbonate of soda in equivalent chemical proportions. Then what is boracic acid? It is simply borax deprived of its soda; in other words, it is *oxide of boron*—a combination of boron and oxygen. The resulting effects of using borax in melting

are that the carbonate of soda becomes decomposed, the carbon is evolved as carbonic acid gas by the heat of the furnace, leaving the borax and soda to unite with the oxygen as fast as it is liberated, and in that manner those substances are converted into oxide of boron and oxide of sodium. Gold, silver, platinum, and mercury, in their pure state, are the only metals which deliver up their oxygen by heat alone, and it will be observed when melted in that condition no dross appears upon the surface of either metal. When, however, these are mixed with base metals to form alloys, the poorer the standards are prepared, the greater they are liable to oxidation.

Gold-brass alloys become largely impregnated with oxygen in melting, and are therefore much more difficult of preparation then simple alloys. To guard against the production of air bubbles in these mixtures, it has been recommended to well stir the fused mass in the crucible with the stem of a long tobacco pipe. It is not, however, a perfect success, nor is it a preventive against the mischievous effects complained of. For it not only crumbles and breaks in the crucible through the heat of the fused metals, but fails to extract or set free the oxygen gas created by this peculiar mixture. The remedy has therefore to be looked for in some other direction. The best known remedy is carbon. The various forms in which this substance is to be used will be lucidly explained as the various operations of the goldsmith come up for treatment, wherein its great advantages can be made the most apparent. To return to the state of the copper previous to its being put in the crucible, I have given several methods that have been experimented upon with the view to cleanliness, and to avoid subsequent oxidation. I will now give my own opinion, and while it may probably differ from some, who can justly claim to be capable and experienced craftsmen, there will be others who no doubt will be able to pick up a wrinkle or two from the writer's fifty years' researches into the subject upon which he now writes. When the copper is badly tarnished before cutting it up for the crucible, I have found *emery-clothing* it an excellent remedy for removing oxide or tarnish. It is a very simple method, and answers perfectly well with all qualities of gold; 18-carat gold I have always found the most difficult to melt successfully with bad or unclean copper, but since I took to cleaning the copper I have not been troubled with the repetition of

melting. With this device, and one or two other little things connected with the melting, and with the ingot mould, I have been enabled to reduce the obstacles formerly found existing to the least possible state of being. Having put the several metals into the crucible in the order already mentioned, it may at once be transferred to the furnace, and the metals melted into one uniform mass. If this is done in a wind furnace, a word of advice here is necessary. The furnace, if it has been previously used, must be thoroughly cleaned out; and this must always be done previous to any subsequent melt, providing the fire has been allowed to die out, or the draught of air will be checked from underneath between the bars, and will therefore only go over the top of the bars in front; and this will cause an unusual current of air to pass over the top of the crucible into the flue of the chimney, making the melting more difficult and the liability of the mixture to oxidation all the greater, for at the bottom of the furnace, where the heat is principally required, the temperature is so low as not to be capable of melting a piece of silver wire if placed on the bars, the heat being centred at the top of the furnace. It is an important point in rapid and successful melting to see that the furnace is not choked, and that it be not lighted on the old clinkers left from the previous fire, and also that the bars are sufficiently wide enough apart so as to let the proper quantity of air through between them, for, if allowed to go over the top only, you will not be able to get heat enough for all the purposes required. The furnace should therefore be thoroughly cleaned out to commence with. Having explained the difference between metallic oxides and gaseous oxygen, and also directed attention to the destructive properties resulting from their union with the alloys of goldsmiths and jewellers, I shall now proceed to show how these defects may be avoided; but before doing this I would further urge upon the reader the knowledge that *metallic oxides* are produced by the combination of *metals* with *oxygen*, the fused metals acting as the base for that union when unprotected from the air. *Oxide* can only occur to a limited extent on the surface of the molten metal in the crucible, the interior and main portion of the mass being unchanged, whereas *oxygen* may be dispersed throughout the liquid metal in its *gaseous form*. It is to this form of oxygen that blistering metals are in the main attributable, while to the oxide can be attributed those

little discs on the surface of the cast bar of metal often to be seen, and these may extend to the inward parts as well, that depending upon how the metal has been poured into the ingot mould; these do not form a true mixture with the liquid metal, and in the rolling and working, this particular form of oxide causes the gold to scale and crack in angular and other shapes, to the great annoyance of the worker, for he never knows at what stage of the process of working the metal they may break out, if once having been allowed to become mixed with the clear metal in the operation of pouring the melted metal from the crucible to the ingot mould. One more example with regard to the effects of oxygen on several of the metals may be given to show how the gas is absorbed. Silver is the best known precedent for this. In the way of experiment, take a little pure silver and melt it with the gas jet and mouth blow-pipe exposed to the air on a charcoal support, and carefully notice, as the metal cools and solidifies, how the *oxygen gas* is liberated by the breaking of the outer crust of metal as the solidification proceeds. This is caused by the gaseous oxygen confined in the interior of the mass forcing its passage through the semi-solid outward parts, thus giving rise to what is generally known as the "spitting" of silver. The *alloys* of the precious metals do not, however, reject it in this manner.

Pure silver is generally regarded as being neutral to the absorbing of oxygen by the mere application of heat; yet, nevertheless, it is prone to absorb a portion at certain temperatures or degrees of heat, and to cast it out again on cooling. With regard to the phenomenon of spitting, my own opinion is that the oxygen is taken up by the silver after the fusion has been effected, by too suddenly withdrawing the liquid metal from the heat of the gas flame, or from the muffle, into a colder atmosphere; and in this manner the oxygen is absorbed, to be again ejected by the silver as the cooling proceeds, and just before the metal has reached the point of solidification. In support of this I will urge that, if the fused silver is held quite close to the gas flame, and allowed to *very gradually* become solid, no spitting will take place; or, if it is quickly poured into a closed ingot mould, without undue exposure to the air, no spitting or sprouting will result from the operation. Therefore the sudden evolution of oxygen from the cooling silver, made evident by the throwing out portions of its

substance on all sides, must depend on its being removed precipitately from the muffle, or from the gas flame, into a temperature abounding with oxygen, such, for example, as atmospheric air, which contains a very large quantity of that substance; and that is how it is absorbed by the silver at a certain stage of the manipulations, I feel confident.

Silver Spitting

Rapid cooling of the silver by means of pouring into a mould, or of very slow cooling by means of keeping it within the gas flame, or withdrawing it to the mouth of the muffle, will prevent the escape of oxygen gas in cooling, from breaking through the outer crust when it is absorbed by the silver; but the oxygen will subsequently show itself, when the silver comes to be rolled and annealed, by a series of blisters appearing after each heating, and this is strong proof that the blistering of metals is almost entirely due to the influences of this gas, and not to several other causes which have been assigned to it.

If, however, the silver is melted at the lowest temperature and well protected from the action of the atmosphere, no blisters will result from the operation. It is the overheating in the melting of silver which causes principally the absorption of oxygen gas, and of its remaining in the fire in a molten condition too long after fusion has once taken place. It is said 3 gr. of cadmium added to a sterling silver alloy will prevent blisters.

In the mixing and melting of jewellers' alloys it will be found much the best to follow certain fixed rules in order to obtain the most satisfactory results, both with regard to the least possible waste of materials and to the procuring of perfectly homogeneous mixtures, without any of those faults and blemishes to which the reader's attention has been already specially directed. Before putting the crucible, with its contents, into the furnace it is advisable to add a small quantity of the *finest wood charcoal* to protect the mixed metals from the action of the air draught of the furnace from the time fusion first commences to its final completion, so that at no time during the operation would any part of the substance forming be exposed to its action, for it is usual for the most fusible metal to liquefy first and so cause the other metals to become dissolved in the order of their fusibility, one into the other, into a liquid

mass. The adoption of this plan protects all the metals all through the process. The quantity of charcoal necessary for the above purpose may vary from a teaspoonful to a tablespoonful, in proportion to the size of the crucible used and to the quantity of metal to be melted. Too much charcoal is an obstacle, but on no account should it be allowed to be withdrawn from the surface of the fused mixture by the draught of the flue, as to expose the metal, for that would cause oxidation to take place. Additions must be made in such cases, as circumstances permit, in small quantities so that a continuous thin layer of charcoal is always covering the metals to act as a protection from outside influences. By following these simple rules very little attention is required to be bestowed on the mixture until complete fusion has taken place. It is much the best plan to let the metals run down of their own accord than to be constantly poking at them with a rod of iron, the idea being that assistance is given to the mixed metals which promotes their more rapid fusion. This is all nonsense, as the process is more injurious than beneficial, for besides being liable to the incorporation of minute particles of iron through their being detached from the iron rod and entering the mixture, which causes the alloy to be harder, it reduces the cohesive power of the several metals which are essential to the production of a perfect working alloy suitable to any of the various branches of the precious metal industries. In short, it tends to make the metal harsh. I have seen operatives at the furnace stirring for upwards of five minutes, and I have been informed that in one of our largest bullion dealers' refinery works the person in charge of melting there actually stirs the mixed metals for quite fifteen minutes continually. Now this is not necessary. Many definite and uniform alloys are formed without any stirring at all, and I have repeatedly tested the proof of this assertion in the better quality of gold alloys for hall-marking purposes, and their having passed safely through the assay offices certifies to their having been completely and intimately mixed, for the slightest error of uniformity would there have been detected. The state to which the fusion of the mixture in the crucible should be extended is to that of a thin watery fluid ; it must be brought much below a creamy consistency, otherwise it would not flow from the crucible into the ingot mould freely enough to produce good castings, and the metal would be incompletely mixed. The thinness

of the liquid should be of such a nature as to offer very little resistance, if any, to the stirrer when tested with that instrument, although a white heat is not necessary, and with the *lower quality of alloys* such a condition must not be allowed; but, on the other hand, if not sufficiently heated, a partial separation of the metals takes place in the pouring, owing to their unequal gravity, and a complete incorporation is thereby not obtained. The very small portions of which mixtures and other substances are composed are called *molecules*, and these, as the heat increases after liquefaction has taken place, are in a state of rapid motion. A peculiar spinning motion is acquired when the heat reaches to a certain stage in the process, and the mixture appears to revolve or roll round in the pot. In this manner the molecules of the mixture constantly strike each other in their passage to the sides of the crucible, and by rebounding have the directions of their motions changed. Now, were it not for this action, the sides of the crucible would become much more worn than they do. The fact that a constant force was being exercised, and the continuous pressure this brought to bear on the inner sides of the crucible, would cause fragmentary pieces to be detached therefrom, and the safety of the crucible would be endangered thereby, were it not that the total pressure is broken by the collision of molecules which occurs through this peculiar spinning or rolling movement of the mixture in the crucible. It can reasonably and practically be assumed that the turning motion commences at the bottom of the fused mass in the crucible and continues its course upwards in the same direction as the heat of the furnace, and, if that is so, it is not possible for an enormous number of molecules, which the mixture would consist of, to be travelling simultaneously to one side of the crucible only; it is by far the more probable that they move in different directions, and in that manner strike each other in their path and cause the molecules to be split up into smaller fractions—for such a thing even as a molecule, small as it is, getting across the crucible without striking another under the circumstances would be impossible, and this is why some mixtures become thoroughly incorporated without stirring. I do not mean to convey the impression that all the metallic mixtures of goldsmiths are capable of becoming intimately associated by heat alone and without stirring. That will depend, firstly, on the fineness of the quality; secondly, on the degrees of heat

to which the mixture is submitted; and thirdly, on the quantity of metal to be melted in one charge. But what I do contend is that under certain conditions the metals mix themselves by revolving each way in the crucible when melted, and the concussions thus occurring cause the molecules of the mixture to break into smaller particles, and these become each time more enveloped with the fine gold, in consequence of the latter's great powers of expansion, until a homogeneous mixture of uniform quality is formed.

The object of adding charcoal with the mixed metals in the crucible at the commencement of the melting operation is twofold in its advantages, for it not only protects the metals of different degrees of fusibility whilst in the fire from all oxidising influences, but by the heat of the furnace in the presence of oxygen it becomes converted into *carbon dioxide* (CO_2), a gaseous compound of one atom of carbon and two atoms of oxygen usually called carbonic acid; and in this conversion it absorbs and takes away that portion of the oxygen gas from the compound mixture which is liberated during the process, for charcoal has a powerful affinity for oxygen, and not only decomposes metallic oxides but will also deprive other substances of their gaseous oxygen. It is a *deoxidising agent* of great value, and is much used for metallurgical purposes, being infusible in any degree of heat to which a furnace can be raised. In a melting charge to which no charcoal covering has been given, or in one which has lost it through the draught of the furnace being excessive, and the mixture, in consequence of this, has its surface covered with a thin film of metallic oxide, that film may be dissolved again by means of powdered charcoal; its chief constituent, carbon, will combine with the oxygen with which the metal has become united, and, by thus compounding itself, forms carbon dioxide through the heat engendered, the gaseous elements being at the same time expelled in carbonic acid fumes; while the mixed metal, from being deprived of its oxygen, is left free again in the metallic state the same as before oxidation, and will join with the mixture in the crucible in the ordinary way. Charcoal is, therefore, classed as a flux, because it causes the metal to flow from its oxide to its metallic and natural state. The quality of the charcoal and also the form in which it is best to use it are points of considerable importance. Some furnace operators prefer *lump charcoal* for covering metal in the crucible, whilst others are strongly in favour

of *finely powdered charcoal.* The latter is much the best when it can be procured free from gritty particles of foreign substances, for it is capable of entirely covering the metal, and this is highly essential, especially when the metals to be fused together in the crucible require very different degrees of heat to melt them. With lump charcoal no complete covering can be effected, and under the conditions named, some of the mixtures would be liable to rapid oxidation ; and one of the effects of this is that some workmen at the furnace continue the heat so long, under the idea that they can melt the oxide into clear metal, that the whole mass becomes overheated and the alloy burnt—a term applied to harsh dry metal. My advice is, always use the powdered charcoal, and see that you get it fine and pure, quite free from grit, for the finest powder should appear to the touch as smooth as flour. There is always a difference in the working of silver standard bars purchased from houses who use lump charcoal in their melting, from those who use powder, for the latter possess far greater pliancy and strength than the former. I am now speaking of the melting of large quantities of metal in one charge, wherein the heat has to be prolonged, and not of small quantities requiring a lower degree of heat to effect a fusion. It is best to use the powder in a perfectly dry state, and not too large in quantity, for, if too much be used, it makes the molten metal more difficult to pour clearly, and the bars resulting from the process would show a roughened surface instead of that clear, smooth exterior which all practitioners aim to produce. But a rough surface to the bar, providing there are no lumps of charcoal embedded in the edges, makes no difference to the working manipulations afterwards to be bestowed, and some of the very best metal for working has sprung from rough-looking ingots. An experienced person can generally tell when an ingot is all right by its looks immediately after casting.

Stirring the metal in the crucible, when melted, with a stick of wood has many claims to recommendation over those of stirring with a rod of iron, for freshly burning charcoal possesses many remarkable properties, among them that of absorbing and condensing gases within its pores, and, as the combustion proceeds, evolving them again in blue fumes ; also in the burning of the wood to the charcoal state by the molten metal great heat is created, which helps to promote a more rapid and intimate mixture of the

different metals, and whilst thus acting as fuel, it at the same time serves as a most powerful reducing agent by withdrawing the oxygen and other gases which may happen to be dispersed throughout the mixture, with the result already stated that carbonic acid gas is principally created by the burning of the wood into carbon in the presence of such deleterious substances, and this gas, by escaping with the fumes which arise in the conversion, leaves the metal isolated and free from oxygen. The conclusions to be drawn from these combinations of forces are that it is highly probable that, by introducing a volatile substance like unburnt wood into the melted metal in the crucible, and stirring at the same time as to cause extra agitation to arise throughout the entire body, any extraneous substances which may have become diffused in the mixture are brought to the surface and there disposed of either in vapour or held in the flux instead of being cast in the bar of metal to break out in the subsequent stages of working it. The thickness of the wooden stirrer must vary in accordance with the quantity of metal being melted at one operation. Wood that burns very slowly and is close grained should be chosen over all other kinds. Dried willow or firwood has always proved satisfactory with me in the matter of work such as I am now describing. In following the simple rules herein laid down, the time usually occupied in stirring the fused mixture is reduced to a very short period, about half a minute or so being ample to effect a thoroughly intimate union of the mingled ingredients within the crucible. The wood must be well dried before using it, for, if introduced into the hot metal in a damp or moist condition, it would cause some of the metal to spit up and become lost in the fire. When the stick is first put into the liquid metal a violent revolution is set up in the fluid, great heat being evolved, and the mixing is thereby much facilitated and its equability is freed from difficulty by its molecules being more evenly distributed throughout the mixture, and uniformity of quality is, by those means, made easier of performance. When the stirring is finished the crucible should be immediately withdrawn from the fire, and the contents at once poured into an ingot mould provided for its reception, so as not to allow time for the precious metals to partially separate from their baser elements by the act of gravitation, and thus cause the mass to be of unequal standard as a whole body.

Fig. 13 shows the position in which the ingot mould should be fixed for receiving the metal, and also the proper mode of pouring, which should be towards the person who performs the work, and not sideways—a system adopted by some. In melting gold and silver of ordinary weights, such as the majority in the trade require for manufacturing purposes, the straight-nose tongs are used, and the crucible is grasped in the manner shown in the illustration (Fig. 13); but when large quantities are to be melted—that is, consisting of hundreds of ounces in one charge—the crucible tongs (Fig. 14) are used, and the manner of gripping the pot with them is also clearly made manifest in the sketch. The

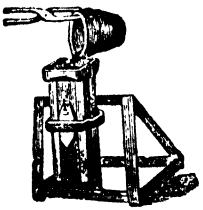

Fig. 13.—Ingot Mould, showing the position in which the metal is poured into it.

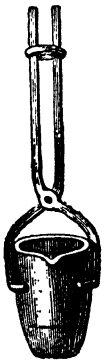

Fig. 14.—Large Tongs gripping Crucible.

pouring of the gold or silver into the ingot requires some amount of skill and practice, as well as steadiness, to perform the act to the best advantage; and it is advisable to place the frame carrying the ingot mould in a suitable trough, for, in case any of the gold or silver got spilled, it would be caught in the trough and saved. The charcoal, including any other substance floating upon the surface of the molten metal in the crucible, may be prevented from running into the ingot mould with the metal by holding a thin piece of flat, dry wood against the mouth of the crucible with the left hand whilst pouring. This will prevent the charcoal, and any other organic substance which the crucible may have acquired in the process of melting, from leaving it, and which may cause defective bars of metal to be produced if allowed to go into the ingot mould with

the metal. A thin strip of match-boarding answers the purpose admirably.

The position of the ingot mould requires a word or two in explanation of the most practical way of placing it to receive the metal. It should not be quite perpendicular, but slightly slanting; not too much so, as that would be as bad as fixing it quite upright. The position should be such as would allow of the mixture flowing straight to the bottom without running down the iron. The ingot mould must be warmed and very slightly greased, and in the case of new moulds, being used for the first time, a thin coating of charcoal must be dusted over the inner surfaces to prevent the metal sticking to the iron. When the ingots have been used a few times this will not be necessary. Too much grease must not on any account be used, for that would cause the metal to spit up and throw itself out of the mouth of the ingot. The ingot mould ought to be made sufficiently hot to just burn off the grease and leave no liquid substance behind. Cold ingot moulds cause the metal to be ejected with violence, and it is a highly dangerous proceeding to attempt to pour molten metal into them.

If the ingot moulds are used a few degrees below a red heat, very much softer working metal is produced than is the case with those of a much lower temperature; but the mixture takes longer to become solid, and the charcoal is liable to be embedded in the surfaces of the casting if allowed to go into the mould with the liquid metal, thus causing its surfaces to present a rougher exterior. And it is also just possible that in the lower qualities of gold alloys it may cause a concentration of gold towards the centre of the bar, through the extra time required in solidifying, in consequence of the high specific gravity of gold above its associates, although I have not as yet detected any of the effects of this with the standards I employ. Nevertheless, it is of some importance that the question of liquidation should here be mentioned and safeguarded, for it has special relationship in the preparation of ingots of the precious metals in which their manufactures are to be hall-marked; and the doubt is—in using the ingot mould too hot—that the gold may have a tendency to separate from its baser ingredients and become concentrated in that portion of the cast bar of metal which solidifies last—the centre—and thus become uneven in quality.

Ingot moulds possessing a tun-dish-shaped mouth are

the best and safest for pouring the liquid metal into. With these moulds the operator is less liable to a mishap by accidentally spilling some of the metal, and less care is required in the process of pouring. Besides, the metal can be poured much more quickly than is the case when employing moulds with narrow openings, which sometimes causes the metal to flow over the top, unless great steadiness and skill be exercised with regard to speed and distance. And with the thick-lipped crucibles, as now manufactured, the operation is rendered much more difficult and trying; especially is it so to the inexperienced and to those possessing a nervous temperament. The ingot mould should be well cleaned inside and the corners well attended to before it is screwed together, or it may let in air, and this would cause irregular edges to be given to the bar, by the force of air preventing the liquid metal from taking its full place in the mould and equally filling its entire space. It may also cause the metal to run out if the two connecting parts of the mould do not mitre perfectly. The latter may be checked by mixing some whiting with water to thick consistency, and applying it to that part of the ingot mould from which the escape proceeds. The ingot moulds should be perfectly close fitting.

The thick plumbago crucibles, as now made, are very awkward to pour from, so as to prevent the charcoal flowing along with the metal, on account of there being scarcely, if any, lip to them. I have found that, by slightly reducing the thickness at the lip by means of a small knife, half-round file, or a three-square scraper, so as to leave a kind of hollow inside the crucible, the pouring is made much easier of success, and the charcoal or other flux covering the surface of the metal is more readily held back in the crucible until all the fused metal has run out into the ingot mould, and the result is eminently satisfactory if the hollow is not made too large.

Gold and silver ingots are more frequently than otherwise cast with a deep hollow in their ends, and when they come to be rolled and slit into wire there exists at one end of every strip of wire a split which, in some cases, extends several inches, having increased in length in due proportion to the sound part of the ingot in the rolling. This makes an enormous quantity of scrap, as it is useless for wire-drawing purposes, and has to be remelted, which not only causes loss of time and metal, but adds to the expenses of the

establishment the further cost of re-rolling. I have seen as much as 40 oz. taken off a 600-oz. ingot of silver for re-melting through this cause. At my suggestion, at some of the bullion establishments the ends are now cut off hollow-end ingots before sale, thus effecting a great saving to those purchasers who find it the most economical to produce their material in ingot form ready for rolling, as they get all solid metal without waste. Hollow-end ingots, when rolled into flat "stuff," present the same difficulties as those above named with regard to a portion being unworkable. This division of the metal at the upper end of the bar is caused by contraction. When the molten metal is poured into a moderately hot mould, it begins to solidify first at the places where it is surrounded and touched by the iron forming the mould. The interior of the mass of metal, therefore, remains liquid the longest, and the solidifying of the interior proceeds upwards to the mouth of the mould. The consequence is this, that as the metal becomes solid it contracts—usually called shrinking—and the last part to become solid—which is the uppermost part of the centre—shrinks the most in the final stage, and in that manner the bar of metal is left with a more or less deep hollow space in its uppermost end. To prevent that hollow space occurring is the problem, and its solution should prove a boon to whole colonies of precious-metal workers, for it has baffled the skill of most of the best furnace operatives, and caused endless annoyance to thousands of workers, besides being expensive to master goldsmiths and silversmiths by its stubbornness in resisting the least change towards more economical productions. Now there are two ways by which these hollow ends may be obviated. The first is, by pouring the molten metal from the crucible very slowly into a moderately heated mould, but with the lower quality of alloys this device may cause a partial separation of the different metals forming the combination, which would be fatal to success when the work executed from the metal had to be assayed and hall-marked, for no true chemical compound is formed by the indefinite proportions of the different alloying metals taken by individual goldsmiths for the composition of their most useful alloys. Such combinations are nothing more than *mere mechanical mixtures*, and on account of the varying proportions of the component metals used, of their unequal degree of fusibility, and of their widely different densities, divisions are likely

to occur in the mass through some portion of the heavier metals separating from the lighter ones, and gravitating, even whilst in the act of pouring, in this case, to the bottom of the crucible, thus causing the last part of the mixture poured from the crucible to be richer in gold than the first, or even the middle part. Too slow pouring of the ingredients from the crucible to the ingot mould is therefore out of the question, and cannot be recommended. But what I am now going to suggest has all the elements of success about it, inasmuch as it is supported by the results of experience, not only of my own, but of others, to whom I have communicated the secret. I have already stated how hollow ends in cast bars of metal are caused, and for their prevention it will not require an expert to see the force of the device I have brought to bear in its relation to this subject for practical and utilitarian purposes. It is this: If the melter of gold and silver bar ingots quickly taps or shakes to and fro the top of the iron mould once or twice *immediately* after the metal has been poured into it, the hollow forming by contraction will be instantly filled up by the surrounding liquid metal, and a perfectly rounded end will be the result. No scrap ends will follow in rolling the bar after the adoption of this principle—in fact, the metal at the end has proved even more tenacious than the most sceptical would have imagined. Of course, the tapping or shaking must be applied before the metal has had time to become solid. It can only be accomplished when in the liquid form. When the workman has acquired proficiency in this art, he will be amazed at the results achieved; he will at once become a more valuable employee in the great saving effected by his skill, for there will be no more cutting off of the ends of the bars before they are rolled, or off those of the metal at any subsequent stage; all will be solid and good, and to which no workman will take exception. The tapping of the ingot mould is done with the tongs holding the crucible. By pushing the mouth of the crucible backwards from the mould after the pouring is completed, a portion of the tongs will be then exposed over the top of the ingot mould; and with this part, while still holding the crucible, the tapping or shaking is to be performed. To facilitate this object, the iron moulds require to be more highly heated.

It may be said by some that by adopting this plan for the prevention of hollow ends to their bars, it would so

shake the partially cooled metal as to interfere with its grain, and thus destroy its working qualities; but such is not the case, for of this I have, along with others I have instructed in the operation, most fully established the fact, by testing nearly every quality of gold and silver alloy likely to be suitable for goldsmithing and silversmithing work; and as nearly all alloys possess different properties from the separate metals which compose them, it must be allowed I have given the plan a pretty fair trial before informing my readers of its inestimable advantages to their trade.

It is not generally known that all the physical properties of native gold and silver are considerably affected by alloying with another metal; and what is said of pure gold cannot be said of its alloy. The alloys become, in most cases, more fusible, less ductile, and infinitely less malleable, whilst they gain in elasticity, tenacity, and become very much more durable; and these advantages to industrial pursuits more than compensate for the loss of the other qualities. Silver and copper are the best metals to alloy with gold, and copper is the best metal to alloy with silver, because they produce the least change in the all-round properties which the noble metals possess. Various grades of colour are produced by using in the mixing indefinite proportions of the two inferior metals along with the gold. When special grades of colour are, however, required, other metals are occasionally introduced, but they mostly deteriorate the working qualities of the mixture. Of the alloys of gold I shall have something special to say at a later period regarding their characteristics and distinguishing properties; suffice it to say here with regard to *pure gold*, every advantage has been taken of its extreme malleability and ductility, in which it far surpasses all other metals, to make the smallest quantity cover the greatest extent of surface, and its perfect freedom from alteration by exposure to the atmosphere and all other influences has greatly enhanced its value in commercial undertakings, for a grain of pure gold has been found to admit of being divided into 95-1,000 million of visible parts by the aid of a powerful microscope magnifying 1,000 times. Another of the great properties of *pure gold* is that when heated, with access of air, it neither loses by evaporation nor combines with oxygen, even at the highest temperature of all ordinary melting furnaces.

Zinc-gold alloys are the next mixtures to be considered,

and as this peculiar method of alloying is generally adopted for special purposes, the processes of melting and working these alloys will now be treated upon as far as my own experience and observation have enabled me to form an opinion, for there are many peculiarities in the preparation and working of them of a nature not to be encountered in the treatment of the ordinary alloys of goldsmiths and jewellers. With a judicious blending of the several ingredients which form these preparations, an alloy of gold can be made presenting all the appearance of one much higher and richer in quality, as well as combining with it the great advantage of lightness, and that in this competitive age means cheapness. The advantages of employing a mixture of this kind are therefore at once made evident, for besides its resemblance to an alloy of gold of two or three carats higher standard, by its lightness it can be made to show a greater surface to the finished article, and the cost of the usual alloying materials may be reduced by about one-half, in the saving of that amount in silver. Such are the advantages to be gained by the use of zinc in gold alloys. The attendant drawbacks are that, if gold is combined by fusion with a small quantity of zinc without regard to the degree of standard, and to the other ingredients used along with it in the formation of the mixture, the resulting compound will be brittle, and unworkable, and not in any way useful for manufacturing purposes. Therefore, great discrimination is required in order to obtain the best results from its employment.

In first attempting to use zinc, in the preparation of gold alloys, of course, there will be a few difficulties to overcome, and these will be found to exist, firstly, in the melting of the metal, through the men not being familiar with the treatment of the metal, and not knowing exactly how to introduce it into the crucible, and that is one of the principal reasons why complete success is not obtained as often as it might be, because the zinc is not properly introduced ; and, secondly, in the working manipulations, which require an exceptional treatment in order to obtain the best results. It is absolutely necessary that certain regulations should be adopted in the melting to prevent the oxidisation and volatility of the zinc, for, if this is allowed, it not only changes the colour of the metal, but makes it much harder than would otherwise be the case, as well as incurring loss in the weight of the cast bar of metal, which

it is essential should be avoided. The requisite information for safeguarding the metal from accident in the working processes will be subsequently given. To return to the subject of melting, one of the most difficult matters in connection with the melting of highly infusible metals along with another metal of easy fluidity is to produce a mixture possessing the same proportionate fineness throughout the whole extent of the ingots cast, owing to the liability of the more fluid metal to liquate from the others in cooling. This is principally due to the different melting-points of the several metals employed in making these alloys, for while gold melts at about 1,922° F., zinc will melt at 779° F.; and when a small quantity of the latter metal is introduced into a much larger volume of the former metals, a portion comes to the surface and is oxidised, and the desired advantages are partly destroyed by such action. Again, when any portion of the zinc does oxidise through the heat being too great, some remains diffused in the mixture, in the form of an oxide of zinc, and this will show on the surface of the gold when it is rolled into a sheet, and then polished to a finished surface. If, however, the zinc is properly introduced, there is no reason at all why it should become oxidised to that state as to prevent the finish on such an alloy from being not only equal to but superior to those usually obtained with the ordinary alloys of goldsmiths, and this is the real object of its introduction into the mixture. The process to be adopted with the view of mixing zinc with the other materials in the melting is this: When the gold, silver, and copper in the crucible are well fused under a thick layer of charcoal powder, the zinc is prepared for dropping in by previously heating it, almost up to its melting-point, and then forcing it under the layer of charcoal; and the moment it becomes dissolved into the mass—the latter process being facilitated by stirring with a stick of charred wood—the whole is poured out, no time being lost in doing this, or the sublimation of the zinc would take place so rapidly as to cause great loss of metal, and the proportions of the various metals would be so affected by the loss as to entirely change the colour of the gold alloy from the one desired to be formed. The charcoal covering will, in a great measure, prevent the burning of the zinc, and should a little oxidisation of zinc take place beneath the surface, which can hardly be expected to be entirely avoided, when it is considered that the fusing-point of the other metals, to be united with it,

are equal to the *boiling-point* of zinc, and at that point zinc becomes rapidly oxidised if the heat be long continued. If, as I have previously said, a little oxide of zinc formed in the mixture through any of the causes to which reference has been made, the addition of a small quantity of chloride of ammonium (sal-ammoniac) to the fused mass in the crucible will dissolve the oxide, and clear the metal so effectually as to prevent any mischievous results from following. After the fusion of the mixture, and an intimate union has been formed by well stirring, a rapid cooling is necessary to prevent unequal disposition of the gold. To assist in the accomplishment of this, the ingot mould should be adapted for casting a much thinner bar, and it need not be heated so hot as for ordinary alloys, so that the mixture may solidify immediately it is poured into the ingot mould. If allowed to cool very gradually, the particles of gold, being much the heaviest, have a natural inclination to fall downwards through the mass, leaving the zinc to rise upwards as the cooling proceeds, and in that manner articles intended for assay and hall-marking would become useless in consequence of imperfect mixing. The sudden cooling will prevent the unequal disposition of the ingredients contained in the alloyed metal, and which, previous to pouring out of the crucible, had been kept in a state of agitation; and when followed by a quick pouring of the fused mass from the crucible, according to the manner suggested above, scarcely any difference will be found to exist in any part of the whole, always providing too much zinc be not used. I have given this subject a most fair trial, and have come to the conclusion that it is unsafe to use too much zinc in gold alloys for hall-marking purposes, on account of the very great difficulty of preparing real homogeneous mixtures, the zinc having a great tendency to disperse itself in unequal quantities in all parts of the mass. These results were verified by assays taken from every part of the prepared bars of metal, and renewed again and again, after remelting several times the same preparation; for no two assays came out the same, and I had to give up the work ultimately, as being thoroughly beyond my capacity to accomplish, with the experience I had at the time of experiment. But it will be only right to say that it was with an unusual proportion of zinc that I was working to obtain a very specific object. If I did not quite accomplish the purpose for which I aimed in those researches, the work entailed taught me a great

deal in the matter of alloys, and of their physical properties, which has not been lost, as the following little incident will illustrate. I was lately consulted by the principal of a firm of melters for the trade about an alloy which had been prepared with a little zinc as one of the alloying metals. The chief difficulty habitually attending the performance of the work was the production of metal of a slightly spilly nature, and of its cracking in places—thus, V. It was a high quality gold alloy, and on my asking: "Why use spelter at all?" the answer was immediate: "Oh, for the colour." The bar of gold came out in the casting all right, and rolled well, with the above exceptions. I concluded that the cracking and the spilliness were due to the oxidisation of some portion of the zinc, and that opinion turned out to be the correct one, for, on asking a few questions, my interviewer admitted the use of *lump* charcoal in the melting, and the possibility of letting the fused mixture remain in the fire too long after the zinc was administered to it. On this admission, I at once perceived the cause of the trouble, and was enabled to render assistance, and thus help the gentleman out of his difficulty. The fault was that, by using lump charcoal, no protection was offered against the oxidisation of that portion of the zinc which rose to the surface, whilst the prolonged heat of the fused mass of metal in the crucible oxidised the zinc below the surface faster than it could rise to the top, and this oxide went into the gold bar along with the liquid metal on its being poured into the ingot mould, to afterwards break out in the way described. My advice was, to well cover the surface of the molten metal with the finest charcoal powder; to nearly melt the zinc before putting it into the crucible, and, when put in, to force it at once under the charcoal covering; to stir the mixture immediately with a wooden stirrer, and to pour without the least delay after that had been done, using as flux a little sal-ammoniac in powder in case any oxide of zinc should happen to form in performing the work. Powdered rosin cautiously administered is an excellent flux in preventing the oxidisation of the zinc. The powdered charcoal covering prevents the oxidisation of any of the other mixed metals as well as the zinc by excluding them from coming in contact with the air. Stirring with a wooden stirrer causes the oxygen gas arising in the mixture, and unable to escape, to be converted into carbonic gas, and it is in that form driven off in vapour. And the sal-ammoniac

decomposes any oxide of zinc which forms in the mixture, thus clearing it of all deleterious substances.

Gold alloys in which zinc forms a part, if cast at too high a temperature, are brittle and hard; but when cast at near their melting-point are comparatively soft and malleable. Overheated metal of this kind is invariably porous, and the other extreme, if too cool when being poured; there will not be the necessary cohesion of the molecular parts of the several metals to form sound and compact ingots of sufficient firmness to bear the strain of working. The metal should be poured in an uninterrupted stream into the mould, otherwise flaws will, as a rule, be formed, and the bars will turn out faulty. Smooth bars are produced by keeping the inner surfaces of the iron ingot mould quite level and smooth, the degree of smoothness depending considerably also on the speed of pouring, slow pouring facilitating the object sought. The mixing of a metal with so low a fusing-point as zinc possesses—with the more refractory metals—is always attended with some difficulty; but its accomplishment may be rendered more easier of success by introducing it in the form of brass, composition metal, or gilding metal. As each of these preparations contain altogether different proportions of zinc, the one could be selected holding the desired quantity of zinc to effect the object in view, and, in the end, the result would be the same as if the zinc had been separately introduced into the molten mixture. The use of any one of these metals I consider more favourable to the production of a definite composition, as zinc when introduced in its natural state so quickly passes off in vapour when heated much above its melting-point; but when protected in the manner above stated, the loss is nothing near so great, and it may be put in the crucible along with the other metals at the commencement of the operation. These alloying metals require to be specially prepared for the use of goldsmiths and jewellers, for the purchase of ordinary brass may lead to difficulties, in that it may contain a little lead, and even tin; a small quantity of either metal would be fatal to the purposes of the manufacturing jeweller, by making his preparations fragile and troublesome in the performance of the various manipulations. Composition metals, suitable for mixing with gold alloys, should possess properties not antagonistic to the other metals, so far as their working qualities are concerned. And in the following table I give the proportions of several of

these alloys which have stood the test of practical experience :—

Table of Composition Metals for Alloying Gold

1. Gilding metal	22 parts copper,	2 parts zinc	=	$\frac{1}{12}$	zinc per oz.
2. Red compo	20 ,,	4 ,,	=	$\frac{1}{6}$	,,
3. Orange compo	18 ,,	6 ,,	=	$\frac{1}{4}$	,,
4. Citron compo	16 ,,	8 ,,	=	$\frac{1}{3}$	,,
5. Golden compo	12 ,,	12 ,,	=	$\frac{1}{2}$	,,

The several proportionate parts of copper and zinc here mentioned may be varied to suit the particular purpose for which the metal is intended to be used ; but as the above extend to within very wide limits, any desired objects may be achieved by using more or less of any of the preparations I have given the reader. But I must caution the student, and also the inexperienced practical man, against the use of too much of any alloying metals containing zinc being mixed with his gold preparations, more especially in the higher standards of gold, as I will now explain.

The smallest fragment of zinc melted with gold to form the 22-carat alloy will cause the latter to fly like glass in the rolling. It is obvious, therefore, it cannot be used with this quality gold, no matter in whatever form it is introduced into the crucible. It can only be used for cast objects in which no working manipulations have to be applied in alteration of the casting after having been once made.

Neither zinc nor any of the compo metals can be alloyed with gold to form the 18-carat alloy of goldsmiths, for if the gold could, with care, be got to roll, it would break asunder with the fingers from the strip, even though the zinc existed in an infinitesimal quantity only.

I now come to the 15-carat standard alloy of goldsmiths, and desire to point out that similar remarks apply to this alloy when prepared with zinc, or with a portion of any other metal containing it, as to those of the superior grades dealt with in the two preceding paragraphs. Thus, the conclusions to be deduced from the above practical trials are that it is absolutely unsafe to use zinc in any form in 15-carat alloys and upwards, for it is injurious to working processes, and can only be used for cast work with any degree of safety.

For the 14-carat alloy it may be used with success, if only sparingly introduced into the gold mixture. The limit

appears to be about 3½ per cent. of zinc, or 10 per cent. of the citron compo No. 4 in the table of metals herewith for safe practical working operations. The quantity of silver also used in the compound mixture, I have found to be an important factor in regulating its capacity for working. For the 14-carat alloy 7½ per cent. of silver seems to me to be about the most suitable proportion to work with the above percentage of zinc, increasing in proportion as the standard is reduced. Seven and a half per cent. of the golden compo No. 5 is the limit for the 14-carat alloy; 15 per cent. of the compo No. 3; and 20 per cent. of the compo No. 2 for the same alloy. The other alloy, No. 1, gilding metal, is only used for special alloys of lower quality. A useful guide to the above subject is the following table of zinc percentages to be added to the various undermentioned gold alloys :—

Table of Zinc Percentages for Gold Alloys

14	carat	.	.	3½	per cent.	zinc,	or 10	per cent.	compo No. 4
13	,,	.	.	4	,,	,,	12	,,	,, ,,
12	,,	.	.	4½	,,	,,	13	,,	,, ,,
11	,,	.	.	5	,,	,,	15	,,	,, ,,
10	,,	.	.	6	,,	,,	17½	,,	,, ,,
9	,,	.	.	7½	,,	,,	22½	,,	,, ,,
8	,,	.	.	8½	,,	,,	25	,,	,, ,,

These proportions may be varied a little each way, without any ill-effects being introduced into the working qualities of the different alloys, but it will somewhat depend on the amount of silver contained in the production; more silver appears to allow of more zinc being used up to a certain limit, and *vice versa*. It will not, however, be safe to exceed the limit named. The result of these experiments has been the acquisition of certain knowledge which cannot fail to be useful to the trade from a manufacturing and commercial point of view, and now for the first time made public, for it shows to what extent zinc can be mixed with gold for safe treatment by all kinds of precious-metal workers. Zinc cannot be used in higher alloys than 14 carat, and then no more than 3½ per cent. is admissible. It is more difficult to melt scrap gold from these alloys with a gas furnace, as that apparatus oxidises the zinc, on remelting, more rapidly than the common furnace, and I have had to provide several firms with new alloys in consequence thereof. If the person

in charge of the melting were to use a little sal-ammoniac, or dried common salt, in remelting these alloys, he would find it an advantage. Some loss of zinc, however, will be inevitable, partly through oxidisation and partly through volatilisation; and both the blue flame which escapes from the surface of the metal, and the white clouds of oxide of zinc produced by the vapour of zinc burning on its coming in contact with the air, are evidence of this loss, which, however, by following the rules I have suggested, need not be very great. For many purposes scrap gold may be remelted with a small addition of zinc, to make up for that lost by volatilisation, by introducing it at the last moment previous to pouring, and according to the conditions of working.

CHAPTER V

METALS WHICH IMPAIR THE WORKING PROPERTIES OF GOLD

I AM often asked the question regarding the subject of softness and hardness in the manufacture of gold alloys, and here will be the proper place to record the necessary information. The softest alloys are produced by using spelter as one of the alloying metals, with a correspondent reduction of the amount of silver used ; and the melting must take place under the most favourable circumstances or you will have a hard, brittle metal. The next softest alloys are those prepared with composition metal, and the hardest alloys of all are those prepared with a preponderance of silver ; but these properties do not apply to all the alloys of jewellers. In some instances just the reverse is the case, for it has been shown spelter cannot be used successfully in qualities superior to 14 carat ; but from this quality down to about 8 carat these remarks may be taken to practically apply. The alloys of goldsmiths are not made according to any law of definite chemical combination, but are nothing more than mere mechanical mixtures of the different metals used ; and when a mere mechanical mixture of metals occurs, the alloy is characterised by distinct crystals being formed in the mass, between which each other is visible, but these are so extremely minute as to consist of millions of molecules. In cooling a melted alloy, that metal which is the most difficult to melt cools first, and that which is the most easily reduced to the fluid state is compelled to hold the space between the molecules of the more obstinate ingredients of the composition, and the longer the cooling is extended, the more likely is liquation to be set up in the compound mixture. Rapid cooling of a mixture while solidifying is an effective means of preventing liquation, and for the purpose of assisting in the action of cooling, very much broader and thinner ingot moulds may be advantageously employed for gold-zinc and gold-compo alloys, for the large iron surfaces thus provided to surround the liquid

would very much hasten the solidification of the metal. By another and very simple process, hollow ends to bars may be almost entirely prevented, viz., by pouring the metal into broad, flat ingot moulds. The mixture should be poured gently into the mould, especially the latter part of it, which is done to prevent so deep a hollow in the top of the ingot of gold as would be made if the gold was poured in too rapidly. The gold comes in contact with a much larger surface of iron in the broader moulds, and thus becomes solid almost immediately, while that in the middle contracts and sinks less in these moulds as it loses its heat, and the slow pouring is to fill the hollow thus occasioned and prevent waste. The pouring, if preferred, may be done more quickly at the start, as the process is just as effective by finishing off slowly.

I will now point out the principal causes to which I consider bad and indifferent working alloys of gold are to be attributed. They are chiefly due to impurity of the alloying metals. The admixture of some substances with gold and silver, however small in quantity, are very destructive, and their evil effects are not easily eradicated. Therefore, it is of the greatest importance that the worker should be safeguarded against all metals having a tendency to impair the properties of gold from becoming mixed with it. The peculiar behaviour of these metals when entering into the alloys of gold will be found described in the following paragraphs, but, as they are never likely to be of any practical commercial utility to the goldsmith, need only be briefly referred to here, as the best mode of treatment with the view to their removal when accidentally entering therein will be dwelt upon in another part of the subject.

ANTIMONY, if mixed with any of the qualities of gold, will cause the latter to be so very brittle as to break asunder with the least pressure. It would be impossible to draw a gold alloy in which antimony had entered into wire, for its ductility would be completely destroyed by the combination. The destructive powers of antimony over gold of the higher standards are so great that, if the fumes arising from antimony when in a separate state of fusion were allowed to come near them in the same state, their physical properties would all be destroyed. A mere trace of this metal is enough to completely destroy the malleability and ductility of all jewellers' alloys, rendering them totally unfit for working. Antimony is a hard, brittle metal of a bluish-white colour

with a flaky crystalline texture; it is not liable to rust or tarnish when exposed to the air at ordinary temperature; its chemical name is Sb, from *stibium*, its specific gravity is 6·71, its atomic weight is 120·00, and it melts at 440° C., or 824° F. The effect of even the smallest quantity of antimony on the malleable metals such as copper, silver, and gold is most injurious, making all of them hard and brittle in the extreme, either in their separate form or when alloyed with each other. This metal has no value to the goldsmith and jeweller, and every possible contingency should be guarded against its entering the workshops, for if allowed to become mixed with the scrap metal in any form whatever, disasters of the gravest kind will follow upon remelting the scrap which contained it, and its pernicious effects will be extended to other alloys which happen to be melted at the same time in the furnace, unless it is thoroughly volatilised by the heat given. Antimony burns with a bluish-white flame, and when combining with the oxygen of the atmosphere produces dense white fumes of oxide of antimony. The fracture of gold containing antimony is finely granular, and of a paler colour than would be the case without it. Antimony is the most mischievous of all the groups of metals when mixed with jewellers' alloys, for which it has a strong affinity, the slightest trace or fume being sufficient to change the malleability of a bar of 18-carat gold to one of great brittleness, as the following example will show: Russian copper pennies have been highly spoken of as consisting of great purity in the copper, and it was with some of these that the writer prepared a fair-sized bar of 18-carat gold, but judge of his amazement when the gold returned from the rolling-mill broken up into fragments unfit for use. Every known method was subsequently tried in the melting with the view to correct the evil and make sound metal, but all to no purpose; not even the reducing of the quality to lower standards would suffice to remove the cause of the brittleness. Fifteen carat, 12 carat, and 9 carat were each tried in turn, all of which maintained the most extraordinary brittleness to the last; and this remarkable alteration of the usual properties of alloyed gold resulted in the copper coins containing traces of antimony, a half-grain of which is sufficient to destroy the malleable and ductile properties of a whole bar of 18-carat gold, and it has the same pernicious effects, more or less distinguishing, on all the

standards. Antimony was discovered by Valentine in the year 1490. It is easily pulverised to powder by hammering.

BISMUTH is another brittle metal which imparts similar properties to the alloys of gold and silver as those ascribed to antimony, however infinitesimal may be the quantities existing therein. This metal possesses a greyish-white colour with a slight pinky tinge of bright lustre, and is not much oxidised by atmosphere influences at the common temperature. Its chemical name is Bi, its specific gravity is 9·80, its atomic weight is 207·50, and it melts at 268° C., or 515° F. It is somewhat harder than lead, but, unlike that metal, is so brittle as to break easily under the hammer into the form of powder. Its internal fracture exhibits films or plates of a thin crystalline order, and when melted without a protective covering, burns with a bluish flame which changes into yellow fumes in contact with the oxygen of the air, forming oxide of bismuth. Both antimony and bismuth, when melted with gold and silver, give rise to intense heat on their addition to the fused metals, for if the latter metals are only brought by heat to a pasty condition, the adding of a small quantity of either antimony or bismuth will immediately bring the pasty mass into the liquid state. Bismuth was discovered by Agricola in the year 1530. If the smallest speck of bismuth be allowed to enter into combination with the mixture of 18-carat gold in a state of fusion, the gold, when cold, could not be drawn into wire; a similar result is exercised over all other qualities, in a more or less marked degree, each being made inductile by the addition, and even if the gold is kept in fusion near that of bismuth the same thing will occur, particularly with the highest standards.

ARSENIC.—This is a chemical element, and is placed by chemists among the metalloids, but when in the metallic state is of a steel-grey colour, and is quite brittle. It is not readily procured in the metallic form; the white arsenic, arsenious acid, or oxide of arsenic, being the form in which it is procured from the shops. Arsenic is very prejudicial to the alloys of gold, even in minute quantities, causing dry alloys which, when broken, show a light reddish-grey colour on the fractured surface with a dull, close grain. Its chemical name is As, its specific gravity is 5·67, its atomic weight is 74·90, and its melting-point is not known, as under ordinary conditions it vaporises without melting, but it may be taken at 412° C., or 773° F., for it readily fuses when

heated under pressure. Arsenic easily combines with gold, for which it has affinity, the products being greyish-white, and without malleability and ductility, and when once united with gold it cannot be removed except with very great difficulty. Metallic arsenic is prepared by reducing its oxide by heating with charcoal in a crucible, having another in an inverted position, placed on the top of it as a lid, and in which the arsenic condenses on the inner upper part. Arsenic heated in contact with the air burns with a blue flame, emitting a garlic-like odour, and becomes converted into a white, volatile substance which, when collected, is the white arsenic, or arsenious acid of commerce. Arsenic is most destructive to the alloys of gold, and in all cases renders them brittle, but it lowers their fusing point and for that reason has been used in very small proportions in the preparation of gold and silver solders for work of a special kind.

LEAD is a soft metal, probably the softest known to industrial science, and its particular behaviour towards gold and silver deserves mention, for it will be seen that not only do hard, brittle metals cause injurious properties to be set up when mixed with gold and silver for manufacturing purposes, but that there are others of a soft, malleable nature, which have the same tendency. Both gold and silver are the most malleable and ductile of metals, but when a little lead enters into combination with either in their pure or alloyed state, an exceedingly brittle mixture is formed as hard as glass, one-half part out of a thousand of lead being sufficient to render pure gold entirely brittle and without ductility ; and eleven parts of pure gold to one part of lead will form a mixture so hard as to break like glass. The action of lead on nearly all jewellers' alloys is so pronounced as to cause dry alloys, some of which may be broken short and sudden with a blow from a hammer when in the ingot form, according to the proportion of lead existing therein, and to their degree of standard. The higher the standard the more destructive is the damage wrought by the influence of lead to their natural properties. Mere traces of this metal, even when combined with the commoner qualities, will cause the bars of gold to crack on the edges in rolling, and when being drawn into wire will break short and sudden, the fracture being close-grained and of a pinky-grey colour. It is a most difficult metal to remove when once having entered into union with the other metals commonly

used in the precious-metal industries as admixtures for gold and silver. Lead is a bluish-grey metal, soft and malleable, but with a feeble tenacity. Its chemical name is Pb, its specific gravity is 11·57, its atomic weight is 206·40, and it melts at 325° C., or 617° F. It has been known from the earliest ages, and was one of the seven metals known to the ancients.

TIN is another metal, although highly malleable and ductile in itself is injurious to pure gold and pure silver, and also to their alloys ; but not quite to the same extent probably as are the metals antimony, bismuth, arsenic, and lead. It is a white metal with a lustrous surface nearly equal to that of silver, which it maintains in dry air for some considerable time. This feature, however, is not entirely upheld through the varying atmospheric influences becoming more easily tarnished and somewhat oxidised where moisture abounds. It is a highly crystalline metal, possessing little tenacity, and when bent gives out a crackling noise caused by the crystals rubbing against each other. Its chemical name is Sn ; it melts at 227° C., or 440° F. ; its specific gravity is 7·29 ; and its atomic weight is 117·40. It is not volatile when raised a little above its melting-point, and does not pass off as vapour when the heat is further increased as do the following metals : antimony, arsenic, bismuth, cadmium, lead, and zinc. But when the heat is raised to the degree known as " white heat," it burns with a bright flame, and this coming in contact with the oxygen of the air is converted into oxide of tin, a whitish powder commonly known by the name of " putty-powder," and largely used in manufacturing processes as a polishing medium for the finer grades of polish. Tin, when in a state of fusion with free access to the air—that is without a protective covering—acquires a film of oxide on its surface in the same manner as do the other easily oxidisable metals. Tin was one of the seven metals known to the ancients, and is mentioned in the history of the earliest period as being the oldest metal employed in the arts ; it has, therefore, been known from the earliest period of history. This metal may be used, though only in small proportions, in the manufacture of silver solder, where increased fusibility is an important feature to the success of the undertaking. But it lowers the tenacity of the mixture, and cannot be used when a solder of great strength is a necessary requisite.

ZINC is commonly known by the name of " Spelter,"

and is a bluish-white metal with a bright metallic lustre, and possesses a highly crystalline structure. This metal has been already so exhaustively treated upon as an admixture to gold in these pages that little additional information is necessary to complete the narration, but I will just point out a few of its chief characteristics which appear to have been overlooked in my former remarks. The chemical name for zinc is Zn ; it melts at 415° C., or 779° F. ; its specific gravity is 7·15 ; and its atomic weight is 64·90. It is a volatile metal, and by heating a little above its melting-point in contact with the air it ignites and burns with a bluish-white flame, subsequently changing into a spongy white powder of oxide of zinc, more generally known under the name of " zinc-white," and employed by house painters as a pigment for producing colours in paint. Zinc by the action of the air undergoes a change when long exposed to it, and is easily oxidised at first. But soon the oxidisation ceases, a grey film of sub-oxide being formed on the surface, which prevents further oxidisation from taking place. Zinc improves bright gold alloys by increasing their cohesive strength, and thus, whilst adding to the toughness of the mixed alloy, its former flexibility and pliancy is improved in a manner which adds to the powers of working alloys in which it becomes an admixture. Another feature in its favour is the lustrous surfaces that can be imparted to bright-finished work. Zinc was discovered by Paracelsus in the year 1541. Metallic zinc was not known to the ancients, although they were accustomed to use its ores, the native calamine, in the manufacture of brass. Ordinary zinc is hard and tough and, when pure, is malleable at the ordinary temperature, but ordinary zinc requires its temperature to be slightly raised. It is not very ductile, and this, no doubt, is partly owing to the difficulty of annealing the metal correctly and evenly. But that has now been overcome by using a boiling solution of salt and water, which brings about the maximum malleability and ductility for the rolling and drawing of the metal, and these processes can now be more easily effected than formerly.

Soft Solder, a mixture of tin and lead, is frequently used by jewellers belonging to the repairing branch of the trade, and the solder is called soft because it has a low fusing point. The composition most often preferred by precious-metal workers consists of two parts of tin to one part of lead. It has a fusing point of 171° C., or 340° F.,

and its specific gravity is 8·37. Though this solder is only used in exceptional cases in the manufacture of goldsmiths' work, it is constantly to be found associated with old and worn articles fit for no other purpose than the melting-pot, and when presented for that purpose the presence of such a body has a most injurious effect upon the malleability and ductility of all the alloys of gold and silver, causing them to crack in the rolling, break short in the drawing, and by thus seriously interfering with these essential qualities the subsequent manipulations are performed with difficulty, if at all, for so pernicious are some of these foreign substances to the desired working properties of gold and silver alloys, that a very small portion is sufficient to split a large bar, and otherwise make it totally unworkable by its extreme brittleness. Soft solder is one of those substances.

ALUMINIUM is a metal of recent date, and its employment in the industrial arts is not yet very extensive. It is unsuitable as an alloying metal for gold, making it pale in colour, hard in substance, and as brittle as glass with the higher standards. An alloy of aluminium with silver can be made possessing the necessary working qualities, consisting of $\frac{1}{12}$ aluminium and $\frac{11}{12}$ silver. These proportions of the two metals produce an alloy both malleable and ductile, and of an exceeding white and brilliant appearance. I have used it for experimental purposes, for electro-silvering, and as an alloy in manufacture. An alloy of equal parts of aluminium and silver is light blue in colour, hard, and brittle. Two parts silver and one part aluminium is also hard and brittle and still blue in colour. Five parts silver and one part aluminium is the colour of spelter, and crumbled into grains in rolling. My researches into the subject of forming various alloys of gold, with aluminium as one of the alloying metals, resulted in the production of hard and brittle metal, and though used in small quantities the alloys were far too pale in colour to be acceptable to the trade, even providing the necessary working qualities were forthcoming, and these were not. Aluminium was discovered by Wöhler in the year 1827, but its true characteristics were not discovered till the year 1855 by Deville. It is of a bluish, silvery-white colour, unacted upon by the air, and is possessed of great lightness, malleability, and ductility—in fact, it is the lightest of all the industrial metals. Its chemical name is Al; it melts at 625° C., or 1,157° F.; its specific gravity is 2·56; and its

atomic weight is 27·00.[1] Gold and silver alloys holding aluminium should not be heated too hot, as the mixture is all the better for it, and the resulting compound should be allowed longer to solidify before opening the ingot mould, for the alloy, like one containing much zinc, remains in a pasty condition for some time after the pouring has been effected. In practice the difficulty of working alloys of gold in which impure metals have been used in their preparation is sometimes very great, as the smallest quantities of antimony, arsenic, bismuth, lead, and tin, which are often present in common copper, would entirely destroy the high malleability and ductility of any alloys prepared with it by rendering them hard, brittle, and unfit for working. The influence of foreign substances on the strength and working properties of the precious metals is a subject of great importance, and their effects are best shown in the cases to which allusion has been made, though only a very small portion of either of the metals named in the previous paragraphs may have been accidentally allowed to enter into their admixture. And I wish to draw particular attention to the points raised, so that the gold and silver workers may obtain a clear idea as to the nature of the difficulties which are likely to arise, unless the exercise of due care be recognised in the workshops in which sometimes foreign elements are found an avoidable necessity to the actual work manufactured, and that their destructive influences may be well known to every worker.

An element is a whole body from which no other substance of a dissimilar nature can be extracted, either by chemical or mechanical means.

The specific gravity of a substance expresses how much heavier it is than an equal bulk of distilled water at 60° F., water being taken as the unit of comparison.

The atomic weight expressed, until recent years, how much heavier was the volume of a substance which occupied the same space as one volume of hydrogen, hydrogen being taken as the unit of comparison. In time past one volume of hydrogen was taken as the basis for adjusting the atomic weight of other substances, because of its being the lightest known element, and the weights of all other elements were regarded as so many times that of hydrogen.

[1] The following table of the most useful industrial metals, with their chemical names, specific gravities, atomic weights, and melting-points, selected from the highest scientific authorities, will be of some service to all workers in metal.

Names of Elements.	Chemical Names.	Specific Gravities.	Atomic Weights.	Melting-Points. Centigrade.	Melting-Points. Fahrenheit.
Aluminium . .	Al	2·56	27·00	625°	1,157°
Antimony . .	Sb	6·71	120·00	440°	824°
Arsenic . .	As	5·67	74·90	412°	773°
Bismuth . .	Bi	9·80	207·50	268°	515°
Cadmium . .	Cd	8·60	111·70	320°	608°
Copper . .	Cu	8·82	63·20	1,050°	1,922°
Gold . . .	Au	19·32	196·20	1,045°	1,913°
Iron . . .	Fe	7·86	55·90	1,600°	2,912°
Lead . . .	Pb	11·57	206·40	325°	617°
Mercury . .	Hg	13·59	199·80	39°	102°
Nickel . .	Ni	8·80	58·60	1,600°	2,912°
Palladium . .	Pd	11 50	106·20	1,500°	2,732°
Platinum . .	Pt	21·50	194·30	1,775°	3,327°
Silver . . .	Ag	10·53	107·66	945°	1,733°
Tin . . .	Sn	7·29	117·40	227°	440°
Zinc . . .	Zn	7·15	64·90	415°	779°

Oxygen is now generally taken as the unit of comparison. Its atomic weight is 16, and other elements are based on this unit instead of that of hydrogen 1 as formally, being found more convenient. But hydrogen is still taken as the unit of comparison in the compilation of chemical equivalent weights, because it is capable of representing the smallest quantity of each substance that is possible to enter into and combine with each other to form chemical compounds so as to fix their molecular weights.

The melting-point expresses the degrees of heat at which the metals melt, these being indicated by the pyrometer, an instrument employed for measuring the fusing point of solids, and all gradations of temperature above those that can be tested with the mercurial thermometer. The scale shown in the table of melting-points is in accord with the English Fahrenheit and the French Centigrade.

Symbols or Chemical Names.—Each element in the foregoing table has an abbreviation of its full name called its symbol. These consist, where practical, of the initial letter of the Latin name of the element. But as there are a large number of elements and only twenty-six letters of the alphabet, a large number of the symbols are composed of the first letter and another distinctive letter selected from the name of each element, and this system has been found sufficiently distinguishing for all purposes. The symbols of

the elements named in the table are given under the heading " Chemical Names."

The mixing and melting of the several metals which almost universally constitute the gold alloys used by goldsmiths and jewellers in their art manufactures having now been extensively treated upon, I will next proceed to the remelting of scrap gold; but before doing this I desire to call the reader's attention to the omission of one point which appears to have been overlooked in this discourse, and as it is of some little importance to the trade, I intend now to briefly refer to it. The rule laid down by some writers for the melting of gold alloys being, " in all cases, to melt the fine gold first, and as it does not oxidise, even at a red heat, a protective covering, we are informed, is not required; and on the gold becoming melted it is to be heated as strongly as the furnace will permit, after which the other metals are to be separately added, in small quantities at a time, according to their degrees of fusibility, until the exact proportion of alloy has been introduced into the crucible. The mixture of the metals is promoted by stirring occasionally with an iron rod sharpened at the point, and made red hot previously to its introduction to the fused mass in the crucible." Such authorities can have had very little practical experience in the melting of gold alloys on the large scale, for employment in industrial pursuits, for the method would not only cause great loss of metal, but would produce a mixture of very indifferent working capacity, either of which evils renders the adoption of this method practically inacceptable to manufacturers in point of economy, and could not well succeed beyond the experimental stage.

In the remelting of scrap gold from the workshop, and old gold purchased from customers for melting purposes, care should be taken to have it well inspected to guard against solder and any other injurious matter, such as bits of iron binding-wire, soft solder, or any of the other base metals which are invariably to be found in the different workrooms of the manufactory; and especially is this the case where a jobbing trade is carried on along with the making of new work, for the presence of these metals, besides lowering the standards and rendering them unfit for hall-marking, has an injurious effect upon the working properties of the recast bars of metal, so that it is the best and safest economy to separate these foreign substances

from the gold by a careful sorting before putting the scrap into the crucible.

In the case of large pieces of scrap, quite free from all traces of the gold or silver solder which may have been used in the construction of the work, there will not be much difficulty in preparing a bar of the same standard, providing the scrap is clean and not too large in the various pieces in which it is returned to the warehouse to enter the crucible, in which case it will have to be cut into smaller pieces by means of cutting shears down to a suitable size for the purpose. Thin sheets of scrap gold soon fill a crucible at the starting-point, no matter how closely the pieces may be packed together; and when a quantity of metal has to be melted at one charge, the crucible will require to have frequent additions made of the scrap to be melted; and to facilitate this purpose a little tubular instrument is used, by which means the scrap is directed straight through the tube into the crucible without any risk of any part of it dropping into the fire. It is made of sheet iron on a graduated scale, the top or mouth being the largest end to receive the metal, whilst the bottom end rests on the mouth of the crucible, being prevented from sinking too low into the crucible by two wire pins secured to the iron tube on opposite sides; and by means of this tube any quantity of scrap can be added to that in the crucible, until the latter is full, without any dangerous obstacles arising at all likely to check the process. The crucibles employed are of graphite or plumbago, and these consist of a number of sizes made to conform to the volume of scrap usually being melted. No reducing flux is necessary to the melting of this kind of scrap. A thin covering of the fused mass—and this should be continued throughout the process—of powdered charcoal is all that is required, and providing the furnace used is not possessed of too strong a draught, the loss of metal will be small—not exceeding from 2 to 3 gr. to the ounce melted, according to the standard. The lower the standard, the greater will be the loss, and this may be provided for by making the necessary addition proportionate to the standard, and to the total quantity of scrap to be melted; and as it is copper that is usually evolved, it will be best to add that metal to make up the deficiency; but extra care must be observed in making this addition, not to add more than that lost in the melting, or the bar, when cast, will be below standard and unfit for hall-marking

purposes. A larger furnace, one capable of taking large crucibles, is an essential requisite to this kind of work, where large volumes of gold and silver scrap—especially the latter—are repeatedly being melted, and Fig. 17 illustrates such a one, which will answer the purpose for the most extensive works, manufacturing gold and silver articles of a sufficiently large size to satisfy all needful requirements. The furnace is about 3 ft. high, and answers best when built in the ground, the entrance to the ash-pit being covered with an iron grating (as shown in the sketch) on a level with the floor of the melting shop. The top of the furnace may either be level with the floor or raised a little above it if found more convenient for working, as per illustration, the fireplace being about 12 in. in diameter. When all the intended scrap has been added and the operation of melting been completed, the workman lifts the pot out of the furnace with a pair of large clipping tongs and pours its contents into the ingot mould prepared to receive it, the latter being placed in a slightly sloping position against that portion of the furnace which rises above the ground floor, or by placing it in any specially provided receptacle for the purpose, in case the furnace does not exceed the level of the ground floor. The dotted lines in the accompanying diagram show the iron grating covering the entrance to the ash-pit, with the top of the furnace slightly elevated above the level of the ground. The remelting of scrap metal in the form above mentioned—that is to say, when it exists in thinly rolled pieces—is far more liable to loss from oxidisation and other causes than when the scrap consists of pieces of a more solid nature, although the surface of the fusing mass may have been as well protected from the action of the air as it possibly can be throughout the whole process in each case. The cause of this is, the thinner the pieces exposed to the heat, the more liable is oxidisation to arise, and the greater is the proportion of the copper or other base metal which is " burnt out " in fumes, and this gives rise to a varying loss in weight according to the quality of the standard which is being remelted. If the charcoal covering is at any time withdrawn from the fused metal by a too strong draught of the chimney flue attached to the furnace, a scum or film of oxidised metal will immediately arise on the surface; and if this should happen to be shaken into the mixture and poured into the ingot mould along with the clear metal, it will cause dry alloys to be produced, which will break short

in wire-drawing and in other processes, much to the annoyance of the operator in charge. If, however, this obstacle is observed to have occurred during the melting, before the

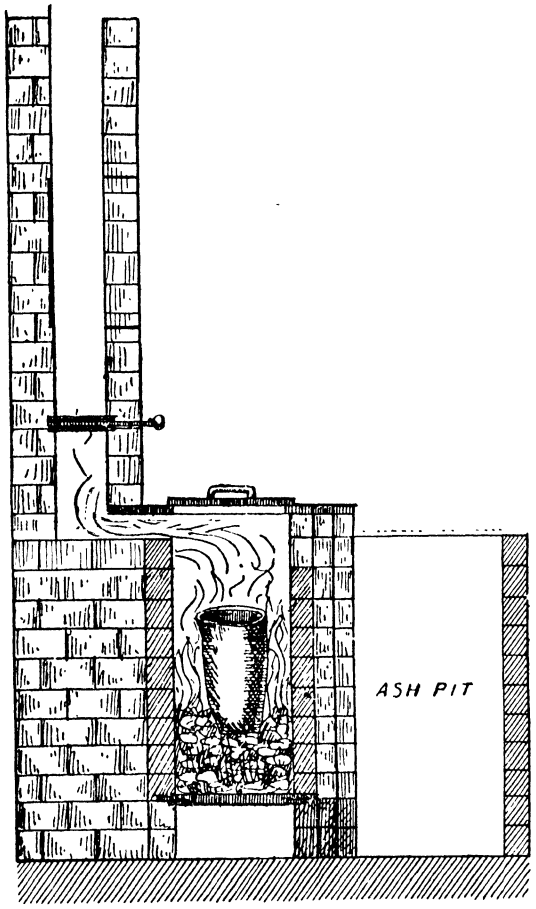

Fig. 15.—Large Wind Melting Furnace.

pot is withdrawn from the fire, by adding the necessary charcoal to well cover its contents, and then by stirring the fused mixture with a thoroughly dried willow or fir stick, the mixed metal will become righted again; the action of the *charcoal and stick* will deoxidise it without any other flux, and the gold alloy, after adopting this simple

remedy, will present the requisite toughness for all the working processes to be successfully followed.

In dealing with small pieces of mixed descriptions of scrap gold, such as links of chains, clippings, points of wire, all defective portions of metal which are unworkable, and other waste (not including the filings removed from the work in course of construction), the whole of them should be first boiled out cleanly, and then undergo a thorough sorting before being put into the crucible, for it is quite possible, even in the best regulated establishments, for portions of the different qualities to occasionally become mixed up a little. The principal standards which are now almost exclusively being worked into jewellery are 18 carat, 15 carat, and 9 carat, and any irregularity caused by the accidental mixing of one quality of scrap with another would be a serious matter, and may lead to some of the work getting cut up at the Assay Office through the standard having been reduced below the proper fineness. All scrap with beeswax or grease attached thereto should be annealed in order to destroy it, and then boiled out quite clean, when the process of sorting will be made easy of accomplishment. The 9 carat will be readily distinguishable from the other two qualities by its less yellow appearance ; but the difference between 18 carat and 15 carat will not be quite so apparent, and probably some difficulty may arise with the scraps of those standards unless the person in charge of the sorting is possessed of the knowledge of discrimination ; fortunately, science here will assist in the means, if properly employed, of ascertaining the difference, for the characteristic is peculiarly distinguishing. This is the remedy for detection. Put a drop of *pure nitric acid* on to the piece of scrap which has aroused your suspicions, and press it with your finger for a few seconds, when, upon the removal of the finger, a deep brown stain will be left on the gold if it is 15 carat. The stain will be more or less deep in proportion to the amount of copper or silver used as an admixture to the gold. The more copper used, the deeper will be the stain. No stain will be visible on 18 carat by adopting this course of treatment. The remedy is therefore simple, and at all times available in gold-working establishments. All solder should be cut from scraps intended for remelting into standard bars, and this waste should be placed in a separate receptacle for subsequent treatment. Lead, tin, and soft solder must be particularly

searched after and removed from this kind of scrap metal, for the reasons already stated. After the boiling-out process such impurities will present a nearly black tinge, so that these metals will then become readily discernible to the naked eye. Little scraps of gold should always be passed through a fine sieve to separate the smallest particles, and the particles going through the meshes may be transferred to the *lemel* box to be treated along with that material; those retained in the sieve must, before the boiling-out process is proceeded with, be well magneted, with the view to the removal of every trace of bits of fine iron binding-wire, and also bits of the steel teeth which may happen to be broken from the files during use, as both of these substances would, in the boiling out, cause a red deposit of iron to appear upon some of the gold scrap, and this is likely to set up a hindrance to the sorting process to be hereafter performed. The kind of scrap to which I am now referring, having been taken through the various processes named, is ready for the melting-pot, and only requires a little charcoal as "a covering" to protect it from the action of the air during the time it is melting. And in order to toughen the metal a small quantity of powdered sal-ammoniac—chloride of ammonia—is added just previous to the pouring. This flux is a volatile one, and whilst flying off in fumes, it tends to eliminate substances which render gold brittle by converting them also into volatile chlorides and carrying them off as vapour, the process of conversion being facilitated by gently stirring the molten mixture with a thin rod of smooth iron, heated just to redness. The melting of scrap gold should be performed at as low a heat as is consistent with its assuming a thin liquid state. By pursuing such a course, the metal will be found far more workable in every degree than if the opposite method was adopted in its preparation. The sal-ammoniac causes the surface of the cast bar of gold to assume a rich uniform appearance, and as it leaves no liquid dross behind, it is much to be preferred to some other fluxes which contain impurities; and these, by acting on the gold, cause it to be bad, as the charcoal covering possesses the power of reducing all the most destructive elements to gold to the metallic state, which then unite with it, tending to effect pernicious results. Some manufacturers always use reducing fluxes in remelting their scrap, and these form a liquid covering to the metal beneath, the object being to withdraw from the metal any existing im-

purity into the flux which may not have been detected in the sorting. The feculent matter which floats upon the surface of the fused metal is prevented from passing into the mould and mixing with the gold by the timely application of a piece of wood held in the left hand whilst pouring with the right hand. Wood that burns slowly is the best to use for this purpose, for the reason that, if a fast-burning wood be used, pieces may be rapidly detached therefrom and carried along with the flowing metal into the mould, to be afterwards found embedded in the gold bar, causing irregular edges and other defects to appear, which are not desirable as they may lead to an extra quantity of waste being formed. Mixed scrap gold, in remelting, always loses in weight, on account of the heat having a greater effect on the many small pieces of gold than when they are of a larger and more solid nature. In the former case, by the far greater surfaces of metal which are being exposed to the compressed heat of the furnace, the more liable is the base alloy to be affected by being consumed in copper or zinc fumes, in accordance with the nature of, and with the quantity of, the alloying materials. In a large manufacturing trade the amount of this loss would be a serious item of consideration on the profits of the establishment, unless it could to some extent be guarded against or otherwise provided for. This loss, which in melting cannot be prevented, is provided against by adding to the various kinds of scraps indefinite proportions of either copper, compo, or zinc, one or the other being made so as to conform to the original alloy, which not only keeps the gold true to standard, if the additions are judiciously made, but also provides against any actual pecuniary loss which would otherwise happen to the manufacturer.

The following table of calculations, carefully prepared, may be relied upon for the different standards now in use :—

Table showing the Additions to be made in Remelting Solid Scrap Gold

18-carat scrap	. . . .	$\frac{3}{4}$ gr. of copper	per ounce.
15 „	. . . .	1 „	„
12 „	. . . .	$1\frac{1}{4}$ „	„
9 „	. . . .	$1\frac{1}{2}$ „	„

Table showing the Additions to be made in Remelting Hollow Thin Scrap Gold

18-carat scrap	. . . .	1	gr. of copper per ounce.
15	„	$1\frac{1}{2}$	„ „
12	„	2	„ „
9	„	3	„ „

These tables must be taken as approximately true only, for no two melting furnaces, working operators, or metallic mixtures will turn out precisely the same results; but they are what my long experience has taught me to be a fair average, from an intimate acquaintance with all sorts of mixtures, and of all quantities in weight. It should be borne in mind the cleaner the scrap of all kinds when put into the melting-pot, the smaller will be the average loss after fusion has taken place; and if this be taken as a guide, the person performing this duty will not be much out in his reckoning.

Sometimes bars of gold will cast with a series of holes in their upper and bottom surfaces, notwithstanding that ordinary carefulness may have been exercised in the operation.

This has been known to follow several times a repetition of the melting, some of the holes being large enough to bury a good sized nut, and no sufficient reason could for a time be assigned for the result. I have found such defects to arise from several causes. If the molten metal is heated too hot, and then immediately and quickly poured into an under-heated iron mould, closed in the usual way, the fused mass meets a larger volume of air in its passage to the bottom of the mould, and a portion of this, being unable to escape, becomes confined in the mould, concentrating itself in particular parts, and so preventing the metal from flowing into the full space of the mould; and as the bladders of air burst, and the gas escapes on the solidification and shrinkage of the metal, a deep hollow is left in the bar at every one of the places where the gas had been detained. The remedy is to remelt the metal, but not raising the heat so high as before, and to pour it more slowly into the mould. The ingot mould will have been sufficiently increased in temperature, through the defective bar of metal having been poured in, to be now in a proper condition to receive the second pouring without further heating.

Blow-holes are also caused through melting in dirty pots,

such as have had fluxes of various kinds used in them, or in pots in which the collected lumps of lemel have been remelted into bar form for assaying purposes, as all these retain certain gaseous impurities. I once melted some 9-carat H.M. gold in a pot, apparently clean, in which I had previously melted a lemel lump, and it came out full of blow-holes. I remelted the bar of gold several times, with the same result each time. I then remelted the gold in a clean pot, using this time a little common salt as flux, and it came out perfectly solid, without any defective places whatever. Common salt prevents the absorption of oxygen gas, and is a useful remedy in difficulties of this kind.

Many difficulties which are very troublesome, and sometimes of an expensive nature, may be avoided by careful attention to the following rules. Do not melt new gold, or clean scrap gold, in a crucible in which a lemel lump has been melted, for it will be certain to make defective metal. It will produce both cracky and blistery gold, as well as blow-holes. Neither should you use a pot for this purpose in which refuse scrap metal of a mixed kind has been melted with fluxes, for, if you do, the same results as above spoken of will follow, through the flux left behind adhering to the inside of the crucible containing impurities, and these act in a destructive manner on the new metal.

Eighteen carat and 15 carat must not be melted in the same crucible in which you have melted 9 carat, if the latter contained any spelter or compo metal as an admixture to the gold, for, if this is done, it will cause the gold of the former standards to crack in a manner little to be expected, and there will be no accounting for the reason by the majority of goldsmiths and jewellers. I have saved many from difficulties of this kind, and those persons who may honour me by reading this book will, before reaching this stage, know the reason of their past failures. Eighteen carat, melted in a pot in which any standard containing a little spelter had previously been melted, will produce cracky and unworkable gold by the retained atoms of spelter permeating the gold and causing its destruction. Eighteen carat should be melted in a pot especially reserved for that purpose, if you are to avoid all difficulties ; and the bars should be cast as thick as possible, so that a tough grain may be imparted to the substance, by high pressure in the rolling, to produce the best metal for working, and to avoid cracks and flaws.

Now and then bars of gold after being cast will come out of the ingot moulds with a hollow space sunken upon their flat surfaces, and at other times long projecting shoots will be found to exist at the top end of the bars. The first of these obstacles is caused through the molten metal being poured into an insufficiently heated ingot mould too quickly, which causes the metal to be ejected upwards, and in conjunction with the air currents arising within the mould not being capable of escape fast enough for the rapidly rising metal to become solid, they are therefore entangled with the gold, and cause the defects above spoken of as sunken places in the body of the gold bars ; a crack occasionally accompanies the hollow places, showing where the air has broken through and been expelled as the metal returns to the solid form. The projecting shoots at the ends may be the results of two causes. Firstly, by allowing the molten metal after its withdrawal from the fire to become chilled, in which case the metal takes the solid form as fast as it is poured into the mould, and the last portion of the pouring thus solidifies as soon as it leaves the crucible, not being liquid enough to run to the full breadth of the ingot mould ; yet some persons would have us believe that the right consistency for the fused mass to be in, when withdrawn from the fire, is that of the *yolk of an egg*. Secondly, in the case of thoroughly melted metal being poured into an imperfectly heated mould, the metal is in a degree rejected, which to all appearance assumes a kind of boiling up, and at the finish the last portions are chilled so rapidly that they solidify before sinking to an even surface, which they would do if poured more slowly when the ingot mould is found to be too cold for the proper reception of the metal, as this would also wholly prevent the boiling up, or spitting, of the liquid mixture after it left the crucible, by driving the cold air before it from the mould, and gradually increase the temperature of the latter at the same time, as to obviate all evil results likely to arise from the process.

With regard to the degree of heat which is necessary to the successful melting of the various qualities of gold alloys much has been said. By some persons it is strongly held that, the larger the proportion of gold constituting the mixture, the higher is the temperature required to melt it. But such is not a question of fact ; it is not owing to the predominating quantity of the gold taken, but to the nature and quantity of the base metals selected as an admixture to the

gold. Nine-carat gold, when adulterated with a superabundance of copper, requires a much greater degree of heat to melt it than does 18 carat, regardless of the mode adopted in alloying the latter mixture, for copper requires a higher degree of heat to melt it than does gold, and this is the reason why 9-carat gold is more difficult to melt than alloys richer in gold.

Eighteen-carat gold bars should be cast into thick ingots to produce the best results, for much depends upon the first rolling of the bars as to whether they crack upon the surface or not. This quality ought in all cases to be subjected to a very heavy draught the first and second times it is passed between the powerful steam rollers used for the purpose of breaking down the bars of gold for the workshop. Light draughts stretch the gold on the middle portion of the bar, the greater part of the strain being on the sides, and this pressure leaves the middle part almost of the same molecular arrangement as when cast, which, when heated in annealing, causes the gold to crack all over the surface. The heating causes an unequal expansion of the different parts, whereby the molecules of the mixture become disturbed and are broken asunder, for gold is a most expansive metal when heated, and this explains the reason why 18-carat gold cracks on the surface when slightly rolled and then annealed. A slight molecular disarrangement is caused in the structure by slight rolling, and in annealing the expansion in the centre of the bar is the greatest, causing it to burst through by unequal pressure. Eighteen carat, therefore, requires very heavy rolling in order to compress its molecules into a more coherent state of existence to produce the best metal for working. Many good bars of gold have been condemned as badly melted, while the trouble has been caused by the bad rolling. When the 18-carat bar has been rolled under very high pressure to about twice the length, it must be annealed and then rolled to the size you require, and you will obviate the difficulty so often attributed to the melting. Lower-quality gold alloys do not exhibit so much this phenomena as to call for any special remarks, further than they should not be rolled so much before annealing as the 18 carat. Fine gold sometimes contains minute traces of lead or antimony, and these have been found most troublesome to deal with in preparing the alloys of gold for the industrial pursuits, for, as has been shown, they render gold extremely brittle. They may,

however, be eliminated by the judicious application of a little *corrosive sublimate* (bi-chloride of mercury). A piece of this substance, about the size of a hazel nut, put into the melted mixture and well stirred, will cause the base metals to become converted into volatile chlorides by the chlorine engendered, and these are expelled from the mixture in the form of vapour, along with the mercury which is liberated, leaving the mixture free of all deleterious substances, for bi-chloride of mercury will not only remove the metals named, but also those of tin, iron, arsenic, bismuth, and zinc, if existing only in minute portions. It does not injure the

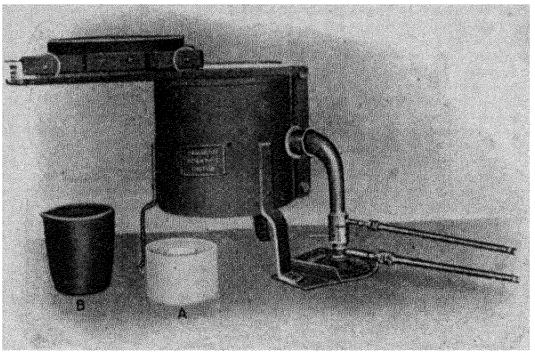

FIG. 16 —"Type C" Méker Crucible Melting Furnace.

mixture in any way, and may with safety be used for all standards of gold.

My attention has been directed to a very useful kind of melting apparatus for the precious metals, of which Fig. 16 gives a representation. It is used in connection with an air blast.

The following are the special features of this furnace, as stated by the makers :—

The illustration shows the general appearance of the "Type C" Méker furnace, with the crucible "B" and the fireclay block "A," on which the crucible stands. This fireclay block is made of a very refractory clay, and is shaped with a trough round its upper surface, so that if the crucible should ever break, the metal is collected in this trough. The furnace lid is mounted on a carriage, which can be easily rolled to one side on guide rails.

Fireclay crucibles cannot be made to stand under the extremely high temperatures (up to 3,000° F.) which can be obtained in this type of furnace. We therefore supply plumbago crucibles usually, although, if requested, we can supply fireclay crucibles which will be quite satisfactory up to 2,730° F. (the melting-point of nickel).

A good pressure of air, say 10 or 15 lb. per square inch, is necessary to obtain the very high temperatures.

The mouth of the burner should be inserted in the side of the furnace for about ½ in., and plastered in permanently with the fireclay which we supply with each of these furnaces.

For melting large quantities of metal very quickly this type of crucible furnace has been strongly recommended for melting the precious metals by means of gas and an air blast. Temperatures up to the melting-point of platinum are said to be obtainable in it. I have not tried these furnaces, so cannot vouch as to their super-excellence; but the commendations are good, and it is stated likewise in their favour that the amount of gas consumed is small in proportion to the great heat which is produced, and that larger quantities of metal can be melted in less time than by any other gas apparatus.

CHAPTER VI

MELTING LEMELS

THE reader has now been presented with an exhaustive exposition of the practice of melting the various adulterated mixtures of gold used in the construction of goldsmith's work and jewellery, and also of the plain scraps arising from the work. But there still remains to be dealt with the clippings, turnings, graver cuttings, lemel, and any other kind of waste metal of a like nature which accumulates in the various workrooms as a result of the numerous processes of manufacture. Before, however, proceeding to point out the best methods of treatment for these descriptions of waste, I will request the reader that if any matter of detail has been omitted in relation to the foregoing, which may have caused any of my gold-working friends some harassing trouble occasionally, and anyone would like the subject further elucidated, to send a communication to my address, Wheeley's Road, Edgbaston, Birmingham, stating the nature of the trouble, when due attention shall be given to the matter with the view to provide a simple remedy, and thus prevent any future difficulty.

Different kinds of crucibles are required for the melting of the above-named wastes to those used for melting new mixtures and ordinary scraps, for in the former case it is the usual practice to employ reducing fluxes; in the latter it is not the custom. What are called clay crucibles are the best for melting "lemel" and all similar kinds of material, because they withstand the action of the various fluxes much better than plumbago or black lead. They are made of fireclay mixed with sand, or other highly infusible substance, so as to render them capable of resisting very high degrees of heat without softening, and also to withstand sudden changes of temperature without cracking, such, for instance, as the removal of a white-hot crucible from the furnace into the cold air. Crucibles should always be selected for service which are best adapted to the special purposes to which they are to be applied in the work of the establish-

ment. Clay crucibles do not require to be annealed before using, like plumbago and black lead ; but it is necessary to carefully warm them through, otherwise they are liable to crack if straightway plunged into a red-hot furnace. Especially is this found to be the case in cold and frosty weather, and I have observed a similar action, though in a lesser degree, and wrought by the same means, to affect plumbago crucibles ; therefore a little extra care bestowed on the pots before commencing the operation of melting is not time and labour lost, but is often found in the end to result in the truest economy being practised by strictly following this mode of procedure.

The crucible No. 1 is recognised as the " London clay pot." It is round in shape, and gradually widens until the

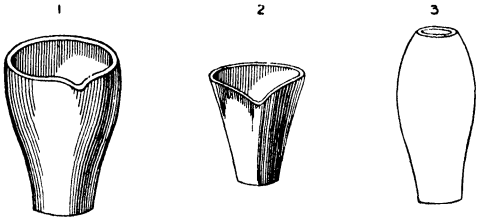

FIG. 17.—Clay Crucibles of Different Kinds.

top is reached. It is made of close-grained material, stands a high degree of heat, and is not so liable to crack as are some others similar in construction. It will resist the destructive influences of oxidising fluxes for a long time in a remarkable manner without cracking, and it is the kind of " lemel " pot I have used for many years with most successful results.

The crucible No. 2 is called the " Hessian " or " Dutch pot." It is triangular in shape, so that there are three corners, from either of which the fused metal can easily be poured if desired. It is very hard in substance, but liable to break at the place where held with the tongs if too tightly pressed ; it is not very liable to be acted on by the ordinary fluxes, hence it is occasionally used in the collection of lemel stuff. In colour it consists of a very dark brown, with a rough exterior ; but I do not recommend its employment for the collection of these wastes as the best and most suitable.

The crucible No. 3 is called the " skittle pot," because in shape it resembles a skittle, being circular in form and tapered from the middle towards each end—the mouth, like

the bottom, being small and of equal dimensions. The advantages claimed for this kind of crucible are that, by its central diameter being the greatest, with the top part curving inwards, a shoulder is formed which safeguards the overflow of the metal whenever the mixture shows a tendency to unduly rise and presents signs of boiling over. I shall, however, endeavour to show how these difficulties may be surmounted in other ways than by the shape of the crucible, the latter of which is not always so successful in its results as some operators have attempted to make out. If the lemel has had its organic matter destroyed by heat, before mixing with the "reducing flux," and the flux used is of the right kind, very little, if any, upheaval will take place of the contents within the crucible. A great many master jewellers use the wrong kind of reducing fluxes for the collection of their lemel and fine waste, with far too great a proportion of flux to a given quantity of metal to work the process to the best advantage, for by such a mode of working the crucible is not only charged with an unnecessary volume of material which is useless, but actually causes less metal to be put into the pot, through the room being taken up with the flux instead of the former body. Also, by such a method of mixing, the crucible becomes less resisting to the action of the flux, and it will not withstand so prolonged a heat as is found to be the case when less flux is employed. There are various processes in operation in the jewellery trade for the treatment of the particular kind of waste material I am now about to deal with; and as it is a subject of some considerable importance, it may prove a distinct advantage to some, more especially those who may be unacquainted with the art of collecting and melting their waste products, to have the general details explained, as it is now becoming an important branch of their industry; and it will, in the midst of increasing vigour in the competition to be first in what the Americans call "Rock Bottom Prices," be necessary to commence a close study of the question of waste products which arises in the various departments of business as an indispensable necessity to those who intend to work for profit.

The term "lemel," for the purpose of its description, will apply to the mixed gold filings which proceed from the filing up of the work, pointing of the wire for wire-drawing purposes, and to the waste resulting from the other processes above named. Many firms have special methods of their

own for the treatment of lemel, according to the particular branch of manufacture in which they are engaged. Some of these collect the lemel and work it up again, whilst others melt the various qualities into a whole mass and sell it to the refiner, purchasing new gold with the money. There are still others who only manufacture in the three principal qualities of gold—18 carat, 15 carat, and 9 carat. These are mixed together, and collected into a button by means of a suitable flux, then reduced with copper to the lower quality, and reworked into the wares manufactured by the firms who adopt this order of progression. It will be almost needless to remark that those who adopt this order of things must be careful to eliminate any destructive element to the gold in the preparation of this mixture with which it may accidentally have become associated whilst in care of the different workmen, or bad and indifferent working gold will proceed from the combination. For lemel nearly always contains impurities, such as iron filings, bits of iron binding-wire, various descriptions of organic matter, and, where a jobbing trade is conducted along with the manufacture of new work, bits of soft solders may also contaminate the lemel; and as this is one of the most destructive elements to all the mixtures of gold, the greatest care should be exercised in freeing the lemel from so dangerous an ally. And the workmen should be compelled, as far as possible, to remove all deleterious substances before weighing in their lemel, for this would not only prevent many difficulties from happening with the lemel bar, but would also tend to economise the working loss of the establishment by reducing the amount of allowance in the workshop. The practice of allowing dirty lemel to be weighed into the warehouse is a wrong one, for each individual workman very soon considers he has weighed up correctly if his lemel is allowed to pass in a dirty condition; and as time wears on he becomes more careless still, so that the actual loss of real metal may be somewhat considerable, in even only a moderate-sized manufactory, by the indulgent use of such a system. When the lemel is kept separate in quality and free from any injurious substances, it may be melted and worked over again in each distinctive quality, without incurring any particular obstacle in the process; but in most cases it is preferable to reduce the higher standards to lower ones than to run any risks, as there is nothing like so great a danger by adopting the latter method of working

as utilising the metal for the same standard over again. In treating of the melting of jewellers' lemel, I intend only to describe those processes which have stood the test of experience in the workshop—those which have proved both economical and of the greatest practical value to the manufacturer. To proceed to the question at issue. The lemel should first of all be sieved through a fine sieve in order to separate the filings from the smaller pieces of scrap, the larger pieces being picked out with the hand before performing the process of sieving. Certain particles, whilst refusing to pass through the sieve, will still be too fine to be melted in the ordinary way, and may conveniently be passed on with the lemel, to be melted along with it, as it may be difficult to define the exact standard of those small pieces. A piece of stout brown paper, glazed, should be utilised for receiving the lemel as it passes through the sieve, and should be sufficiently large in extent to prevent any of the lemel from being lost by passing over the sides. When this is done the iron filings are removed with a magnet; the lemel is next burnt in an iron ladle to destroy the organic matter, and it is then ready to be mixed with the reducing flux, to be finally melted into a button of solid metal. Many fluxes have from time to time been recommended for this purpose, all of which have their merits and demerits; but I shall only mention a few which, by their general effectiveness, are applicable alike to all the metals commonly met with in manufactories especially set apart for working the precious metals.

Lemels which do not become very impure by the addition of solder filings and other foreign substances may be worked over again, and thus save refiners' expenses, by adopting the following useful method of treatment, which is generally applicable only to the three highest working standards—22 carat, 18 carat, and 15 carat. The cuttings from carved rings, the turnings from solid metal free from solder, and the filings from the same work are fitting objects for this special mode of treatment; also those dust-like particles from the better qualities of gold wedding rings are amenable to the process without any particular preparation. The only important point is to see that each quality is kept entirely separate from that of another of a different standard, and this is a part of the duty of the workman who manipulates the work to look after in the workshop, who has the gold weighed out to him, and who is responsible for the care of

this waste until he weighs in his executed work, together with the waste accruing therefrom, when his responsibility ceases; but it is of the highest importance that he should weigh in his scrap and gold dust as free from grease or other organic matter as possible, to effect which it is usual to heat it in an iron ladle or pan until all fumes cease to be evolved, indicating that all grease and other contained matter of a similar nature has been destroyed. When cool, it is weighed into the warehouse along with the made-up work, and it is then quite ready for the next process—that of eliminating any base metal, if such has accidentally become mixed with it during any of the working stages. It is the duty of the workman to remove any filings of iron or steel with the magnet before weighing in the waste resulting from his work. Pieces of soft solder or lead, at all discernible, should also be picked out by means of the corn-tongs. The process I am about to describe does not refine the gold into a higher state than is the standard under treatment, but merely removes the filings of copper, silver, brass, and German, or any other base metal, if any of these have become intermixed with the gold filings during the execution of the work entrusted to the care of the workmen in the factory, leaving the gold of the original standard. The lemel (from 12 carat upwards) is subjected to the action of nitric acid and water, in the following proportions :—

Gold lemel	1 oz.
Nitric acid (HNO_3)	1 ,,
Water (H_2O)	5 ,,

The mixture should be placed in an enamelled iron vessel or earthenware dish, shallow in dimensions, so as to present as large a surface as possible to enable the filings to be spread out thereon, and for the acid to act to the best advantage. The acid mixture should be poured over the filings in sufficient quantity to entirely cover the lemel, and on its first being added an agitation will commence, bubbles of nitrous acid gas will arise, and these will be in proportion to the impurities existing in the lemel. When the bubbles cease, and perfect quietness exists, the acid should be poured off, and, if it is suspected that any base metal remains, fresh acid mixture must be added, and the contents of the vessel well stirred with a glass stirrer, when, if no bubbles show themselves after this addition, the operation is complete. The lemel being sufficiently purified of its base adulterants,

the acid is then poured off, and the metal is well washed, dried, and melted by means of a reducing flux, for further use in manufacturing the particular articles of the firm. Filings treated in this manner seldom require more than one melting to make the metal easily workable, after they have been collected together into a button by the reducing flux. The very best flux for this purpose is bicarbonate of potassium, the most suitable proportion being 1 oz. of the salt to each 10 oz. of lemel. Fig. 18 represents the kind of vessel to be used in which the acid mixture may with every advantage perform the work of removing any contamination from the lemel; it is provided with a lip for pouring off the acid, and also the rinsing waters, when subsequently freeing the lemel from all traces of acid before drying it ready for the process of melting. After melting into bar form an assay

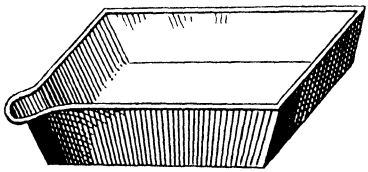

FIG. 18.—Vessel for Dissolving Base Metals from Lemel.

will have to be taken, in order to be assured of the correct standard, particularly when the metal is required for the execution of work to be hall-marked. This process is economical, and only requires a little care, no particular skill being at all necessary to attain success in its performance. The diluted acid mixtures, and the rinsings, should not be thrown away, but put into the waste-water tub for future treatment with the other general waste waters of the establishment. Any quality of gold lemel from 15 carat upwards can be subjected to this mode of treatment when necessary. To accomplish the more rapid performance of the work it is sometimes advisable to heat the mixture, in which case it may be used a little weaker.

The next method for the collection of lemel which I shall describe is one applicable to those firms who fabricate articles from the three principal standards of gold, which it is now the custom to use in the manufacture of goldsmiths' work and jewellery—18 carat, 15 carat, and 9 carat—with the view to receive the hall-mark as a guarantee of their respective fineness in the quality of the gold. Ring makers

and others who only work in these three qualities, and who desire to save refiners' charges in the selling of the lemel, or the exchanging of it for new gold, will find this mode of treating their lemels a distinct advantage to them, provided it is carefully carried out and that no deleterious metals are allowed to enter into the workshop and become mixed with the lemels. The object under consideration is to provide a metal possessing all the original working qualities at the smallest possible cost to the masters, and to enable it to be worked with the same ease and comfort by the men as the mother metals were. The three qualities stated are melted together with a suitable reducing flux, then assayed and afterwards reduced to the lowest—or 9 carat—standard with copper, in a clean plumbago pot, with a little charcoal powder to cover the surface and prevent oxidation of the metals. There is nothing better than this as a flux for melting gold or silver, or their alloys, when presented for that purpose in a thoroughly clean condition.

Every particle of iron or steel should first be removed from the lemels with the magnet, the larger pieces of scrap being previously separated from the lemel by passing the latter through the meshes of a fine sieve, allowing it to fall on to a large sheet of glazed paper, when, if thought desirable, the lemel is next heated to redness in order to destroy all organic impurities—but I have not found this necessary in my business—as lemel is subject to a little impurity of that nature in the best-managed workshops. The particles of iron removed with the magnet should not be thrown away, as they will probably contain a little gold, but be preserved for further treatment, which I shall describe in another place. When the mixed lemel has had all the iron or steel removed therefrom, it is intimately mixed with the reducing flux, and the whole transferred to a clay crucible which has been well warmed through. Fig. 17, No. 1, represents the kind of crucible I have found the best for this purpose. The relative proportion of the ingredients which have invariably proved the most successful with me are as follows for the fluxing material, to enable *lemel* to be successfully melted and have its workable properties fully restored :—

Lemel	10 oz.	or 100 oz.
Bicarbonate of potassium . .	$\frac{1}{2}$,,	,, 5 ,,
Nitrate of potassium . . .	$\frac{1}{4}$,,	,, $2\frac{1}{2}$,,
Borax	$\frac{1}{4}$,,	,, $2\frac{1}{2}$,,

The crucible with its contents is put into the furnace, but before doing this a thin layer of common salt, or a portion of the potash, may be spread over the top of the lemel in the pot, to prevent the draught of the chimney from withdrawing any of the fine particles of dust out of the pot with the current of air passing over it up the chimney, and thereby causing loss to take place; beyond this no other flux is necessary in the reduction of this kind of dust to the solid compact form. It will be better not to fill the crucible too full of the mixture, for, in case it rises, it may overflow and carry some of the metal over the top of the pot into the fire; about two-thirds full is a measure requiring the least care. But if it should show signs of boiling over, immediately drop into the crucible a little *dried common salt* in powder, which should always be kept in readiness for the purpose. When the boiling up of the flux is regular in its composition, and no gaseous bubbles are observed to be evolved, the lemel has pretty well run down, which can be tested as to its uniform consistency by stirring with an iron rod, when, if no obstacles are met with in stirring up the mixture, it can be taken for granted that the fusion of the metallic particles within the crucible is complete; but, if any doubt still exists, remove some of the flux by means of the end of the iron stirrer, and if it runs off at once, the process is finished. The pot should then be taken from the fire, placed on the floor to cool—if a bricked one—and, when cool, it can be broken at the base with a hammer, when the button of mixed metals will fall out on to the floor. The flux resulting from the process, being quite free from metal of any kind, is put into the general sweep.

Another method for running down "ordinary mixed lemels," when these are intended to be sold as waste products to the refiner, is the following formula devised by the author for the special treatment of this class of waste, for which purpose it will be found eminently successful in its results, the chief merit of this flux, in its preferment to be employed in the reduction of the gold dust, being in the power it possesses of reducing so large a quantity of lemel into a metallic lump with so small a proportion of flux. Then, again, it does not sensibly act on the crucibles, and is inexpensive in use. The proportions I take of each are:—

Lemel	10 oz. or 100 oz.
Soda-ash	1 „ „ 10 „

The flux, which consists of a fine dry powder, is well mixed with the lemel and placed in the crucible, but not within some distance of the top, as sometimes the contents rise and may overflow if the pot is filled too full. This flux, however, has a tendency to prevent that happening to a very considerable extent. A small portion of the soda-ash may be reserved for covering the top of the lemel in the pot, or a little dried common salt may be used for that purpose instead if preferred, either of which will prevent the current of air passing over the top of the crucible from withdrawing any portion of the lemel therefrom. The lemel requires no previous burning, and if the pot is large enough, no boiling over need be feared, for the flux soon liquefies ; and as the contents of the crucible become melted, by its weight the lemel sinks through the thin liquid flux down to the bottom of the melting-pot, from which it is ultimately recovered in a lump, when the pot is withdrawn and cooled off enough to be broken for that to be done. The advantages of this flux are : that it readily melts and produces great liquidness, forces the metal as it becomes fused downwards, prevents ebullition or the boiling over of the contents of the crucible, does not act on the crucibles so much as most other fluxes do, does not become damp under atmospheric influences, costs very little to purchase, and only a small quantity is required in proportion to a given weight of the lemel, which is to be reduced to the solid form. The covering of flux placed on the top of the lemel in the crucible is best left loose, and not pressed down with the hand, compact and solid, as that prevents the gases which arise from escaping ; and these in their endeavour to escape, as the heat increases, cause an upheaval of the contents within the crucible, and, where much organic matter is intermingled with the metallic dust, a possible overflow may be the result, and some metal lost. When the metal has all run down the mass will appear to the operator as a liquid with a perfectly even surface, and when stirred up with the iron rod no lumps of any kind will be felt ; and if on withdrawing the rod any adhering flux runs off like water, it is time to take the crucible out of the furnace, for complete fusion has then been effected.

In melting board sweepings and rough lemels resulting from a jobbing jeweller's business, and containing all sorts of extraneous substances, such as bread crumbs, bits of wood, sawdust, traces of polishing materials, dirt, and other

feculant matter, a much greater quantity of flux will be required for the purpose of reducing residues such as the above into bar form than the amount named for reducing ordinary lemels. The proportion may exceed, even in some few cases, double the quantity of flux, to the fixed weight of lemel, as previously given, to make the operation successful. This is the formula which I have used, and it has proved very effectual :—

Rough lemel and board sweepings	10	oz.	or	100	oz.
Dried carbonate of soda (soda-ash)	2	„	„	20	„

This kind of lemel is best burnt down into a smaller compass in an iron ladle, although the flux will reduce it, by prolonging the time of melting, into a solid button without. A large clay pot must be provided for its reception to prevent boiling over into the fire. Plenty of heat must be given when in the furnace, and, when thoroughly melted, the pot is withdrawn from the fire and allowed to cool, when it is broken at the bottom, and the button of metal which falls out is remelted in a black-lead or plumbago crucible, and this time cast into an ingot mould or an open casting mould, if preferred, with a view to an assay being taken as to its value. When the last method of pouring is adopted, the liquid metal may be poured right off into the mould from the clay crucible in which it has been reduced, flux and all ; the latter will rise to the surface, and may easily be detached, when cold, from the metal. The advantage to be gained by this mode of working is that you will save one melting process, and where time is of value, the suggestion is worthy of consideration, as assayers will sample as readily from this form of ingot as those usually prepared by the bulk of the trade. If the flux is found difficult of removal, it may be poured from the mould when the metal has become firm, and before the flux congeals, or the whole may be plunged into water before the cooling has too far advanced. One of the faults in melting lemel is that sufficient heat is not given to the mass to bring the metal down clear and bright, so as to render its separation from the flux a matter of little difficulty. When well performed, the uppermost surface of the button of metal adjoining the flux should be level and smooth, no concavity in the middle should appear, nor should little eminences cover the whole surface, for, if so, the heat has not been sufficient to clear the metal of impurities, and many bars prepared from lemel to be worked

over again have been found unworkable solely from this cause.

When gold lemels contain various metallic impurities, and these consist of easily oxidisable metals, they are generally removed by little additions of saltpetre, repeatedly made in the last stages of the melting operation, which generally exerts a powerful oxidising action on some of the so-called base metals, and withdraws them into the flux; but too much of this flux oxidises also a portion of the gold and silver when existing in separated minute divisions.

The exact quantity of the reducing salts required for a fixed quantity of "lemel stuffs" is not easily determined without an inspection of the material which is to be melted down. But it will be correct to state that it should always be used in proportion to the condition of the kind of waste sought to be treated as regards the nature and extent of its impurity. The more impure it is, and the more refractory are the ingredients of impurity to ready fusion, the more flux will be necessary to cause the mass to melt into a thin watery fluid, without which it is possible the whole of the gold dust would not agglomerate into a solid button, but leave small shots of metal in the slag. Thus a greater loss in the weight of metal may apparently be adjudged to have been incurred through the melting process than otherwise would be found to be the case had the whole of the gold left the flux and collected into a lump at the bottom of the pot; and to thoroughly effect this, the whole mass must be reduced into a thin watery fluid. A little melting practice, however, with the various kinds of lemels to be found in the different jewellery establishments is the best instructor as to the right proportion of flux to lemel to employ in each individual case.

The melting of lemel in gas furnaces cannot be so expeditiously done as in a good wind furnace, using as fuel good hard coke. In the former several separate fusions have to take place to accomplish as much work as one fusion in a wind furnace, in consequence of the furnaces not being large enough to take the necessary sized crucibles; and, further, if you have to contend with an occasional broken crucible, the lemel as it runs out will destroy the furnace by becoming cemented to the fireclay in union with the flux if allowed to solidify, and in effecting the removal of the metal, bits of fireclay, forming the body of the furnace, come away with it. Thus the furnace is

damaged—in some cases beyond repair. The remedy to avoid damage to the furnace in cases of the pots breaking is supplied by at once pouring the contents out on to the top of the stand, which is provided as a support for the furnace. The stand should be provided with an iron top, having a rim surrounding its edges, and this prevents any metal from running off on to the floor. The iron on the top of the stand will become sufficiently heated from the furnace to prevent any spitting of metal if occasion should arise for it to be utilised for the purpose named.

In melting jewellers' lemels in large quantities, it will be found much the better plan to fuse at two operations than to melt it all in one pot by a series of additions of lemel and flux being made to the one crucible until full of the molten metal, as the long-continued heat necessary for this purpose, together with the fluxes generally employed, tends to destroy the pots by making them crack if kept too long in the fire. But if a pot should be observed cracking from the top downwards, immediately throw on to the place some fine glass dust; this will work into the crack and prevent the running out, if not already too far gone. I can record cases where this has been very effectual, and the glass powder has gone through the crack and appeared like adhering cement on the outer side of the crucible. Of course, in most cases of the kind, nothing will prevent a spill in the fire; but it is quite as well to be provided with every little remedy which may help to guard against such accidents from happening too frequently. A London round lemel pot 7 in. high and 5 in. across the top will melt 60 oz. of metal without feeding. One crucible of these dimensions will melt 100 oz. with feeding; but, as already remarked, I do not approve of trying the pot too much, as it is a dangerous thing to do, and may cause the pot to crack by the prolonged heat. Better by far use two pots for that amount than risk the danger of breakage.

The nitric acid process for removing base substances from the lemel previous to its being melted can be very much modified in its proportions, and still be effective where *large quantities* of metal have to be treated. On the grounds of economy the following will amply suffice:—

Lemel	. . . .	10 oz. or	100 oz.
Nitric acid	. . . .	1 ,, ,,	10 oz.=½ pint.
Boiling water	. . .	8 ,, ,,	80 oz.=2 quarts.

The acid should be added to the boiling water, and the mixture gradually poured over the lemel from a jug, with constant stirring. To 200 oz. of lemel double the quantity will be required; or fixed quantities, such as the above, may be taken in succession and treated with the pickle, which will remove all the deleterious materials in a few minutes and prepare the lemel ready for the crucible. Further, if the pickle has not become exhausted by the first portion of lemel operated upon, it may be used for a second quantity of lemel, and so on, until its corrosive powers have become exhausted; but it will be necessary, to get the full benefit of its action, to raise the temperature of the pickle upon each subsequent application to a fresh quantity of lemel.

Much difficulty is often experienced in the melting of jewellers' lemels and other residues impregnated with such substances as plaster of Paris, lime, oxide of iron, emery, and sand. The two last named become mixed with the gold dust during the execution of the work by the free use of the emery stick and sand-paper in smoothing down plain surfaces ready for polishing, whilst the former may result from small detachments from the plaster models used in the different kinds of articles manufactured—the backing of stones when being set, the scraping of the gold from old picture-frames, and other causes. All these processes will cause particles of infusible matter to become mixed with the precious metals, and thereby increase the difficulty of fusion; but this may be overcome by the employment of some flux that will reduce the mass to a fluid state, through which the metal may sink and aggregate in a button at the bottom of the crucible. Now oxide of lead—litharge—will fuse lime, plaster of Paris, metallic oxides; and soda-ash—dehydrated carbonate of soda—partly assists in the process of promoting the fusion of the above-named substances, as well as causing emery and other mineral earths to assume the liquid state. A mixture, therefore, of these two ingredients will cause waste products of the kind with which I am now dealing to very readily yield up their metal when well mixed together and submitted to a good heat in a furnace. But I have devised a much better fluxing mixture for use by manufacturing firms, which never fails in its object in reducing the precious metals, by causing them to part away from all these substances and become melted. The proportions may consist as

follows when all the above materials are included in the mass :—

Waste product	10 oz.	or	100 oz.
Soda-ash	3 „	„	30 „
Fluor-spar	1 „	„	10 „

The common soda-ash is to be preferred for use in this process, because its chief adulterants consist of sulphate of soda and common salt, both of which are good fluxes for the fusion of silicious and calcareous substances, when, through unavoidable causes, they become mixed with the finer particles of the waste resulting from some of the manipulations which have to be practised in the precious metal industries for utilitarian purposes. Litharge (oxide of lead) is a useful flux in reducing refractory materials.

I have assumed, by describing several kinds of lemel melting for the purpose of reducing these processes to a simple form of practical working on the large as well as on the small scale, that the waste now under consideration is much impregnated with foreign materials, and that is the reason why so large a proportion of flux is required in examples of this kind to reduce the product to the fluidity of water, for the latter requisite is necessary to allow of the particles of metal to collect and deposit at the bottom of the crucible ; and the advantage in employing a portion of litharge is that the precious metals readily unite with the lead when brought together in a state of fusion, and completely separate them from the dross. The oxide of lead may permeate and destroy the crucibles by continuing the firing too long, and on that ground is objectionable. But there are other substances which may replace it for this particular purpose, notably borax and glass. Borax will reduce lime, oxide of iron, and silica, absorbing them into the flux. Glass acts on calcareous and other bases containing no silica, combines with the lime, and serves to economise borax in melting jewellers' products debased by those substances. Two very good formulas for the use of those who do not like the oxide of lead recipe are here given, but I have found nothing better than fluor-spar, and when this is used less flux is required.—

For process No. 1 the ingredients are :—

Waste product	10 oz.	or	100 oz.
Pearl-ash	2 „	„	20 „
Soda-ash	2 „	„	20 „
Salenixon	1 „	„	10 „

For process No. 2 the ingredients are :—

Waste product	10	oz.	or	100	oz.
Soda-ash	3	,,	,,	30	,,
Dried borax powder . . .	1	,,	,,	10	,,
Pounded glass	1	,,	,,	10	,,

These fluxes are used in a state of fine powder and intimately mixed with the waste from which the precious metals are to be recovered, and then thoroughly melted into a thin, watery fluid in a clay crucible ; and when this becomes cool, after its withdrawal from the fire, it is broken and the metal recovered. The crucible should be placed in a moderate fire at the start, as a medium temperature to begin with has proved in practice the least destructive to the pots, after which the heat is increased until the mass assumes the liquid form and becomes tranquil, when it is well stirred in order to ascertain if there are any undissolved lumps remaining ; if not, the crucible is withdrawn from the fire, placed aside to cool, and the button of metal subsequently obtained by breaking the crucible. These two processes will run the waste down into clear metal ; but the one adopted by refiners for treating such products on their own account for the recovery of the precious metals, is to mix the waste with red lead and soda-ash, and in that manner prepare it at once for the cupel.

Waste residues containing such ingredients as those just described are kept separate as far as they possibly can be, in the best-regulated workshops, by performing such work in a different part of the manufactory, and thereby simplifying a department of work which would otherwise be a constant source of difficulty in the collection of the finer metallic particles from the substance which requires to be operated upon, in order to obtain the precious metals in their free state, apart from the foreign materials with which they become associated in certain processes of manufacture.

Hydrochloric acid will, it has been stated, dissolve plaster of Paris and remove it in a liquid condition from lemel ; but this is not a reliable eliminator, and in my hands has failed under all the methods to which it could usefully be applied by goldsmiths and jewellers in perfecting the work above named.

It is curious to note the prevailing ideas which exist in the minds of some members of the precious metal trades with regard to the treatment of their lemels and other fine

dust-like particles of waste materials which are ever accumulating when working on an extensive scale; and I have purposely extended my remarks on this particular branch of the goldsmiths' trade, in order to establish a thorough basis to work upon. Since my "Goldsmiths' Handbook" appeared in the year 1877 I have endeavoured to profit by my earlier experience and improve on the mode of working, so that I may now justly claim to have reduced the calculus of variations regarding this particular branch of our industry to a distinct science, by laying the groundwork upon which all the processes can be practically and profitably followed by anybody, with very little or no previous experience; and in giving to the public these additional instructions, I trust some of the results of my researches may be improved upon and turned to still more profitable account by this further store of knowledge.

Before proceeding further in the direction of collecting the precious metals from waste solid residues, I will make one or two observations with regard to the mode of treatment adopted by some masters, so as to show the loss that must be continually taking place in the trade by carrying out such rules. Saltpetre is freely used as a fluxing agent in the running down of lemel and other fine waste, and it is a difficult matter to persuade people that it is not only entirely unsuitable, but causes a large waste of both gold and silver, especially when these exist in a minute state of division like lemel. The loss of weight in melting filings when this substance is employed along with others for reducing purposes is enormous. I have been told that they are compensated for this loss by the raising of the standard in the fineness of the gold resulting from the process, and by the reduction in the refiner's expenses in not having so large a bar to refine as there would be had considerable less loss taken place from the original bulk, the loss incurred being assumed to be base metal. Now this argument is all very well if it can be upheld, but it cannot! and when a case was brought under my notice by a friend, I was very soon able to show that a most serious loss had occurred financially in the case in question. More than half the quantity of lemel had been lost, and the fineness of the metal recovered by assay was altogether out of proportion to the value of the metal lost in the melting. Let me take the case in point in order to show this more clearly, when it will be seen that the matter is of more serious import than at first

sight appears to be the case. A quantity of lemel of 9-carat quality, and weighing 20 oz., being melted with saltpetre and common salt, becomes under the process so reduced as not to exceed 10 oz. of clear metal, but this then assays at 15 carat. Has any money loss occurred? Yes, very large. Compare the following tables for the sequel:—

	£	s.	d.
20 oz. of 9-carat lemel at 31s. 10½d. is worth . .	31	17	6[1]
10 oz. of 15-carat gold at 53s. 1½d. is worth . .	26	11	3
The total loss in monetary value is therefore . .	£5	6	3

Note.—Saltpetre and common salt cause the volatilisation of gold in considerable quantities, when the gold consists of fine particles—like lemel.

The net loss may not be quite so great as this, because in melting such materials a loss is always occasioned; but this loss is in proportion to the kind of reducing flux employed in the process; to the cleanness of the lemel; and to other conditions of skill exercised by the operator at the furnace. And if you assume 20 dwt. to be the average loss on clean 9-carat lemel of the weight named, and that a little adulterating ingredient had become mixed with the lemel in the course of filing up the work, etc., your lemel ought then to assay at 9-carat quality. In which case you will have to deduct the loss of 1 oz. of the value of £1. 11s. 10½d. from the amount of the total loss, £5. 6s. 3d., leaving as net loss the sum of £3. 14s. 4½d. on 19 oz. of lemel, or 3s. 11d. per oz., without regarding the value which attaches to the silver forming one of the ingredients of alloy. It is essential that I should mention that the slag resulting from the process was tested for gold and silver without any being found. Query: Where have the missing gold and silver gone? the amount of *fine gold alone entirely lost* being 17½ dwt.

Another method in operation by some makers is to reduce the lemel (when it is intended to be worked up again into the articles of the firm) with bicarbonate of soda, and then subject it to another melting with borax, with the view to render it soft, the test for the latter being by hammering the bar backwards and forwards in the vice, when, if it proves tough by standing this process, it is remelted into bar form with charcoal. It will thus be seen that three distinct processes have to be followed in providing workable

[1] Pre-war prices.

metal under the conditions here described, which makes it unduly expensive in re-preparing the metal for the workshop.

Eighteen-carat lemel is the most difficult of all standards to remelt for practical purposes without exhibiting cracks and flaws in the rolling, and much depends upon the melting and the fluxes employed in obtaining the full measure of success. The fluxes should be of the best kind, the metal of this quality heated very hot, and when it looks clear and bright on the top, without any scoria covering the surface, the gold will be almost certain to roll well when remelted with a little charcoal and sal-ammoniac into bar form. I will provide my readers with a special formula I have devised for fusing this particular quality of gold dust so as to save a process of melting and ensure its working capacity :—

18-carat lemel	10 oz.	or 100 oz.
Bicarbonate of potash . .	½ ,,	,, 5 ,,
Calcined borax	¼ ,,	,, 2½ ,,
Nitrate of potash . . .	⅛ ,,	,, 1¼ ,,
Common salt	⅛ ,,	,, 1¼ ,,

If the brightness of the surface does not present itself when the metal has run down, and it is suspected that the gold dust contains traces of any of the more oxidisable metals which the fluxes have not withdrawn, the following remedies will suffice for their removal. If iron or steel filings have got into the lemel and every particle of these have not before the melting operation been removed with the magnet, drop into the crucible a piece of sandiver—glass gall—about the size of a common nut; this will attract the iron or steel and withdraw it into the flux. If lead or tin in the form of soft solder gets into the lemel, it is difficult of detection, if existing in the dust form, when you are sorting through the lemel previous to the melting operation; but if one or two small pieces of bichloride of mercury—corrosive sublimate—are added at intervals to the fused mass in the crucible, and followed by well stirring up the mixture, they will oxidise the lead and tin, and remove both from the gold, purifying it of such destructive elements. This chemical will also destroy iron and steel, and can be utilised for the double purpose of removing small traces of iron and steel, lead and tin; and it is not wasteful of the gold either, as stated by some persons engaged in the trade, but absorbs the common metals, leaving the desirable metals almost as

originally prepared if used in the manner stated. A synopsis of the best special fluxes are here given as the results of a large practical experience, and the worker must adopt the one, after putting it to a fair trial, which he finds best adapted to the particular branch of the goldsmith's art in which he is engaged. The special formula I have devised, however, is found effectual *in all cases* without the addition of the other two chemical salts.

Soda-ash is the best flux to employ for running down all descriptions of lemel intended for sale to the refiner.

Bicarbonate of potash is the best flux to employ for running down clean lemels of all standards when these are to be worked over again; it is the best purifying agent within my experience for this description of melting, and causes the least loss of metal.

Sandiver is the best flux to withdraw iron or steel filings from the gold in melting lemel, or from any other melting charge.

Corrosive sublimate is the best flux to withdraw soft solder in fusing gold dust which is intended to be worked over again. It also toughens the metal resulting from this process, and also that resulting from the melting of new mixtures.

Saltpetre is used largely in the precious metal trades for correcting all the evils here spoken of, but is not a suitable flux in all cases, being too much oxidising, and is therefore not so safe to employ as the others I have named, for it corrodes the copper alloy and causes great waste of metal, especially when the copper in the alloy predominates. When, however, used in any of these processes to which I am now directing attention, it should be used very sparingly.

With regard to the boiling over of the lemel into the fire when melting, that usually proceeds from the quantity of organic impurity contained in the lemel, and the heating of the lemel to redness is recommended to destroy such impurity and lessen this danger in melting. When the metal has been freed from organic matter previous to the melting process, there need be little fear entertained as regards its boiling over.

Old gold and silver laces which have been discarded as unfit for further service may have the precious metals recovered therefrom by carefully collecting the remnants and well burning, in order to destroy the silk, and all other organic matter which may have accumulated during wear,

and the repeated cleanings to which they may have been subjected. The burning should be effected in a strong wrought-iron box fitted with a lid, to prevent the loss of any of the powder as it becomes reduced to that condition, by the heat given, from going with the draught up the chimney. The box in which the burning is done should not be heated too hot, or some of the light particles of gold and silver may attach themselves to the sides and bottom of the vessel, and this would cause their separation a matter of some little difficulty ; but by placing some thick brown paper round the sides and bottom of the box it will, when burnt into powder, protect the gold and silver from adhering thereto, and if the burning is cautiously effected, and at a moderate heat, the risk of the precious metals attaching themselves to the bottom or sides of the iron pan will be reduced to a minimum. The process of burning will considerably reduce the bulk of the product, by destroying the silk, and also any organic matter that may be present. When the material is sufficiently burnt, the box is withdrawn from the fire, allowed to cool, and then, if there are any lumps found in the ash, they should be pulverised into powder by means of a cast-iron mortar and pestle—this being continued until the whole of the ash readily passes through the meshes of a very fine sieve. The resulting fine powder will contain the whole of the gold and silver, which is then collected together and intimately mixed with two-fifth parts of its weight of reducing flux, and finally melted into a solid lump of metal in the following manner. The proportions are :—

Gold lace product . . .	10 oz.	or 100 oz.
Soda-ash	4 „	„ 40 „

This mixture is fused in a clay crucible of the dimensions previously given as the most convenient size for the fusion of jewellers' residues ; and, in propounding the quantities of all kinds of wastes and their fluxes, I have conformed to that size of crucible which is best suited for a medium trade. Of course, it is open for anybody to enlarge or diminish on the quantities of the materials to be run down and the sizes of the crucibles to be employed for the purpose, according to judgment and to the extent of their businesses. I simply formulate a set of rules as a basis for successful practice which experience has proved to me to be both reliable and economical. When the metal is thoroughly melted it will leave the flux and the other undesirable materials and sink

down to the bottom of the crucible. At this stage the flux will assume the appearance of a very thin fluid, when the metal may be taken to have all run down. The mixture should be repeatedly stirred during the period of fusion, in order to break up such portions which otherwise might not come immediately under the action of the flux, but remain isolated, and are therefore not brought into direct fusion with the rest unless assisted with the stirring iron. There is no difficulty when using this flux to detect the right time for the withdrawal of the crucible from the fire, as it melts into a fluid as thin as oil; and when this point has been reached in the melting it is quite safe to remove the pot from the fire, for the process will have become efficiently performed. When the pot is cool enough to be broken, this may be done, and the auriferous metal recovered. Refiners will not make an offer for a button of gold or silver in this form, it not being considered sufficiently uniform in quality, a feature caused through the slow cooling and the high specific gravity of gold which forces its way through lighter metals to the bottom, thus making that part richer in gold than the top or middle part. It will therefore have to be remelted in a clean crucible, and cast into a bar, for a test of assay to be taken by the refiner with the view of sale.

How to treat the iron filings which have been magneted from the various lemels I will next narrate, as it will be best to preserve these until a quantity has accumulated, it being almost impossible to withdraw them from the lemel with the magnet without a little of the precious metals coming away with them. It is the common method in most jewellery establishments to throw these filings into the general sweep. But a better system would be the following, by which every particle of gold and silver may be recovered without trusting to the work of the refiner, with its doubtful results. Take the filings and put them into a rather large but shallow earthenware or enamelled iron dish, like Fig. 18, wherein they could be spread over a large surface and better submitted to the action of a certain pickle, which dissolves out the iron whilst leaving the gold or silver in the metallic state. The following makes a good mixture :—

Iron filings . . .	10 oz. or	100 oz.
Oil of vitriol . .	1 ,, ,,	10 oz.=½ pint.
Boiling water . .	8 ,, ,,	80 oz.=2 quarts.

The water must be boiling, for this exerts a peculiar

influence in its action on the iron. Sulphuric acid—oil of vitriol—has great chemical attraction for iron when used in the manner to be described. Put the filings into the dissolving vessel and spread them over the bottom, next pour over them the boiling water; the vessel must not be quite filled with water, for if so, when the acid is added it would boil over and carry some of the liquid away without its being utilised. In putting in the acid to the water, great care will have to be taken to prevent its flying about and injuring the person in charge of the operation, as the scald or burn will destroy everything it comes in contact with. This danger can be avoided by taking an ordinary copper boiling-out pan, into which is put the oil of vitriol, and then, by taking hold of the mouthpiece with a long pair of tongs, and extending them to their full length, very gradually pour the oil of vitriol into the boiling water covering the iron filings. On the acid first coming in contact with the water, detonations will occur, so that you must not pour the acid in too quickly, but very slowly, and as you proceed with the pouring in, the detonations will become less forcible, until only a hissing noise is made; at this stage enough acid has been added to the water, for the dissolution of the iron appears to proceed then more rapidly. The temperature of the liquid should be kept up by means of a sand bath; but if such a convenience is not to hand, put the vessel upon a sheet of corrugated iron with a gas-light underneath, which will keep the mixture at a regular heat. When the bubbles cease to be evolved, the liquid may be poured off, and another addition of hot water and oil of vitriol, as before, put on to the filings if the iron has not all been dissolved by the first liquid. The sediment left will be the precious metals, and these are washed, dried, and melted into a lump with $\frac{1}{10}$ part of their weight of soda-ash as flux. The iron by this process is converted into sulphate, and if the solution should by any omission of attention be allowed to crystallise into a hard cake of sulphate of iron, put some soda-ash into the vessel and pour on to it a small quantity of boiling water, and well agitate the liquid; this will dissolve the crystallised sulphate of iron again into the liquid state, when it may be poured off cleanly from the gold lemel. This pickle can also be used for dissolving iron and other base metals from 9-carat lemel, so as to purify it before being melted into solid form for subsequent working again in the factory.

CHAPTER VII

FLUXES AND THEIR PROPERTIES

THE best and most useful fluxes adaptable to the business of a manufacturing goldsmith and jeweller in the various stages of working are included in the following table. Only those chemical substances are mentioned which will be found of real service to the practical man, and cannot well be dispensed with in treating of the art of the craft in its simplest form, for the more simple are the practical processes for the working of all metals and their alloys, the more universal is the success of the labour bestowed on the work by the ordinary craftsman. To avoid mistakes when purchasing these substances, I not only place before my readers their common names, but also their chemical names and compound formulas, the latter being the symbols expressive of the union of elements of which the fluxes may be composed. Thus common salt consists of sodium and chlorine, in equivalent proportions, and it has therefore written for its formula NaCl, a point union of the symbols of the two elements.

Table of Fluxes

Common Names.	Chemical Names.	Compound Formula.
Borax	Biborate of Soda	$Na_2B_4O_7$
Common Salt	Chloride of Sodium	NaCl
Salt of Tartar	Carbonate of Potassium	K_2CO_3
Sal-Ammoniac	Chloride of Ammonium	AmCl
Saltpetre	Nitrate of Potassium	KNO_3
Litharge	Oxide of Lead	PbO
Fluor-Spar	Fluoride of Calcium	CaF_2
Corrosive Sublimate	Bichloride of Mercury	$HgCl_2$
Salenixon	Bisulphate of Potassium	$KHSO_4$
Salt of Tartar	Bicarbonate of Potassium	$KHCO_3$
Glass	Glass, Sand, and Fixed Alkalies	...
Soda-Ash	Impure Carbonate of Soda	Na_2CO_3
Sandiver	Glass Gall. Slag from Glass-Melting	...
Pearl-Ash	Impure Carbonate of Potassium	K_2CO_3
Minium	Red Lead Oxide	Pb_3O_4

There are, of course, other fluxes which may be used for effecting the several purposes for which these have been designed ; but none of them answers the purposes so well, neither are they so successful and economical in their results. I will, before proceeding direct to the several practical methods which may be adopted for the recovery of "lemel stuff," make a few observations regarding the nature and characteristics of the fluxes I have named, and also of the advantages to be gained by their use.

Borax—Biborate of Soda, $Na_2B_4O_7$—is a compound consisting of 2 atoms of sodium, 4 atoms of boron, and 7 atoms of oxygen. Borax of commerce is a substance consisting of boracic acid and carbonate of soda in equivalent chemical proportions fused together, and then by dissolving the mass in water, and subsequently crystallising, the neutral borax is formed. Borax was formerly much used in melting operations, but is not now so much used, being superseded by other substances possessing greater advantages in the preparation of the admixtures of gold and silver. Borax becomes easily fusible on adding it to a melting charge, firstly, rising up as a white powder as its water of crystallisation is evolved, then subsiding until it assumes the liquid form, spreading over the contents of the crucible in due course, and forming a complete covering so as to thoroughly protect the metal from the oxidising influence of the air. It also assists in forming fusible compounds with earthy matter, and nearly all bases, being especially useful in consequence of its forming a readily fusible slag, and also of uniting with metallic oxides ; for which reason it is taken advantage of by some furnace operators to dissolve away any oxide which may have formed on the surface of the metal during melting ; and by using it earlier in the process it can be utilised as a covering to prevent this oxide forming on molten metal. Borax is also used as a coating for diamonds in the form of a thick paste to exclude the air when being heated. This coating prevents the oxygen of the air from acting on the surface of the stone when being subjected to a soldering heat, and thus this protecting film allows of the stone following the laws of heat without outside influence. Borax is also used in enamelling and in soldering. In the latter process it is the chief essential to the working goldsmith and silversmith, and to most other metal workers, no other substitute having been found so suitable for the purpose. Borax in the common form con-

tains many molecules of water, and as these are given off on heating, causing a great increase in its volume, the burnt borax is much the best to employ by those who prefer it for the ordinary melting operations. But it is not the best flux for the purpose, which I shall show, the commercial salt being frequently adulterated with common salt and alum.

Common Salt—Chloride of Sodium, NaCl—is a compound consisting of equivalent proportions of chlorine and the metal sodium. It forms a liquid slag, and acts on some metals as an oxidising flux; removes small quantities of antimony and arsenic from a melting charge by converting them into chlorides of their respective metals, which are partly evolved and partly retained in the flux; in this action it tends towards the formation of tougher metal being prepared. It may be used as a cover to prevent the absorption of oxygen gas in melting the alloys of gold and silver; this acts as a safeguard to the production of indifferent working material. It therefore very materially assists in preventing the formation of spilly gold, and also preserves the substance beneath it in the crucible from the action of the atmosphere. Common salt is used as a cover to moderate the action of organic substances which cause the too violent boiling up of the contents of a crucible, and to prevent the mixture from boiling over the top of the crucible into the fire; especially is it useful in the collection of lemel and other waste containing much organic matter. This salt should be used in a fine powder, and as dry as possible, for in the ordinary form it contains an unknown quantity of water, and the crystals would cause a crackling noise on adding them to a heated substance. Neither would the remedy suggested, if applied in the moist state, be half so effective in checking the ebullitions which arise within the crucible, as is found to be the case by using the fine dry powder. Common salt is not recommended as a flux for the melting of new mixtures or their clean scraps in too large a quantity, because it has the power to destroy some of the copper used as an alloying ingredient to the mixture, and it also lowers the tenacity of the compound mixture when formed.

Salt of Tartar—Carbonate of Potassium, K_2CO_3—is a compound consisting of 2 atoms of potassium, 1 atom of carbon, and 3 atoms of oxygen. It is a very deliquescent and soluble salt, and forms an easily fusible slag, being one of the best fluxes for the use of goldsmiths and jewellers,

melts at a low temperature, and by the action of its carbonic acid oxidises many pernicious substances, and then absorbs them into the flux, along with other infusible materials with which the waste of precious metal workers becomes contaminated. It thus acts as a purifying agent to dirty scrap metal, being especially valuable in that respect, as it has great reducing powers, whilst being one of the least injurious fluxes known to the physical properties of gold and silver alloys as used by goldsmiths for manufacturing purposes into personal ornament. Being possessed of much carbonaceous matter, it operates successfully in the treatment of products containing siliceous or drossy substances, by reducing them into a fusible slag from which the precious metals separate, the latter collecting together and sinking to the bottom of the crucible in a mass, whilst the former enters into union with the flux which rises to the top of the mixture and becomes easily detachable from the metal when cast. The real object in forming slags in melting metals is to create readily fusible compounds which shall absorb and contain the impurities it is desirable to remove from the mixture under treatment, and at the same time leave the latter as free as possible from injury to its subsequent working qualities. Pearl-ash is another name for this salt, and is supposed to be prepared in an impurer and cheaper form, but for the purposes named in this paragraph the ordinary carbonate of potash is quite cheap enough, and has always with me proved eminently satisfactory, being much more effective than carbonate of soda, cream of tartar, argol, and similar fluxes, for the contents of a crucible are rendered more liquescent with much less of this salt than with any of the others.

Sal Ammoniac—Chloride of Ammonium, AmCl—is a compound consisting of 1 atom of ammonia and 1 atom of chlorine. This is a volatile salt, and does not liquefy on heating, but becomes decomposed, passing almost directly into the gaseous state, liberating the ammonia, whilst the disengaged chlorine attacks any foreign substances existing in the mixture, converting them into chlorides and expelling them either as vapour or leaving them as dross on the surface of the fused metal intermingled with the charcoal covering; and this property in the flux has been taken advantage of to remove foreign metals from the alloys of jewellers and silversmiths. For melting new mixtures, or for the remelting of clean scrap metal, no other flux is

necessary besides the charcoal covering to ensure complete success in the preparations undergoing fusion, ready to be cast into bar form, the first stage in the multifarious manipulations belonging to the craft of a worker in gold on a large scale. Sal ammoniac will dissolve oxide of zinc formed on the surface of a gold-zinc or gold-brass alloy. It causes the bars of metal melted with it to be tougher, cleaner in appearance, and thoroughly applicable to the work of any branch of the trade. Only a small quantity is needed for the objects stated to be achieved, for, by means of the chlorine it contains, any little impurity that may be present in the mass of metal is destroyed.

SALTPETRE—Nitrate of Potassium, KNO_3—is a compound consisting of 1 atom of potassium, 1 atom of nitrogen, and 3 atoms of oxygen. This salt is an oxidising substance, and is principally used for that purpose. It yields a large volume of oxygen and converts the metals into oxides; therefore it is not safe to use much of this salt for any ordinary purpose, being only useful when oxidisable impurities are required to be removed. It will oxidise tin, lead, zinc, iron, bismuth, antimony, arsenic, cadmium, and other foreign metals, but always at the expense of loss of weight of the alloying metals not intended to be removed. Saltpetre contains nearly half its weight of oxygen, which is readily given up to other substances, and this causes it to act as a most powerful oxidising agent; therefore it is apparent that the other contents of the crucible must suffer considerably if much of this ingredient be used in fluxing metallic mixtures. In melting with a gas furnace it is a dangerous ally to the ingredients in the crucible, in consequence of the already superabundance of oxygen set up within the furnace by the blowing apparatus. It causes blistery gold to be produced with this form of melting, and for that reason alone it should not be used. In reducing lemel, if too much be taken, it will cause such an ebullition of the contents of the crucible to take place, particularly if much organic matter be present, that a certain overflow of the contents will take place, carrying much of the metal with it into the fire. It will thus be seen that this flux is not a suitable one, either for the melting of the regular bars required for daily working or for the collection of lemel; in short, it should only be used for special purposes, and then in a moderate manner, or too much of the alloy would be refined away if an indiscriminate use was made of this substance in the

act of performing the work above named. A lump about the size of a small horse-bean is sufficient to clear away any little impurity from the contents of a good-sized crucible which may happen to exist in the alloying metals undergoing preparation for the workshop.

LITHARGE—Oxide of Lead, PbO—is a compound consisting of 1 atom of lead and 1 atom of oxygen. It is a semi-vitreous substance possessing a bright, glassy appearance, and might be taken for crystals of glass were it not for its colour, which is yellow. Litharge acts as a powerful flux, and possesses the property of imparting fluidity to most metallic oxides; flint glass owes its ready fusibility to the presence of this substance. Oxide of lead has the further property of rendering fusible other oxides which, without such admixture, could not practically be changed to the liquid conditions, and these oxides are constantly to be met with throughout the routine of a manufacturing trade like that of the goldsmith's and jeweller's, and this fact is not so widely known to its members as the exigencies of working a costly material through many processes demands it should be. For instance, some master goldsmiths collect their lemel from the dust into bar form by fusion with saltpetre and salt; now, as saltpetre is an oxidising flux, the metals, copper and silver, in the alloy become in a great measure oxidised by the influence of this flux and the application of sufficient heat, and although it would not be correct to say that the resulting oxides are absolutely infusible, yet with regard to all the usual methods commonly practised by goldsmiths, the degree of fusibility is such as to render the product thus formed practically infusible by them in the ordinary way; and to be successful in recovering the metal from the slag, advantage must be taken of some substance which will so act on the residue as to cause it to liberate the oxygen and give up the metal again. Oxide of lead is the proper solvent to employ. This ingredient will render liquid infusible oxides and liberate the metal into the metallic state; with such oxides it forms easily fusible compounds, and also acts as a flux to any mass of fine particles of siliceous matter, causing all such impediments to liquefy and melt. When heated along with any other ingredient containing carbon, oxide of lead is reduced to the metallic state, and in this conversion, the lead, by being liberated from the oxygen, carries the other metallic substances along with it down through the slag to the bottom

of the crucible, and there collects into a button of mixed metals, which, on the crucible being allowed to cool, and then broken, is recovered.

Litharge is an excellent flux for use in the recovery of the precious metals from the waste gilding solutions, the colouring salts, and the polishings; also in other cases where similar residues of waste are dealt with separately by the goldsmith. After the grinding of the common or general sweep, there is always left behind a residue of a most stubborn nature which the powerful iron-cased rollers appear incapable of grinding to powder. Now, this resulting product usually contains a quantity of the precious metals, and any attempt to melt it with ordinary fluxes is almost certain to result in complete failure in consequence of the very thing happening of which I have been speaking—that of an infusible oxide having formed on the surface of the metal, which is intensified from having been brought in contact with the earthy matter of the sweep, and contributed to by the various sources to which the precious metals had been exposed in their course of travel subsequent to being lost from the work-bench or from the furnace to their return as the residue of the general sweep. Anybody who has tried to melt a piece of gold or silver, taken from this kind of residue, on the charcoal block with borax as flux, knows how difficult it is to melt it with the gas jet and mouth blow-pipe, and that a constant scoria is floating over the fused bead when that has been effected, which absolutely refuses to melt and join the metal, or be separated therefrom. This explains the difficulty why this kind of waste product of the goldsmith so obstinately refuses to melt under the commonly applied methods of the workshop. It is this infusible oxide which you have to contend with, and the litharge will not only remove this by dissolving it into the lead, but will also form highly fusible mixtures with most other mineral substances which intermingle therewith, and which are found to be very refractory in melting, oxide of lead being a deoxidising flux of great power and value in the collection and refining of the precious metals from several of the residuary products of the workers in those noble metals. The use of litharge in these processes is not to oxidise all the base constituents of an alloy, as in the process of cupellation, the operation being so arranged as to retain every particle of metal in the lead button at the bottom of the crucible after it has been collected together

from the residuum mass by the litharge, so that as a final result the metallic globules after fusion are made to aggregate and cohere by its means. Litharge is manufactured by the oxidisation of lead in a current of air, and forms a yellow powder which readily melts at a red heat.

FLUOR-SPAR—Fluoride of Calcium, CaF_2.—This is a well-known mineral, and is especially found in Derbyshire, from which it takes the name of *Derbyshire Spar*. It consists of 1 atom of calcium—the base of lime—and 2 atoms of fluorine, an elementary substance allied to chlorine. Fluor-spar acts as a flux, and when strongly heated it melts into a fluid state, doing this much more readily when mixed with the siliceous matter of metallic ores, forming a fusible slag from which the metal separates. It is used as a flux in *sweep refining*, from the property of combining with silicates and other matter to form fusible compounds, by greatly assisting to melt the whole into a liquid. With bone-ash, plaster of Paris, sulphate of lime, and similar substances at a high temperature, it acts as a reducing flux, and is, therefore, a very valuable auxiliary in the recovery of the precious metals from the floor sweepings of the workrooms of all those who have dealings in gold and silver contaminated with those substances.

CORROSIVE SUBLIMATE—Bichloride of Mercury, $HgCl_2$—is a compound consisting of 1 atom of mercury and 2 atoms of chlorine. This substance may be used for removing all deleterious metals from a melting charge of either gold or silver, of whatever quality it may consist; its chlorine combines with the base metals, converting them into their respective chlorides, which are then expelled as vapour, together with the mercury which is liberated. Arsenic, antimony, bismuth, lead, tin, and zinc are all converted, if existing in small quantity only, into chlorides, and driven off as stated above, the gold and silver alloys being practically unaffected. Corrosive sublimate is an excellent remedy for cracky gold, and also for toughening all the preparations of gold and silver, a small quantity of which, if only thrown on the surface of the metal when in a fused condition in the crucible, will toughen the whole mass by its action. Alloys which have proved most difficult to work, have, after a remelting with a small portion of this salt, been noted for the softness which has been brought about by its use, and the remarkable ease with which the manipulations could then be performed with the metal. It is the best known flux for

the removal of soft solder from the alloys of gold and silver in melting. Soft solder in large quantities must first be oxidised with KNO_3, and then withdrawn into the flux with $HgCl_2$.

SALENIXON—Bisulphate of Potassium, $KHSO_4$—is a compound consisting of 1 atom of potassium, 1 atom of hydrogen, 1 atom of sulphur, and 4 atoms of oxygen. It is a by-product in the manufacture of nitric acid, being the substance which is left in the retorts formed by the action of the oil of vitriol on the saltpetre ; the potassium salt having a greater affinity for the sulphuric acid, unites with it, forming sulphate of potash, and liberating the nitric acid. It is an acid salt, and is useful in collecting lemels, and in sweep refining, in consequence of its cheapness—about 2d.[1] per lb. It will destroy organic substances in melting charges, prevents lemel boiling over during the operation of reducing it to the molten state, and in this performance acts in the same manner as common salt. It forms a liquid flux, and readily melts, its only drawback being a tendency to destroy the pots if kept too long in the fire in a state of fusion. This salt is white, and exists in blocks, which should be reduced into a fine powder before using. It is not recommended as a flux for ordinary melting purposes, but in dealing with many of the waste products of the manufacturer it may safely claim to be of great value.

SALT OF TARTAR—Bicarbonate of Potassium, $KHCO_3$—is a compound consisting of 1 atom of potassium, 1 atom of hydrogen, 1 atom of carbon, and 3 atoms of oxygen. It is a white crystalline substance, and does not become reduced to the wet state like the ordinary carbonate of potash when unprotected from atmospheric influences. It is a most excellent flux in the collection of lemels, and when these are intended to be worked over again, no better flux can possibly be employed in the procuring of good workable metal. Bicarbonate of potassium has the property of oxidising many metals, such as tin, iron, zinc, etc., by the action of its carbonic acid and absorbing them into the flux ; it thus acts as a purifying agent, and when uncertain substances are to be melted, the extent of their impurity being unknown, oxidising agents are necessary to convert the impurities into oxides which do not alloy with the metal, but are either made to enter into union with the flux, or rise to the surface as dross or scum. Bicarbonate of

[1] Pre-war price.

potassium is just the right flux for this purpose. It is also a most excellent preventive to blistery gold, when an admixture of that metal is being prepared by means of a gas furnace and blower, in lieu of a good coke furnace; and I have been the means of removing many difficulties from the path of less-experienced craftsmen by advising the use of this flux as a remedy for removing the besetting evils which are constantly arising. It is far superior to saltpetre, for while it does not oxidise the copper in the mixture, it eliminates all the pernicious metals and reduces the resulting metal to a thoroughly workable condition again.

Glass.—This is a hard, transparent substance, formed by fusing a mixture of sand with some fixed alkalies, such as soda and potash, with the addition, for some purposes, of certain metallic oxides and other substances. Flint glass contains oxide of lead, and this kind would be detrimental to use as a flux without discriminating powers being exercised with regard to the purposes for which it is suited. Glass is employed by some operators as a covering in melting metals, so as to exclude the air and prevent oxidisation, as it easily fuses at a high temperature, and readily combines with lime and other bases. Plate or window glass is best for this purpose, being free from oxide of lead. Glass will prevent clay crucibles from being destroyed; if a pot should crack, withdraw it immediately from the fire, and throw some powdered glass on to the cracked place where the metal is oozing through, and this will stop it, or touch the place with a piece of iron, when, after a few seconds, the molten metal will become set on the outside of the crucible and effectually prevent any further loss of metal. Glass, when used as a flux, should be reduced to fine dust by pounding in an iron mortar; and if some of this powder is added to a melting charge, in which the pot shows evidence of cracking, the glass powder will work to the crack, and stop the metal from running out into the fire. It is, therefore, a useful addition to the other substances usually at the command of metal casters as fluxes.

Soda-Ash.—This is an impure kind of carbonate of soda, being deprived of the water which exists as a constituent in carbonate of soda. It is, in reality, a dehydrated carbonate of soda in the form of a white dry powder, being the by-product in the manufacture of the pure carbonate of soda, and contains about 50 per cent. of pure soda, the remainder being chiefly sulphate of soda, common salt, and

other foreign salts, which makes it a very suitable salt for fluxing the rough lemels and other products when being collected together for sale to the refiner. It costs about 1½d.[1] per lb., and, considering its price, together with its many advantages as an auxiliary to running-down lemels, it is one of the best for the purpose in the whole range of fluxes, when the mixed metals are not intended to be used over again, but sold to the refiner with the view of having the gold and silver separated from the base metals into their pure state.

SANDIVER.—This is a grey powder, and is the saline scum which is cast up from the materials of glass during fusion, and found floating on the top of the mixture. This flux, which arises on molten glass in its manufacture, is scummed off as it arises, and is then called by the operatives glass-gall ; it is, therefore, a by-product of the glass furnaces, and has been found useful for many purposes outside the glass trades. In the jewellery trades it serves several useful purposes, among them being the following : it will draw iron out of a melting charge into the flux, and is especially useful in the collection of lemels containing iron filings, and residues which have been formed by precipitation with sulphate of iron, as in the colouring wastes, wash-hand residues, and the like productions. It is used to prevent the solder from rising and leaving the place where it is intended to flow on delicate and intricate articles of jewellery. It will also prevent iron binding-wire from soldering to the work when bound into position for soldering purposes with that material. Its present price is 2s. per lb. It is put by experienced manipulators to several other uses besides those named.

There is one other salt, and although I have not given it a place in the table of fluxes, it is worthy of mention, from the fact that it is variously used at the present time in some of the processes connected with the precious metal industries by several manufacturing firms, by whom its advantages and merits are highly spoken of. It is therefore entitled to a brief notice in these pages, along with the others I have named. Nevertheless, I do not consider it equal to any of them as a flux for use in the collection of *lemel stuffs* or other solid wastes. It is a potassium salt of the following description :—

CREAM OF TARTAR—Bitartrate of Potassium, $KH_5C_4O_7$—is a compound consisting of 1 atom of potassium, 5 atoms

of hydrogen, 4 atoms of carbon, and 7 atoms of oxygen. Cream of tartar, when pure, is white. It is collected from the sides of wine casks and purified with bone-black. The impure variety is commonly known as argol, and the kind chiefly used is coloured, and purchased as *red argol*. This substance is cheaper than pure cream of tartar, and is probably the best for fluxing purposes, as it contains other carbonaceous matters which gives it greater reducing powers. It is valuable in operations which require a considerable quantity of carbon and potash to facilitate fusion, such as the reduction of the waste residues left from the grinding of the floor sweeps and other products, in which litharge is employed as one of the acting ingredients to effect their reduction, for the therein contained carbon assists in reducing the litharge to the metallic state, and this, by its conversion, carries all the other metals along with it through the slag down to the bottom of the crucible; it is therefore most useful, when oxides of an earthy character come up for treatment, for the purpose of being reduced to the metallic state, and the precious metals recovered therefrom. For other purposes, such as the collection of gold dust and rough lemels, it is unequal to soda-ash, which is much the cleanest and the best flux to employ. The objection to cream of tartar, or argol, is that, when heated to fusion, it bubbles very much, and the acid which it contains, being the actual reducing agent, decomposes, giving off combustible gases of an unpleasant odour.

Having now very fully enumerated the fluxes of most common application to the work of a manufacturing goldsmith, and defined their several uses, I will at once proceed to explain the various kinds of treatment to which gold dust, cuttings, lemel, and other wastes may be subjected for the recovery of the precious metals. I shall, therefore, lay before the readers not only the processes usually employed, but give some valuable details in connection with the subject which my long practical experience has enabled me to observe and profit by; and who knows but that some of the hints thrown out may be new to some, and add considerably to the benefit of manufacturers generally by enabling them to effect some improvements in the waste-saving operations of a more economical nature than those now generally employed?

CHAPTER VIII

LAPPING WASTE

THE waste which accumulates in the process of gold-cutting, or "lapping," as it is called in the trade, is very great in some branches; consequently it should be very carefully watched, where a large business of this description is done, to prevent loss and waste of material, as much as two pennyweights of metal being cut from some classes of work in each ounce weight. It is therefore advisable in practising this art to not only specially safeguard the knots

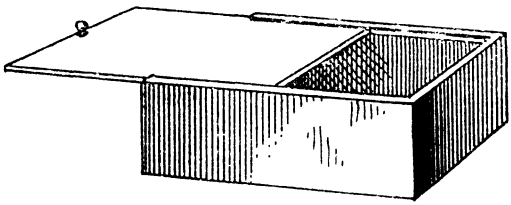

FIG. 19.—Iron Box for Burning Lapping Waste.

of cotton waste with which the laps are repeatedly being cleaned of all adhering gold as it is cut from the work, and the greater part retained thereon, but also to have the lapping boxes frequently cleaned out, the lathes themselves cleaned and the contents removed to some place of safety outside any of the irregularities of the workshop by being placed in a box lined with either sheet lead or zinc, which will preserve in perfect safety the material placed therein until the time arrives for the particular kind of treatment it has to undergo for the recovery of the precious metals. This kind of waste, when very rich in metal, should be treated separately, and not be mixed with the *polishings* or with the *floor sweep*. I will now proceed to describe the manner by which this should be done, so as to bring back the metal into its solid compact form ready to be subjected to assay, and sold to the refiner who makes the highest offer.

The cotton waste is first burnt in a strong wrought-iron box (Fig. 19), made of a suitable size to fit the muffle, having the edges of the two sides and one end turned over as a protection for the lid, which slides underneath the turned-over edges, and in that manner safeguards the loss of any of the powder. The iron box is placed on a moderate fire in the muffle furnace, the damper and draught-hole being closed; and when every particle of matter has become thoroughly burnt, the box is allowed to cool, when the contents are removed and passed through the meshes of a fine sieve. A slight pulverising of the coarse parts which are unable to go through the meshes of the sieve readily reduces it to a fine powder, and a repetition of this pounding is continued until all the parts have passed through the sieve. The product will then be in a fine state of division, and fit for the next operation—that of collecting all the fine particles of metal together into a solid lump by melting with a reducing flux. The following formula for this purpose is probably one of the most reliable that can be put into practice. The ratio of ingredients are :—

Gold lappings	10 oz.	or	100 oz.
Soda-ash	6 ,,	,,	60 ,,
Common salt	2 ,,	,,	20 ,,

Nine-tenths of the above flux should be intimately mixed with the stated weight of gold powder which has been reduced from the cotton waste, then placed in the crucible of the form and size previously described, and the one-tenth remaining placed upon the top of the mixture; the crucible is then put into the furnace and great heat given until all the fine metallic particles have undergone fusion and collected into a mass of metal at the bottom of the crucible. The heat of the furnace should be continued until the flux assumes the form of a thin watery fluid, and appears almost motionless, for if this stage in the operation be not reached, it will be highly probable that all the metal has not run through the flux and joined the mass of metal at the bottom, but left minute shots behind dispersed throughout the flux. To facilitate the success of the operation frequent stirrings are necessary during the period of fusion, in order to recover such portions by bringing them immediately under the action of the flux. It is for that reason that I recommend soda-ash as the most perfect flux, on account of its great liquidness when in fusion. The same kind of

treatment follows when the button of metal has been recovered from this process as those which have been already described. If it is suspected that a little lead from the laps has got mixed with the gold, a few small pieces of *corrosive sublimate* added at intervals to the fused mass in the crucible, and well stirred, will destroy it by converting it into chloride, and this is then retained in the flux. There are other methods in practice by goldsmiths for burning their residues besides the iron box named by me. Where a large volume of trade is continually being carried on, special muffles made of iron are erected, these being heated—some with gas and some with coal or coke—from a fireplace underneath the muffle, the flue being at the back. Others, again, prefer a small wrought-iron furnace, similar to those used by laundry women when boiling their clothes for washing, a fume hood being provided to take off the noxious vapours. But these will depend upon the space at the disposal of the manufacturers, the size of the premises, etc.; it is not every one who has sufficient room at his command for building the best and most convenient apparatus for his use, and I have described a simple method that may be employed by all with a very little outlay of expenditure.

CHAPTER IX

GILDING AND SCRATCH-BRUSH WASTE

THE gilding waste will form the next subject of this discourse, and in describing the treatment for this waste I shall include the sludge or sediment which settles at the bottom of the gilding and plating vessels, as well as that which accumulates in the scratch-brush boxes, as these will sometimes contain a fairly large amount of gold and silver, the result of several causes, such as the removal by the brushes of small particles of the deposit in smoothing down the surfaces of the work, or in frosting for a dead surface, or from articles which have stripped in places through the imperfect adhesion of the gold or silver; these, and other refuse of a similar description, should be collected at stated intervals and well dried in an iron box, then mixed with a reducing flux and melted. The precipitate from old cyanide solutions, whether effected by means of mineral acids or by evaporating the volume of liquor to dryness, is to be included in this waste, also that resulting from the old stripping solutions and the pickling baths, for they will all contain more or less of the precious metals, and to know the way to recover these by a separate process may be an advantage to some workers—whether it is worth while to do so depending, of course, upon the particular branches of the trade which they practise and to the extent of the business done. The recovery of the gold and silver from all these baths may be effected by precipitation or by evaporating them to dryness, and then heating the residue until red-hot, when it is fused with soda-ash or pearl-ash in a crucible until the molten globules of metal gradually subside and unite in the form of a melted mass at the bottom of the melting-pot. The object in heating the residue red-hot is to destroy as much of the organic matter as you can, and thus prevent as far as possible the rising up of the contents of the melting-pot, which may lead to its overflowing; but if this should appear likely to occur, a few pinches of dried common salt—kept in readi-

ness—should at once be thrown into the pot if a large one, and this will cause the rising mass to subside again. Many prescribed formulas have been in use for fusing these deposits, but the following, besides being effectual, is cheap :—

Gilding waste	10 oz.	or	100 oz.
Soda-ash	3 „	„	30 „
Common salt	1 „	„	10 „

The gilding waste must be intimately mixed with the fine dry soda-ash which is to act as the flux ; the whole is then put into the crucible and fused as before directed. The resulting button of metal will consist of an alloy of gold, silver, copper, etc., and this may be sold to the refiner after an assay has been taken. Here is another formula very effective in reducing waste products and causing them to give up their metal. It consists of :—

Gilding waste	10 oz.	or	100 oz.
Soda-ash	2 „	„	20 „
Red lead	2 „	„	20 „

A carbonated alkali like soda-ash is, perhaps, one of the best-known fluxes for causing ordinary products to melt; but when the substance contains a considerable quantity of metallic oxides it is not quite so efficacious, for their degree of fusibility is so enhanced that the intermediation of lead oxide has to be taken advantage of for their complete reduction. Oxide of lead possesses the property of imparting fluidity to other metallic oxides, and it is for this reason that it is so useful a flux in most metallurgical operations, for, while borax has the same property in a high degree, it is unsuitable as a flux in some of these operations, because it does not always liquefy thin enough in the crucible to allow of the very fine globules of metal, when thinly dispersed in the fusing product, sinking through the flux to the bottom and then collecting together in a lump ; on the other hand, when the lead oxide is becoming fused a portion is transformed back to lead, and this by its weight carries the precious metals with it as it sinks through the fast-forming slag above. Saltpetre has been much recommended as a flux in these operations, but it is a dangerous substitute, in consequence of its great oxidising influence, a quantity of metal being entirely lost by its use which otherwise would

have been recovered, and if refiners used less in assaying trial samples of polishings, jewellers would have better offers for their products. It is for individual jewellers to decide if it is worth while to carry out these processes separately; otherwise the products, if large, after they have been burnt and powdered, might be severally submitted to a refiner for an offer, and, if small in quantity, then they might be put with the polishings and treated as one product.

SWEEP PICKINGS.—There is only one other waste product resulting from manufacturing operations in the gold and silver trades, besides the "polishings" and the "floor sweep" now to be dealt with—namely, that uncrushable refuse which is left behind after the grinding and pounding of these residues have been thus treated; this substance, as it is returned from the grinding mill, contains gold, silver, copper, iron, lead, zinc, and probably other accompanying metals, according to the nature of the trade carried on, besides much earthy matter. Now this substance, which I shall describe as "sweep pickings," oft-times contains a considerable amount of the precious metals, and how to extract the gold and silver therefrom will form the next part of the subject under consideration. The following processes will be found most economical for dealing with it. Take the "pickings," place them in an iron pan, and heat red-hot in the muffle; then, while hot, plunge the mass into cold water, or water slightly acidulated with oil of vitriol, by which means much of the earthy matter will break away from the surrounding metal, and become separated therefrom. The metallic parts are next collected together and dried, then pulverised and sieved, in order to further separate any remaining portions of earthy matter and the rust of iron. The residuum, after the iron is extracted with the magnet, is submitted to the following treatment, by which means the whole of the metal is made to fuse and collect into a solid lump. It is sometimes a matter of difficulty to melt this stuff on account of its infusible nature, and I give two recipes for simplifying the process very much, either of which can be used according to the kind of stuff to be run down:—

Formula No. 1.—The ingredients are, for clean material—

Sweep pickings	10 oz.	or 100 oz.
Soda-ash	1½ ,,	,, 15 ,,
Fluor-spar	½ ,,	,, 5 ,,

Formula No. 2.—The ingredients are, for rough material—

Sweep pickings	10 oz.	or	100 oz.
Salenixon	3 „	„	30 „
Fluor-spar	1 „	„	10 „

These fluxes are to be intimately mixed with the "pickings," and the entire mass placed in a clay crucible and exposed to sufficient heat in the furnace to reduce the fluxes to a thin pasty mass, at which stage it will be found that most of the inferior metals have entered into combination with the fluxes, the others having run down into a lump at the bottom of the crucible. By stirring the slag which arises over the top of the fused metal it can be observed if all the metal has left it, and if the slag thickens as the heat is prolonged, you need not fear as to the success of the process if it has been well conducted, for the metallic oxides existing along with the earthy matter are apt to render the flux somewhat dry and thick in composition when the heat is prolonged. The fluor-spar used in this operation is best finely powdered before using. It forms fusible compounds with products such as "sweep pickings" by taking up the foreign matters generally with which they become associated from contact with the sweep, while at a high temperature of the furnace it will combine with metallic oxides by dissolving them and withdrawing the oxygen portion therefrom into the flux, by which means the metals are set free to form a button. The fluxes I have given are more commonly replaced by lead oxide and borax. The oxide of lead—litharge—acts in the same way as borax in imparting fusibility to other oxides; but here their similarity ends, for whilst the carbon of the soda-ash converts back to lead some of the oxide of lead, the borax undergoes no parallel change. The advantages of lead oxide in melting "sweep pickings" are its great fusibility and the ease with which lead combines with oxygen, and if any other oxide is present in this product, the two will combine, thus rendering the mass the more easily fusible. When the lead substitute is used, the crucible, after it is removed from the furnace, must be allowed to become quite cold before it is broken for the withdrawal of the button, or it will crumble into pieces, on account of the slight admixture of lead transformed from the litharge which has been used as one of the fluxes, some of which has become mixed with the metallic button in the operation of melting the product. The resulting

button is again melted and poured this time into an ingot mould, an assay taken by the refiners, when the product is sold to the one who offers the most for it. Other reducing fluxes may be used for this product instead of the soda-ash, along with the litharge, such as red argol, carbonate of potash, salenixon, etc., if preferred by some, and saltpetre may be used as an oxidising agent when this is actually necessary, and common salt is used as a cover in the crucible to prevent overflowing. When the litharge is used, the fluxes employed should so react upon it that a portion is reduced to metallic lead, which, by reason of its greater gravity, falls to the bottom of the crucible, alloying in its course with the liberated particles of the precious metals, and carrying them down with it, so that when the crucible has been cooled and broken an apparent button of lead is found at the bottom, and this contains all the precious metals. The reducing agents employed should be thoroughly dry and in the finest state of division, entirely free from lumps, and this applies equally to all the fluxes.

CHAPTER X

POLISHING WASTE

THE "polishing waste" generally consists of a high percentage of the precious metals, and this is particularly the case where the standards worked are of the best quality. The waste resulting from the several polishing processes is therefore very rich, and should *not* be mixed with the "floor sweep," but treated to a separate process; but when poor in quality, it will be much the better plan to sell the polishings to the refiners after they have been well burnt and pulverised into a very fine powder, and competitive trials made by them with the view to an offer. The waste product which forms the "polishings" consists of sundry materials such as are used in the work of polishing, and these contain the principal parts of the metal which are taken from the different articles in smoothing down their surfaces. Emery, pumice, rotten-stone, putty powder, crocus, rouge, worn-out polishing threads, disused brushes, and the refuse from the lathes are the chief substances of the "polishing wastes." In running down this "waste," from four to six parts of flux are amply sufficient to yield a thin fluid slag with ten parts of earthy matter. Fuse until quite thin liquid. Large quantities of polishings, rich in metal, will not require so much reducing flux—probably about two-fifths the weight of the polishings. When, however, running down test samples into clear metal it is better to employ the larger quantity—that is, six parts of flux to ten parts of polishings.

The method adopted by refiners in taking trials of and testing polishings is, after well mixing the bulk by means of a small trowel, to extract small portions from different parts of the mass until sufficient is abstracted to weigh 2 oz. avoirdupois. This is divided into four portions, after being again well turned about and sieved through a very fine sieve. Thus four assays are made from the original 2 oz. of polishings taken as a trial sample from the manufacturing goldsmith's or silversmith's workshop, and from these four assays a balance is struck and an offer of purchase made.

It is much to the master jeweller's advantage to have the polishings burnt to as small a quantity as possible, and any waste parts pulverised into the finest powder, for refiners do not assay the particles which do not pass through their fine sieve, but only the fine powder; therefore these shots of metal are not taken into consideration at all in making their offer, much to the vender's disadvantage. Assayers usually run down trial samples of polishings with red lead and soda-ash, so as to prepare them at one process ready for cupellation. The following are two of the many formulas used :—

1		2	
	Oz.		Oz.
Polishings . . .	1	Polishings . . .	1
Calcined borax . .	1	Soda-ash . . .	2
Soda-ash . . .	1	Red lead . . .	2
Pearl-ash . . .	1		
Saltpetre . . .	1		

Red lead is considered better than litharge, as the latter is supposed to carry over silver with it as it flows over the cupel into the receiving-pot beneath in the cupellation process. Two assays would be made from the above as a check one on the other, and to guard against an excessive offer being made in the purchase. When it is desired to run down the "polishings" into clear metal, the formula No. 1 is considered one of the best for the purchaser.

The object of this mixture is to get a button of metal free from lead and other metallic oxides of a base nature from which it is desired to separate it, as well as from the existing earthy impurities.

The action of the above salts may briefly be described as follows: saltpetre will oxidise the base metals, such as iron, zinc, and lead, causing them to take the form of oxides of their respective metals; and the borax will dissolve these oxides into the flux, and cause them to be retained in the slag, and it is also especially valuable in fluxing lime and other calcareous matter, whilst the potash and soda-ash are both good fluxes for dissolving such earthy minerals as silica and quartz, forming readily fusible silicates or slags with those substances at a moderately high temperature.

I shall only describe those methods for treating the "polishings" which are applicable to the manufacturing jeweller's workshop, and which can be recommended with

safety for the recovery of the gold and silver therefrom, in a simple manner. The sediments from the waste water-tubs and the wash-hands, when not large in quantity, should be put with the "polishings," and treated as one residue. The whole of these substances are collected together periodically and well burnt in an iron box, or in a specially provided boiler-furnace built for the purpose; when cold the coarse parts are crushed and pounded so *thoroughly fine* until every possible portion readily passes through the meshes of an *extra fine* sieve, the uncrushable parts being added to the "sweep pickings" and melted together.

The "polishing waste" contains very much more of foreign and organic substances than the worst kinds of "lemel," and therefore requires a greater proportion of reducing salts to make the mixture sufficiently fluid to allow the metal to gather together and settle down at the bottom of the pot in a button; and in all cases where the slag does not become reduced into quite a liquid state, more flux must be added until it does. Of all the fluxes I have named, none is more useful or possesses greater merit in recovering the gold and silver that accumulates in the polishing residues in the different jewellery establishments than those now to be described. One of the two following mixtures may be selected for employment, in accordance to the nature of the particular kind of polishing refuse to be treated, for the extraction of the precious metals:—

1			2		
	Oz.	Oz.		Oz.	Oz.
Polishings . .	10 or	100	Polishings . .	10 or	100
Soda-ash .	$4\frac{1}{2}$,,	45	Soda-ash . .	3 ,,	30
Fluor-spar . .	$1\frac{1}{2}$,,	15	Salenixon . .	2 ,,	20
			Calcined borax .	1 ,,	10

All the constituents of these mixtures must be reduced to the finest possible powder, and well mixed together, before putting into a fireclay crucible; and, as great heat will be required in the fusion, it is much the safest plan to set the pot in a moderate fire at the start, and gradually raise the heat until the melting-point has been reached, for by those means the cracking of the crucible is less endangered than if it were put in a red-hot fire at the commencement. The reason why a greater proportion of reducing salts is necessary to the treatment of this product is, because the substance to be operated upon contains more earthy

matter and less metal than the other products and residues I have discoursed upon in the foregoing chapters. It, therefore, when thoroughly well burnt, is composed of materials of a much lighter species and of a drier kind than most other substances, and this necessitates an increase in the fluxes employed in order to fuse the gold and bring it down into a mass of metal at the bottom of the crucible. The whole of the fluxes above named possess more than the average power of ordinary fluxes in becoming readily liquid, and this assists the process very much—the salenixon especially being a valuable agent in the hands of a skilful craftsman entrusted with this work, for it not only causes the most refractory substances to melt, but prevents ebullition in the crucible, whilst it will cut through almost any kind of material, and thus the precious metals become the more easily separated from the dross, and are recovered. It is the more economical plan when the operation—that of recovering the gold from the "polishings"—is being performed, and if the crucible withstands the heat of the furnace well, to add, as the mixture sinks towards the bottom of the pot, more of the "mixture of polishings" (prepared in the proportions stated) from time to time, until the crucible has received as much as it will conveniently hold, for by the adoption of this plan a fairly large quantity of the residue may be fused in one crucible, and an unnecessary expense in the purchase of crucibles saved. A precaution against breakage is to place the fireclay pot inside a large plumbago pot like those used by brass casters, and this effectually safeguards the metal from running into the fire in the case of a pot happening to break when nearly full of metal. In melting this stuff the heat of the furnace must be well continued until the entire mass in the crucible is dissolved or liquefied into a thin fluid. The fusing mass should be kept well stirred up until the mixture is complete, as this helps the process very much by assisting the metal when in fusion to collect together, and then by its greater gravity leave the slag and concentrate at the bottom of the melting-pot. At this stage of the process the pot is withdrawn from the fire, allowed to cool, and then it is broken at the base with a hammer, and the lump of mixed metals recovered, remelted, and poured into an ingot mould with the view for sale to the refiner after competitive trials have been invited from two or three smelting firms. A test sample of 2 oz. of the thoroughly well-burnt material is

taken by each smelter from the bulk of the polishing waste, and if the substance entered for competitive trial is rich in the precious metals, the losers in the competition usually pay for 1 oz. out of the 2 oz. taken for testing purposes.

To those unacquainted with the processes adopted in the workshop for the recovery of the precious metals from the "polishings," and it is the wish to have the aforesaid residue run down on the premises, the preceding information will be useful; but the competition among smelters is now so keen that it is advisable to consider seriously whether it is worth while to collect the gold and silver from these wastes by individual firms, considering the cost of materials required in the process and the workmen's time in effecting it, or whether it would not be the better plan to sell all such residues containing particles of gold and silver to the smelters of such products as being the more economical and the least expensive course to pursue.

Photographers', dentists', gold sign-writers', gold-blockers', gilders' and carvers' skewings, cottons, bookbinders' rubbers, and all other refuse of a similar description containing gold and silver, after being well-burnt (which generally reduces the bulk about two-thirds) may be treated by one or other of these processes for the recovery of the precious metals with eminently satisfactory results.

CHAPTER XI

FLOOR SWEEPS

Methods for Treating Them in the Workshop

The last residuary product of precious metal workers is the "sweep," and this includes the dust and dirt from the sweeping of the floors of the different rooms of the workshop; the wastepaper and discarded sawdust; the burnt ashes from the furnaces and the muffles; the old disused melting-pots and their fluxes; and the accumulations of every other kind of waste refuse worth preserving. These substances are reduced in bulk by well burning, by as much as one-half to two-thirds of their original quantity, in proportion to the nature of the materials which compose the sweep. In well-managed places the shop floors are swept, at the least, once a day, the first thing in the morning, by the porter engaged on the premises, and before the workpeople arrive to commence their daily duties. In some manufactories the sweeping is extended to twice a day—morning and dinner-time. The sweepings are carefully sorted through every morning with the view to recover every particle of gold and silver visible to the naked eye which may have been dropped during the working operations of the previous day. After this has been performed, and the precious metals which have been recovered handed over to the person in charge of the rough warehouse, the sweepings are well burnt in a muffle furnace, the object being to destroy as much of the organic matter as possible, and in that manner reduce the bulk of the substance before the pounding or grinding is undertaken. The sweep is preserved either in a strongly made wooden bin or in a room specially reserved for the purpose, until the period arrives for its sale to the smelter. It is unnecessary to preserve the cinders and ashes from stoves or fireplaces used for heating purposes only, as these are not employed for purposes of annealing, or for any other requirements necessary to the forwarding of manufacturing processes. No metal is

therefore likely to become mingled with the burnt residue; it may be thrown away as worthless material.

There are numerous methods practised in the different workshops with regard to the treatment of waste gold products, nearly every manufacturer having a mode of his own for dealing with them. A system suitable to a large manufactory would be altogether unsuitable to a small one, so that it will be difficult to describe any particular process, and call it the best, which will be applicable for all workers. The following general directions are, therefore, given from which a very simple process may be selected available for

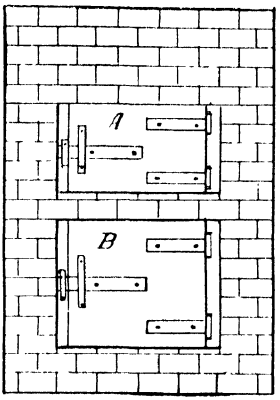

FIG. 20.—Front of a Sweep Muffle.

all the practical purposes of goldsmiths and silversmiths, whether of large or small extent, if they only go the right way to work.

In large manufactories the sweep is burnt in a large muffle furnace specially built for the purpose. This furnace is similar to the jeweller's or chain-maker's annealing muffle, but much larger in size. It consists of an inside width of 24 in., the same depth, and a length of 30 in., contains about twenty fire-bars, and is built somewhat on the reverberatory principle—that is, a mode of burning to powder by which the bodies subjected to it are struck by the fire from every side. It is usually erected in the flue of the shop chimney, and built in the wall of the ground-floor shop. (See Fig. 20—*a* is the muffle proper, and *b* is the draught-hole through which the air is admitted, and this door can either be closed

or left open according to circumstances and to the condition of the burning mass within the muffle.) When the "sweep refuse" is burning too rapidly, the bottom door is closed, and, on the other hand, when it is desired to increase the speed of burning, the bottom door is opened and the top door closed, by which means the muffle attains its greatest heat; and in that manner the regulation of the heat is continually being controlled, the slowest heat being when the top door is open and the bottom door closed. The roof of the muffle is not open into the chimney like an ordinary fireplace would be constructed, with a draught-hole beneath, but the particular construction of this muffle is that its top is built entirely over to within a very narrow limit, which serves as the flue; and this flue is not at the back end of the muffle as would be supposed, but right at the front, just inside the door. This causes the flames to be brought forward from the farthermost end and sides of the muffle, over the sweep to the front, thus causing a thorough calcination of the material within the muffle. The covering is made with firebricks or by substituting a thick plate of iron to withstand the flames which arise from the burning sweep. This muffle will take the iron box (Fig. 19) designed for burning lappings, polishings, and wastepaper sediments in factories where no boiler-furnace has been provided for the reduction of such substances. The sweep is burnt from time to time as it accumulates, in this muffle, the resulting ashes and other residue being removed with a shovel and taken to the place reserved for unground sweep, until the time arrives for it to be sent to a grinding-mill to be pulverised into fine powder. It is the common practice for this to be done half-yearly or yearly. Steam power is employed at the grinding-mills, where sweep and other products of a like nature of precious metal workers are crushed into powder, and where a very large quantity of sweep refuse can be reduced in a short time.

The process consists in submitting the product to the weight of two large iron wheels fixed on the wall and inside a revolving pan of iron which contains the sweep. The wheels have swivel action, and pass over the same mass again and again, until all the crushable parts are pulverised to a fine powder. Sweep grinding is charged for at an agreed rate between the mill-owner and the manufacturing jeweller, according to circumstances; but it is a usual practice for the master

goldsmith to send a representative on his behalf to watch the operation and to take care of all shots or lumps of metal found in the sieves of the workmen whose duty it is to sieve the material as the grinding reaches certain stages.

In small manufactories the sweep is passed through a fine sieve into a wooden box, the fine dust being allowed to remain therein without burning, the sorter setting aside the paper and the other extraneous matter which refuses to pass through the meshes of the sieve for the purpose of burning. When the burning has been effected, and the substance again sieved, the remaining residue is well pounded in a large cast-iron mortar, by means of a long-handled pestle, also of cast iron. This is again passed through the fine-meshed sieve, and this process is repeated until every possible particle of the material is so reduced in size as to readily pass through the sieve. The burning of the sweep in small manufactories is more commonly performed in the annealing muffle after the work is finished for the day, the muffle being filled with the product and the two doors closed, when by the morning the quantity put in will have become well burnt, and at the same time will have cooled down ready for pounding. By the systematic adoption of this practice the sweep product will be well kept down, and very little extra work will be required in preparing it ready for trial when choosing a selection of smelting firms to compete with the view of selling it to the one who offers the most for it.

When it is desired to run down a portion of the sweep in order to ascertain how much metal there is in it, the following mixtures will be found efficient according to circumstances and to the character of the sweep. It takes about equal parts of flux to those of well-burnt sweep to produce a thin liquid mixture, and soda-ash and salenixon are the best fluxes to employ in extracting the metal from sweep products by means of crucible operations. I give four formulas for the purpose, either of which may be taken at the will of the operator, and according to the peculiar admixture of foreign substances contained in the sweep :—

1			2		
	Oz.	Oz.		Oz.	Oz.
Sweep . .	10 or	100	Sweep . .	10 or	100
Soda-ash .	5 ,,	50	Salenixon .	5 ,,	50
Pearl-ash .	4 ,,	40	Soda-ash .	4 ,,	40
Common salt .	1 ,,	10	Common salt .	1 ,,	10

3			4		
	Oz.	Oz.		Oz.	Oz.
Sweep . .	. 10 or	100	Sweep . .	. 10 ,,	100
Soda-ash .	. 6 ,,	60	Salenixon .	. 6 ,,	60
Fluor-spar .	. 2 ,,	20	Fluor-spar .	. 2 ,,	20
Common salt .	. 1 ,,	10	Common salt .	. 1 ,,	10

The melting is conducted in the manner recommended for running down "polishings," and the heat must be continued until the mixture assumes the form of a thin fluid slag, at which stage the mixed metals of the sweep will have collected together by sinking through the fast-forming scoria to the bottom of the crucible, leaving all the extraneous matter connected with them above. The fluxes should be intimately mixed with the sweep before putting the preparation into the crucible; and it is advisable to thoroughly well calcine the sweep previous to the addition of the fluxes, because that product invariably contains so many substances of an injurious nature, of which sulphur is one, and this has the power of destroying a portion of the precious metals, like saltpetre. A well-burning of the product, therefore, has a tendency to eliminate this ingredient by converting it into vapour, which then escapes in the form of sulphurous acid gas. The recovery of the waste gold and silver from jewellers' and silversmiths' sweeps is altogether too expensive a process to be adopted generally by manufacturers with success, and I only provide the reader with this information to show how it may be done in order to ascertain the approximate amount of metal that gets into the sweep. The recovery of the precious metals from sweeps can only be brought about successfully by a process of smelting.

CHAPTER XII

REDUCING GOLD AND SILVER TO LOWER STANDARDS

IMPROVING GOLD AND SILVER TO HIGHER STANDARDS

HAVING now provided craftsmen in the trade with an exhaustive description of the principal methods employed in the melting of gold and silver into ingots, and also of all the other products of goldsmiths and silversmiths which accumulate as a consequence of industrial working, I shall next direct attention to some of the most important alloys of gold and silver, and to the manual operations employed in the different workshops with those alloyed metals in the construction of articles of jewellery for personal adornment. The course that this descriptive matter will take, besides the alloying of gold for the production of different colours of artistic beauty, will consist of a properly adjusted system whereby one quality of gold may be reduced to another quality of lower degree; or the same quality may be raised to a higher standard, at the will of the operator, in the course of a few minutes by the adoption of this system, which is very simple in itself; and quick and accurate means are here provided for determining any quality required. Following this, space permitting, the rolling and slitting of gold and silver ingot bars, wire-drawing, modes of working the different alloys of gold, methods of manufacture; making tube, wires of different shapes, chain links, workshop tools; colouring, gilding, and finishing, will all be treated of in due order, and the difficulties likely to surround the craftsman will be pointed out, so that failures may become fewer, and success in the various departments of work made more certain.

A speedy and correct system for reducing any quality of gold down to another quality lower in standard.

Rule.—Multiply the number of carats, between the standard to be reduced and the carat standard required

by 20, and divide the product by the carat numeral required. This will give the quantity of alloy in pennyweights and fractions of a pennyweight that must be added to each ounce of the alloy, being reduced from that standard to another one of lower degree.

The following examples will show how this is done most clearly with regard to all the principal standards now used for hall-marking :—

24 carat reduced to 22 carat—
$2 \times 20 = 40 \div 22 = 1\frac{9}{11}$ dwt., or 1 dwt. $19\frac{7}{11}$ gr. of alloy.

To 1 oz. of 24-carat gold you must therefore add 1 dwt. $19\frac{7}{11}$ gr. of alloy to make 22-carat gold.

24 carat reduced to 20 carat—
$4 \times 20 = 80 \div 20 = 4$ dwt. of alloy.

To 1 oz. of 24-carat gold you must therefore add 4 dwt. of alloy to make 20-carat gold.

24 carat reduced to 18 carat—
$6 \times 20 = 120 \div 18 = 6\frac{2}{3}$ dwt., or 6 dwt. 16 gr. of alloy.

To 1 oz. of 24-carat gold you must therefore add 6 dwt. 16 gr. of alloy to make 18-carat gold.

24 carat reduced to 15 carat—
$9 \times 20 = 180 \div 15 = 12$ dwt. of alloy.

To 1 oz. of 24-carat gold you must therefore add 12 dwt. of alloy to make 15-carat gold.

24 carat reduced to 12 carat—
$12 \times 20 = 240 \div 12 = 20$ dwt., or 1 oz. of alloy.

To 1 oz. of 24-carat gold you must therefore add 1 oz. of alloy to make 12-carat gold.

24 carat reduced to 9 carat—
$15 \times 20 = 300 \div 9 = 33\frac{1}{3}$ dwt., or 1 oz. 13 dwt. 8 gr. of alloy.

To 1 oz. of 24-carat gold you must therefore add 1 oz. 13 dwt. 8 gr. of alloy to make 9-carat gold.

22 carat reduced to 20 carat—
$2 \times 20 = 40 \div 20 = 2$ dwt. of alloy.

To 1 oz. of 22-carat gold you must therefore add 2 dwt. of alloy to make 20-carat gold.

22 carat reduced to 18 carat —
$4 \times 20 = 80 \div 18 = 4\frac{4}{9}$ dwt., or 4 dwt. $10\frac{2}{3}$ gr. of alloy.

To 1 oz. of 22-carat gold you must therefore add 4 dwt. $10\frac{2}{3}$ gr. of alloy to make 18-carat gold.

22 carat reduced to 15 carat—
$7 \times 20 = 140 \div 15 = 9\frac{1}{3}$ dwt., or 9 dwt. 8 gr. of alloy.

To 1 oz. of 22-carat gold you must therefore add 9 dwt. 8 gr. of alloy to make 15-carat gold.

22 carat reduced to 12 carat—
$10 \times 20 = 200 \div 12 = 16\frac{2}{3}$ dwt., or 16 dwt. 16 gr. of alloy.

To 1 oz. of 22-carat gold you must therefore add 16 dwt. 16 gr. of alloy to make 12-carat gold.

22 carat reduced to 9 carat—
$13 \times 20 = 260 \div 9 = 28\frac{8}{9}$ dwt., or 1 oz. 8 dwt. $21\frac{1}{3}$ gr. of alloy.

To 1 oz. of 22-carat gold you must therefore add 1 oz. 8 dwt. $21\frac{1}{3}$ gr. of alloy to make 9-carat gold.

20 carat reduced to 18 carat—
$2 \times 20 = 40 \div 18 = 2\frac{4}{9}$ dwt., or 2 dwt. $5\frac{1}{3}$ gr. of alloy.

To 1 oz. of 20-carat gold you must therefore add 2 dwt. $5\frac{1}{3}$ gr. of alloy to make 18-carat gold.

20 carat reduced to 15 carat—
$5 \times 20 = 100 \div 15 = 6\frac{2}{3}$ dwt., or 6 dwt. 16 gr. of alloy.

To 1 oz. of 20-carat gold you must therefore add 6 dwt. 16 gr. of alloy to make 15-carat gold.

20 carat reduced to 12 carat—
$8 \times 20 = 160 \div 12 = 13\frac{1}{3}$ dwt., or 13 dwt. 8 gr. of alloy.

To 1 oz. of 20-carat gold you must therefore add 13 dwt. 8 gr. of alloy to make 12-carat gold.

20 carat reduced to 9 carat—
$11 \times 20 = 220 \div 9 = 24\frac{4}{9}$ dwt., or 1 oz. 4 dwt. $10\frac{2}{3}$ gr. of alloy.

To 1 oz. of 20-carat gold you must therefore add 1 oz. 4 dwt. $10\frac{2}{3}$ gr. of alloy to make 9-carat gold.

18 carat reduced to 15 carat—
$3 \times 20 = 60 \div 15 = 4$ dwt. of alloy.

To 1 oz. of 18-carat gold you must therefore add 4 dwt. of alloy to make 15-carat gold.

18 carat reduced to 12 carat—
$6 \times 20 = 120 \div 12 = 10$ dwt. of alloy.

To 1 oz. of 18-carat gold you must therefore add 10 dwt. of alloy to make 12-carat gold.

18 carat reduced to 9 carat—
$9 \times 20 = 180 \div 9 = 20$ dwt., or 1 oz. of alloy.

To 1 oz. of 18-carat gold you must therefore add 1 oz. of alloy to make 9-carat gold.

15 carat reduced to 12 carat—
$3 \times 20 = 60 \div 12 = 5$ dwt. of alloy.

To 1 oz. of 15-carat gold you must therefore add 5 dwt. of alloy to make 12-carat gold.

15 carat reduced to 9 carat—
$6 \times 20 = 120 \div 9 = 13\frac{1}{3}$ dwt., or 13 dwt. 8 gr. of alloy.

To 1 oz. of 15-carat gold you must therefore add 13 dwt. 8 gr. of alloy to make 9-carat gold.

12 carat reduced to 9 carat—
$3 \times 20 = 60 \div 9 = 6\frac{2}{3}$ dwt., or 6 dwt. 16 gr. of alloy.

To 1 oz. of 12-carat gold you must therefore add 6 dwt. 16 gr. of alloy to make 9-carat gold.

A speedy and correct system for raising any quality of gold up to another quality of higher standard.

Rule.—Multiply the number of carats between the standard to be raised and the higher carat standard required by 20, and divide the product by the number of carats existing between the required standard and 24 carats. This will give the *quantity of fine gold* in pennyweights and fractions of a pennyweight that must be added to each ounce of the alloy being raised from that standard to another one of higher degree.

The following examples will show how this is done most clearly with regard to all the principal standards now used for hall-marking :—

20 carat raised to 22 carat—
$2 \times 20 = 40 \div 2 = 20$ dwt., or 1 oz. of fine gold.

To 1 oz. of 20-carat gold you must therefore add 1 oz. of 24 carat to make 22-carat gold.

18 carat raised to 22 carat—
$4 \times 20 = 80 \div 2 = 40$ dwt., or 2 oz. of fine gold.

To 1 oz. of 18-carat gold you must therefore add 2 oz. of 24 carat to make 22-carat gold.

18 carat raised to 20 carat—
$2 \times 20 = 40 \div 4 = 10$ dwt. of fine gold.

To 1 oz. of 18-carat gold you must therefore add 10 dwt. of 24 carat to make 20-carat gold.

15 carat raised to 22 carat—
$7 \times 20 = 140 \div 2 = 70$ dwt., or 3 oz. 10 dwt. of fine gold.

To 1 oz. of 15-carat gold you must therefore add $3\frac{1}{2}$ oz. of 24 carat to make 22 carat gold.

15 carat raised to 20 carat—
$5 \times 20 = 100 \div 4 = 25$ dwt., or 1 oz. 5 dwt. of fine gold.

To 1 oz. of 15-carat gold you must therefore add $1\frac{1}{4}$ oz. of 24 carat to make 20-carat gold.

15 carat raised to 18 carat—
$3 \times 20 = 60 \div 6 = 10$ dwt. of fine gold.

To 1 oz. of 15-carat gold you must therefore add 10 dwt. of 24 carat to make 18-carat gold.

12 carat raised to 22 carat—
$10 \times 20 = 200 \div 2 = 100$ dwt., or 5 oz. of fine gold.

To 1 oz. of 12-carat gold you must therefore add 5 oz. of 24 carat to make 22-carat gold.

12 carat raised to 20 carat—
$8 \times 20 = 160 \div 4 = 40$ dwt., or 2 oz. of fine gold.

To 1 oz. of 12-carat gold you must therefore add 2 oz. of 24 carat to make 20-carat gold.

12 carat raised to 18 carat—
$6 \times 20 = 120 \div 6 = 20$ dwt., or 1 oz. of fine gold.

To 1 oz. of 12-carat gold you must therefore add 1 oz. of 24 carat to make 18-carat gold.

12 carat raised to 15 carat—
$3 \times 20 = 60 \div 9 = 6\frac{2}{3}$ dwt., or 6 dwt. 16 gr. of fine gold.

To 1 oz. of 12-carat gold you must therefore add 6 dwt. 16 gr. of 24 carat to make 15-carat gold.

9 carat raised to 22 carat—
$13 \times 20 = 260 \div 2 = 130$ dwt., or 6 oz. 10 dwt. of fine gold.

To 1 oz. of 9-carat gold you must therefore add 6 oz. 10 dwt. of 24 carat to make 22-carat gold.

9 carat raised to 20 carat—
$11 \times 20 = 220 \div 4 = 55$ dwt., or 2 oz. 15 dwt. of fine gold.

To 1 oz. of 9-carat gold you must therefore add 2 oz. 15 dwt. of 24 carat to make 20-carat gold.

9 carat raised to 18 carat—
$9 \times 20 = 180 \div 6 = 30$ dwt., or 1 oz. 10 dwt. of fine gold.

To 1 oz. of 9-carat gold you must therefore add 1 oz. 10 dwt. of 24 carat to make 18-carat gold.

9 carat raised to 15 carat—
$6 \times 20 = 120 \div 9 = 13\frac{1}{3}$ dwt., or 13 dwt. 8 gr. of fine gold.

To 1 oz. of 9-carat gold you must therefore add 13 dwt. 8 gr. of 24 carat to make 15-carat gold.

9 carat raised to 12 carat—
$3 \times 20 = 60 \div 12 = 5$ dwt. of fine gold.

To 1 oz. of 9-carat gold you must therefore add 5 dwt. of 24 carat to make 12-carat gold.

A speedy and correct system for raising any quality of gold up to an intermediary quality by means of a higher standard.

Rule.—Multiply the number of carats between the standard to be raised and that to be made by 20, and divide the product by the number of carats between the required standard and the higher standard taken, to effect the mixed alloy.

The following examples will show how this is done most clearly with regard to all the principal standards now used for hall-marking :—

18 carat raised to 20 carat with 22 carat—
$2 \times 20 = 40 \div 2 = 20$ dwt., or 1 oz. of 22 carat.

To 1 oz. of 18-carat gold you must therefore add 1 oz. of 22 carat to make 20-carat gold.

15 carat raised to 20 carat with 22 carat—
$5 \times 20 = 100 \div 2 = 50$ dwt., or 2 oz. 10 dwt. of 22 carat.

To 1 oz. of 15-carat gold you must therefore add 2 oz. 10 dwt. of 22 carat to make 20-carat gold.

12 carat raised to 20 carat with 22 carat—
$8 \times 20 = 160 \div 2 = 80$ dwt., or 4 oz. of 22 carat.

To 1 oz. of 12-carat gold you must therefore add 4 oz. of 22 carat to make 20-carat gold.

9 carat raised to 20 carat with 22 carat—
$11 \times 20 = 220 \div 2 = 110$ dwt., or 5 oz. 10 dwt. of 22 carat.

To 1 oz. of 9-carat gold you must therefore add 5 oz. 10 dwt. of 22 carat to make 20-carat gold.

15 carat raised to 18 carat with 22 carat—
$3 \times 20 = 60 \div 4 = 15$ dwt. of 22 carat.

To 1 oz. of 15-carat gold you must therefore add 15 dwt. of 22 carat to make 18-carat gold.

12 carat raised to 18 carat with 22 carat—
$6 \times 20 = 120 \div 4 = 30$ dwt., or 1 oz. 10 dwt. of 22 carat.

To 1 oz. of 12-carat gold you must therefore add 1 oz. 10 dwt. of 22 carat to make 18-carat gold.

12 carat raised to 15 carat with 22 carat—
$3 \times 20 = 60 \div 7 = 8\frac{4}{7}$ dwt., or 8 dwt. $13\frac{5}{7}$ gr. of 22 carat.

To 1 oz. of 12-carat gold you must therefore add 8 dwt. $13\frac{5}{7}$ gr. of 22 carat to make 15-carat gold.

9 carat raised to 18 carat with 22 carat—
$9 \times 20 = 180 \div 4 = 45$ dwt., or 2 oz. 5 dwt. of 22 carat.

To 1 oz. of 9-carat gold you must therefore add 2 oz. 5 dwt. of 22 carat to make 18-carat gold.

9 carat raised to 15 carat with 22 carat—
$6 \times 20 = 120 \div 7 = 17\frac{1}{7}$ dwt., or 17 dwt. $3\frac{3}{7}$ gr. of 22 carat.

To 1 oz. of 9-carat gold you must therefore add 17 dwt. $3\frac{3}{7}$ gr. of 22 carat to make 15-carat gold.

9 carat raised to 12 carat with 22 carat—
$3 \times 20 = 60 \div 10 = 6$ dwt. of 22 carat.

To 1 oz. of 9-carat gold you must therefore add 6 dwt. of 22 carat to make 12-carat gold.

15 carat raised to 18 carat with 20 carat—
$3 \times 20 = 60 \div 2 = 30$ dwt., or 1 oz. 10 dwt. of 20 carat.

To 1 oz. of 15-carat gold you must therefore add 1 oz. 10 dwt. of 20 carat to make 18-carat gold.

12 carat raised to 18 carat with 20 carat—
$6 \times 20 = 120 \div 2 = 60$ dwt., or 3 oz. of 20 carat.

To 1 oz. of 12-carat gold you must therefore add 3 oz. of 20 carat to make 18-carat gold.

9 carat raised to 18 carat with 20 carat—
$9 \times 20 = 180 \div 2 = 90$ dwt., or 4 oz. 10 dwt. of 20 carat.

To 1 oz. of 9-carat gold you must therefore add 4 oz. 10 dwt. of 20 carat to make 18-carat gold.

12 carat raised to 15 carat with 18 carat—
$3 \times 20 = 60 \div 3 = 20$ dwt., or 1 oz. of 18 carat.

To 1 oz. of 12-carat gold you must therefore add 1 oz. of 18 carat to make 15-carat gold.

9 carat raised to 15 carat with 18 carat—
$6 \times 20 = 120 \div 3 = 40$ dwt., or 2 oz. of 18 carat.

To 1 oz. of 9-carat gold you must therefore add 2 oz. of 18 carat to make 15-carat gold.

9 carat raised to 12 carat with 15 carat—
$3 \times 20 = 60 \div 3 = 20$ dwt., or 1 oz. of 15 carat.

To 1 oz. of 9-carat gold you must therefore add 1 oz. of 15 carat to make 12-carat gold.

A speedy and correct system for reducing any quality of gold down to a lower quality by means of any inferior standard.

Rule.—Multiply the number of carats between the standard to be reduced and the carat standard required by 20, and divide the product by the number of carats existing between the inferior one which is to be used for alloying and the standard required. This will give the quantity of the inferior standard in pennyweights and fractions of a pennyweight that must be added to each ounce of the superior alloy about to be reduced to a lower grade.

The following examples will show how this is done most clearly with regard to all the principal standards now used for hall-marking purposes :—

22 carat reduced to 20 carat with 18 carat—
$2 \times 20 = 40 \div 2 = 20$ dwt., or 1 oz. of 18-carat gold.

To 1 oz. of 22-carat gold you must therefore add 1 oz. of 18-carat gold to make 20-carat gold.

22 carat reduced to 20 carat with 15 carat—
$2 \times 20 = 40 \div 5 = 8$ dwt. of 15-carat gold.

To 1 oz. of 22-carat gold you must therefore add 8 dwt. of 15-carat gold to make 20-carat gold.

22 carat reduced to 20 carat with 12 carat—
$2 \times 20 = 40 \div 8 = 5$ dwt. of 12-carat gold.

To 1 oz. of 22-carat gold you must therefore add 5 dwt. of 12-carat gold to make 20-carat gold.

22 carat reduced to 20 carat with 9 carat—
$2 \times 20 = 40 \div 11 = 3\frac{7}{11}$ dwt., or 3 dwt. $15\frac{3}{11}$ gr. of 9 carat.

To 1 oz. of 22-carat gold you must therefore add 3 dwt. $15\frac{3}{11}$ gr. of 9-carat gold to make 20-carat gold.

22 carat reduced to 18 carat with 15 carat—
$4 \times 20 = 80 \div 3 = 26\frac{2}{3}$ dwt., or 1 oz. 6 dwt. 16 gr. of 15-carat gold.

To 1 oz. of 22-carat gold you must therefore add 1 oz. 6 dwt. 16 gr. of 15-carat gold to make 18-carat gold.

22 carat reduced to 18 carat with 12 carat—
$4 \times 20 = 80 \div 6 = 13\frac{1}{3}$ dwt., or 13 dwt. 8 gr. of 12-carat gold.

To 1 oz. of 22-carat gold you must therefore add 13 dwt. 8 gr. of 12-carat gold to make 18-carat gold.

22 carat reduced to 18 carat with 9 carat—
$4 \times 20 = 80 \div 9 = 8\frac{8}{9}$ dwt., or 8 dwt. $21\frac{1}{3}$ gr. of 9-carat gold.

To 1 oz. of 22-carat gold you must therefore add 8 dwt. $21\frac{1}{3}$ gr. of 9-carat gold to make 18-carat gold.

20 carat reduced to 18 carat with 15 carat—
$2 \times 20 = 40 \div 3 = 13\frac{1}{3}$ dwt., or 13 dwt. 8 gr. of 15-carat gold.

To 1 oz. of 20-carat gold you must therefore add 13 dwt. 8 gr. of 15-carat gold to make 18-carat gold.

20 carat reduced to 18 carat with 12 carat—
$2 \times 20 = 40 \div 6 = 6\frac{2}{3}$ dwt., or 6 dwt. 16 gr. of 12-carat gold.

To 1 oz. of 20-carat gold you must therefore add 6 dwt. 16 gr. of 12-carat gold to make 18-carat gold.

20 carat reduced to 18 carat with 9 carat—
$2 \times 20 = 40 \div 9 = 4\frac{4}{9}$ dwt., or 4 dwt. $10\frac{2}{3}$ gr. of 9 carat.

To 1 oz. of 20-carat gold you must therefore add 4 dwt. $10\frac{2}{3}$ gr. of 9-carat gold to make 18-carat gold.

20 carat reduced to 15 carat with 12 carat—
$5 \times 20 = 100 \div 3 = 33\frac{1}{3}$ dwt., or 1 oz. 13 dwt. 8 gr. of 12-carat gold.

To 1 oz. of 20-carat gold you must therefore add 1 oz. 13 dwt. 8 gr. of 12-carat gold to make 15-carat gold.

20 carat reduced to 15 carat with 9 carat—
$5 \times 20 = 100 \div 6 = 16\frac{2}{3}$ dwt., or 16 dwt. 16 gr. of 9-carat gold.

To 1 oz. of 20-carat gold you must therefore add 16 dwt. 16 gr. of 9-carat gold to make 15-carat gold.

20 carat reduced to 12 carat with 9 carat—
$8 \times 20 = 160 \div 3 = 53\frac{1}{3}$ dwt., or 2 oz. 13 dwt. 8 gr. of 9-carat gold.

To 1 oz. of 20-carat gold you must therefore add 2 oz. 13 dwt. 8 gr. of 9-carat gold to make 12-carat gold.

18 carat reduced to 15 carat with 12 carat—
$3 \times 20 = 60 \div 3 = 20$ dwt., or 1 oz. of 12-carat gold.

To 1 oz. of 18-carat gold you must therefore add 1 oz. of 12-carat gold to make 15-carat gold.

18 carat reduced to 15 carat with 9 carat—
$3 \times 20 = 60 \div 6 = 10$ dwt. of 9-carat gold.

To 1 oz. of 18-carat gold you must therefore add 10 dwt. of 9-carat gold to make 15-carat gold.

18 carat reduced to 12 carat with 9 carat—
$6 \times 20 = 120 \div 3 = 40$ dwt., or 2 oz. of 9-carat gold.

To 1 oz. of 18-carat gold you must therefore add 2 oz. of 9-carat gold to make 12-carat gold.

15 carat reduced to 12 carat with 9 carat—
$3 \times 20 = 60 \div 3 = 20$ dwt., or 1 oz. of 9-carat gold.

To 1 oz. of 15-carat gold you must therefore add 1 oz. of 9-carat gold to make 12-carat gold.

There is a difficulty very often experienced with hall-marking alloys in that they fall short occasionally, through various causes, of the requisite fineness to pass the assay office at which the work is presented for assay with the

view to receive the official marks, which serve to show the genuineness of the standards they bear; and if only the barest fraction of a grain under the reputed standard exists, the wares are defaced and smashed up, to be consigned again to the melting-pot. Now, it seems to be a simple thing to add in the melting a few grains of fine gold to make up for the deficiency and so improve the standard, that, on a second presentation at the assay office, its safety could be absolutely assured, but it is not so simple as it looks to the ordinary person, and I have known work, after two and even three of what were considered ample additions of fine gold have been made and the same number of meltings have been carried into effect, to still get smashed up. I shall probably be told that the cause of the trouble was owing to the solder getting mixed with the gold in remelting, but I can at once dispel such an idea, for no person at all experienced in dealing with hall-marking alloys would be so *insane* as to put the soldered parts in the pot again when it is not intended to take an assay from the resulting bar of metal before reworking it. The trouble is due to an entirely different cause, which I will now explain. It is necessary, however, to point out that, when the work is cut and broken up, through the different assays varying in the fineness of the gold for better and worse, it is owing to imperfect mixing in the melting, and this can be remedied by remelting and well stirring of the fused mass in the crucible. For instance, if the fineness of a batch of 18-carat work is represented by the five following assays in diagram :—

·746, ·748, ·750, ·752, ·754,

it will naturally follow that a remelting of the same metal and properly mixing will cause it to be of the proper standard, because some of the parts assay better in direct ratio to those parts which assay worse. But when the alloy is, through the fine gold taken for its preparation, of inferior fineness, the whole lot will be below the authorised standard, with the result, of course, that the work gets broken up. Now, suppose the 18-carat alloy assays at ·746, or 2 gr. below the required fineness, some people imagine that 3 or 4 gr. of fine gold added to each ounce of the ·746 alloy will be sufficient to restore it to the proper standard; but this is not so, the difficulty arising through the product being increased in weight, and there will not be sufficient gold

in the overweight to make it equal to the 18-carat standard, but with 9-carat gold it would about suffice.

To find the correct amount of fine gold to be added, you have to multiply the 2 gr. by 24 and divide the product by 6—the number of carats between 18 carats and 24 carats —and this principle governs all the standards—taking the difference in each case between the standard to be raised and 24 carats, according to the following examples, which represent two typical cases :—

To improve ·746 to ·750=18 carat—
$2 \times 24 = 48 \div 6 = 8$ gr. of fine gold.

Therefore to 1 oz. assaying 2 gr. under 18 carat you will have to add 8 gr. of fine gold to make 18 carat full quality.

To improve ·371 to ·375=9 carat
$2 \times 24 = 48 \div 15 = 3\frac{1}{5}$ gr. of fine gold.

Therefore to 1 oz. assaying 2 gr. under 9 carat you will have to add $3\frac{1}{5}$ gr. *only* of fine gold to make 9 carat full quality.

To improve gold ·746 to ·750=18 carat decimally—
·750 − ·746 = ·004 ÷ ·250 = ·016 oz. of fine gold.

To improve gold ·371 to ·375=9 carat decimally—
·375 − ·371 = ·004 ÷ ·625 = ·0064 oz. of fine gold.

In all cases the required fineness in gold alloys may be most rapidly adjusted, and the correctness assured by adopting this principle in their preparation.

The fine gold as purchased from bullion dealers is seldom quite pure gold, and for this generally understood reason it is customary to add an extra 2 gr. of fine gold to the statutory quantity of fine gold required in the mixture, to allow for its shortcomings. Notwithstanding this, the fine gold contains sometimes more than the usual traces of silver, and this brings about the most disastrous results to the safety of the work manufactured from alloys prepared with it, when it is intended to have the articles hall-marked. Fine gold must be always added in excess in preparing alloys for hall-marking to cover this impurity, for the ordinary fine gold averages about a $\frac{1}{2}$ gr. worse than 24 carat, and this will require two excess grains to be added to each ounce to make up for the deficiency. It is far the safest to purchase the gold from a bullion dealer of repute

and undoubted respectability, for it is a matter of some difficulty to prepare safe standards, unless the fine gold can be depended upon for purity. To decide whether the bullion dealer is to blame for selling you gold of inferior quality, I will here supply a test whereby the blame can be put on the right shoulders; and not always then—as is invariably the case now—can the charge be laid to the fault of the melter. The test is as follows:—

Pure gold (Au)	1 dwt.
Pure hydrochloric acid (HCl) . . .	$1\frac{1}{2}$ dram.
Pure nitric acid (HNO_3) . . .	$\frac{1}{2}$ dram.

Put these into a glass dissolving flask and apply gentle heat until the whole of the gold is dissolved, allow to cool, and, when cold, pour into the flask half a pint of clean, cold water, when the silver—if any exists in the liquid—will be observed to settle at the bottom of the flask in a white spongy powder, as *chloride of silver*. This mixture will have the effect of separating any remaining silver left in the gold from the refining process. The mixture has the power to dissolve the gold and silver, and while holding the former in the liquid, the silver, on the water being added, is precipitated in a white powder, which is readily perceived through the glass vessel and yellow-looking liquid. Mere traces of silver are soluble in concentrated hydrochloric acid, and may not be found out, but when the water is added it loses its hold on the silver, and the latter becomes reduced, so that by this test detection is easy. By acting on this hint, much uncertainty as to the cause of the work getting broken up at the assay offices may be avoided, and the blame attached to the right person. Melting sovereigns is a sure remedy against impurity in the gold, and they are also considerably cheaper to melt than fine gold. It is now unlawful to do this, and great risk is being run by the person who follows this rule, even providing he melts his own sovereigns.

I will next explain how to reduce various odds and ends from several standards down to a definite standard. Proceed by melting all together so as to procure a uniform mixture. When this is done, have the bar assayed, and should it assay at 10 dwt. 6 gr. fine gold in the ounce troy, and you wish to reduce it to 9 carat full standard quality, take the difference in grains there are between 9 carat and that which the bar assays at (which in this example is

66 gr.), and divide that by 9—the carat quality you want —thus :—

To reduce a mixed standard to 9 carat—
10 dwt. 6 gr.—7 dwt. 12 gr.=2 dwt. 18 gr., or 66 gr.
66 gr. ÷ 9 carat—$7\frac{1}{3}$ dwt., or 7 dwt. 8 gr. of alloy.

You have, therefore, to add 7 dwt. 8 gr. of copper, or some other alloy, to each ounce of the assay bar of the above fineness—10 dwt. 6 gr.—to make 9-carat gold for hall-marking. Any other assay may be accurately calculated on this basis, which in the circumstances is sufficiently explanatory for all purposes.

To improve any quality of silver to standard quality.

Rule.—Reduce to grains the difference existing between the fineness of the inferior alloy and standard silver, which, speaking decimally, is ·925; then multiply the grains by 40, and divide the product by 3, when the result will show in grains how much fine silver must be added to 1 oz. of any inferior quality to raise it to standard silver.

For example, suppose you want to improve some silver alloy assaying at a certain number of pennyweights worse, in order to raise it up to standard silver containing 18 dwt. 12 gr. of fine silver in the ounce of that mixture, and if the alloy is reputed $2\frac{1}{2}$ dwt. worse than standard in the ounce troy weight, you must thus proceed :—

To improve ·800 silver to standard ·925 fine silver—
18 dwt. 12 gr.—16 dwt. 0 gr.=2 dwt. 12 gr., or 60 gr.
60 × 40—2400 ÷ 3 = 800 gr., or 1 oz. 13 dwt. 8 gr. of fine silver.

You have, therefore, to add to an alloy assaying $2\frac{1}{2}$ dwt. worse, 1 oz. 13 dwt. 8 gr. of fine silver to each ounce in order to make it standard silver capable for hall-marking purposes; and in this way you will obtain a total of 2 oz. 13 dwt. 8 gr. of standard silver. When the inferior alloy assays an even number of pennyweights less than standard, the following general rule is applicable : multiply the number of pennyweights short of standard by 40, and divide by 3, when the result in all such examples will be in pennyweights and not in grains, as shown in the diagram. The reason of this is apparent, for in the one case the figure 40 has been multiplied by the number of pennyweights worse, while in the other it has been multiplied by the number of grains worse. When the number of pennyweights worse is even,

the method of mixing is very much simplified by adopting this principle.

To reduce standard silver down to an alloy containing any number of pennyweights worse than standard.

Rule.—Reduce to grains the difference existing between the ·925 standard and the quality wanted, multiply that by 20, and divide the product by the number of pennyweights of fine silver required in the lower grade alloy. The result will be the number of grains of alloy wanted.

Example.—Suppose you want to make a mixture assaying 3½ dwt. worse than standard in the ounce troy weight—that is, one containing 15 dwt. of fine silver in the ounce—proceed as follows :—

To reduce standard silver ·925 to ·750 fine silver—

18 dwt. 12 gr.—15 dwt. 0 gr.=3 dwt. 12 gr., or 84 gr.
84×20=1680÷15=112 gr., or 4 dwt. 16 gr. of alloy.

You have, therefore, to add 4 dwt. 16 gr. of copper to each ounce of standard silver, in order to make an alloy holding 15 dwt. of fine silver in every ounce troy weight, and in the result you have a total weight of 1 oz. 4 dwt. 16 gr. of a mixture assaying ·750 in fine silver. All these calculations may be worked out decimally in a very simple manner.

The following is the method by which this may be satisfactorily carried out. Taking the last example by way of explaining the system, proceed thus :—

To reduce standard silver $\frac{\cdot 925}{1000}$ to $\frac{\cdot 750}{1000}$ fine silver decimally—

$$\frac{\cdot 925}{1000}-\frac{\cdot 750}{1000}=\frac{\cdot 175}{1000}\div\frac{\cdot 750}{1000}=\frac{\cdot 233}{1000}\text{ oz. of alloy.}$$

To improve ·750 fine silver to standard ·925 fine silver decimally—

$$\frac{\cdot 925}{1000}-\frac{\cdot 750}{1000}=\frac{\cdot 175}{1000}\div\frac{\cdot 075}{1000}=2\cdot 333\text{ oz. of fine silver.}$$

To improve silver ·800 to ·925 sterling silver decimally—

·925—·800=·125 ÷ ·075=1·666 oz. of fine silver.

To improve silver ·904 to ·925 sterling silver decimally—

·925—·904=·021 ÷ ·075=·280 oz. of fine silver.

It will be observed that this method of mixing silver alloys is very simple indeed, entailing little or no work in its performance, whilst its accuracy can always be depended upon. Gold mixing may be dealt with in a precisely similar manner.

I shall next direct attention to some of the alloys of gold and silver used in the manufacture of goldsmiths' work and jewellery, and point out some of those which are best suited for particular kinds of work, through their possession of certain physical properties not existing in others; and I am often called upon to advise in the matter of the mixing and the melting of the precious metals, when exceptional working properties are required in the metal, without which the successful accomplishment of the object could not be achieved to the best advantage. Much has been said and written regarding the preparation of mixed alloys, and it is frequently supposed, even by those who ought to know better, that all are possessed of a high degree of ductility, no matter how careless may have been the attention bestowed upon them in the fire; but the property above named is only brought about to its fullest extent by precautionary measures being exercised during the fusion of the mixture, no matter how good may be the component parts of the mixture in their definiteness towards that object; and unless special precautions are taken against the overheating of the mixture, and for the protection of those metals which readily oxidise when exposed to the action of the air, perfect ductility in an alloy cannot be secured. Since the overheating of an alloy in which copper predominates causes oxidisation to take place, and the portion of the metals which are thereby converted into oxides do not enter into the alloy as perfect metal, but only as dross, and this exerts a powerful influence more especially on alloys to be drawn into wire, by destroying their ductility, alloys prepared for the manufacture of articles in which the manipulations are to be subjected to much stretching and to wire-drawing after casting must not be heated too hot, as, apart from the other defects I have spoken of, they acquire a too coarsely crystalline structure in their molecular arrangement to be physically suitable for the intended purposes.

CHAPTER XIII

ALLOYS OF GOLD OF VARIOUS STANDARDS

THE alloying of pure gold with copper only is not now so much resorted to as formerly by manufacturing goldsmiths and other workers in the precious metals, when only a few alloys were known, as the colour of the metal at the present time is of far greater importance to the success of business enterprise; hence a large number of mixtures are used in the various industries to produce the desired colour. For many purposes, alloys possessing great ductility are required; for others, the chief requisite is malleability; others, again, must possess hardness, and have a high degree of elasticity, while softness is a necessary qualification in others. Thus it will be seen that, besides alloying gold bullion with silver, copper, brass, and zinc, sometimes very rare metals are employed to impart special properties. But I must caution the reader that an indiscriminate use of these base or rare metals cannot be indulged in without disastrous results happening, and, unless certain precautions are observed, the metal will be liable to split and crack in a very peculiar manner, rendering it unworkable and reducing it to a state of scrap metal. The different properties can only be effected by adding to the gold suitable quantities of the different metals in varying proportions.

The table on p. 171 gives the parts of the various metals which are usually mixed together to produce the different shades of gold by gold-beaters in the preparation of gold leaf for sign-writers, for gilding picture frames, and for other artistic purposes in which leaf-gold is employed.

The gold-beater uses silver and copper only for the purpose of alloying his gold, and these are mixed in various proportions with the view of obtaining different colours. Other metals would be injurious, as they present practical difficulties in the reduction of the gold by limiting its malleability, and perfect malleability—even before the colour—is the most important quality which the gold should possess in the interests of the gold-beater, for gold has sometimes

Table of Various Alloys used by Gold-Beaters

No.	Carats.	Gold.	Silver.	Copper.	Colours.
1	$23\frac{7}{10}$	·988	·012	·000	Pale Fine Gold.
2	$23\frac{3}{5}$	·982	·010	·008	Yellow.
3	$23\frac{1}{2}$	·979	·006	·015	Rich Yellow.
4	$23\frac{2}{5}$	·975	·019	·006	Pale Yellow.
5	$23\frac{2}{5}$	·975	·006	·019	Pale Orange.
6	$23\frac{1}{5}$	·966	·000	·034	Pale Red.
7	23	·958	·042	·000	Pale Pale.
8	23	·958	·017	·025	Deep Yellow.
9	23	·958	·034	·008	Lemon.
10	$22\frac{4}{5}$	·950	·025	·025	Deep Yellow.
11	$22\frac{4}{5}$	·950	·038	·012	Pale Pale Yellow.
12	$22\frac{4}{5}$	·950	·000	·050	Red.
13	$22\frac{3}{5}$	·942	·029	·029	Deep Pale.
14	$22\frac{1}{2}$	·938	·025	·037	Deep Yellow.
15	$22\frac{1}{2}$	·938	·000	·062	Orange.
16	$22\frac{1}{5}$	·925	·050	·025	Extra Pale Yellow.
17	22	·917	·008	·075	Extra Deep Yellow.
18	22	·917	·083	·000	Greenish Yellow.

to be beaten out to $\frac{1}{367650}$ of an inch in thinness, or about 1,200 times thinner than ordinary writing-paper, but this extraordinary tenuity is rarely required in the industrial pursuits, and I merely mention the fact to show the unlimited malleability of some of the alloys of gold, and how they may be extended into leaves under the methods for reduction applied to them by gold-beaters. Sometimes these alloys are prepared with not more than from 3 to 12 gr. of alloy to the ounce of gold, and in other cases it may be so extended as to reach 40 gr. of alloy to the ounce of gold, but this extension so hardens the metal as to make its reduction somewhat more difficult of accomplishment. There is, therefore, a wide range of alloying with gold of so fine a standard, and the shades or tints of gold follow each other rapidly, of which there are about thirteen distinguishing colours, as follows:—*fine gold*, *red gold*, *pale red gold*, *extra deep gold*, *deep gold*, *orange gold*, *lemon gold*, *deep pale gold*, *pale gold*, *pale pale gold*, *deep party gold*, *party gold*, and *white gold*. The fine gold is that containing the least amount of alloy; the deep colours are alloyed with varying proportions of copper, the middle colours with varying proportions of both silver and copper, and the paler colours with varying proportions of silver only. The colours are made all the more distinguishing by slightly varying the quantity of pure gold when mixing it with definite proportions of alloy,

or, as above stated, by using more or less of the alloying mixture to a definite proportion of gold, so as to arrange the standards in fineness from 22 carat upwards. The alloys I have given the reader will show how the baser metals are to be apportioned to produce the results stated. The mixed metals, after carefully weighing each one separately, are melted together in a plumbago crucible and cast into flat oblong ingots, each about $1\frac{1}{2}$ in. long, $\frac{3}{4}$ in. wide, and $\frac{3}{16}$ in. thick. Each ingot of gold is then rolled into a ribbon by passing it again and again between two polished steel rollers at the rolling mill, and this rolling process is continued—with intervals for annealing the metal—until the ingot is spread out to a surface of 960 sq. in., which then consists of a thickness little more than $\frac{1}{800}$ of an inch, below which further reduction would be impossible with the rolls. The ribbon of gold is finally annealed and pickled, that is, softened by heating red-hot in the fire, and cleaned free from oxide. It is then ready for the manipulations of the gold-beater, to be applied to it for the production of gold-leaf, to be afterwards used by sign-writers, by gilders of picture frames, by decorators, for purposes of gold lace manufacture, for fringe for embroidery, and for other purposes too numerous to mention. A detailed description of these processes is reserved until the time comes for the treatment of manufacturing processes generally, the alloys of gold demanding prior attention as being a part of the subject in which many of my readers are the most interested.

The proportion of the various metals in the above table when mixed together compound an ounce of each respective colour named. Gold, though usually called "red," is really "yellow" in fact; it is the only yellow metal as an element, that is, without any admixture as an alloy. The colour of gold alloys depends on the greater or smaller contents of gold, silver, and copper, or on some other metals. Gold alloyed with various proportionate parts of silver imparts a range of colours from pale yellow, through several shades of green, down to a whitish tinge, and even to white, and those with copper treated in the same manner, from brown, through several shades of red to quite a deep red colour. The more copper used, the more reddish will be the tinge imparted to the mixture. It is curious how many variations may be effected in the colour of gold alloys; one would naturally assume that the colour in all cases approached

that of the metal present in the greatest quantity, but this is not a fact with all gold alloys; for instance, an alloy consisting of definite proportions of gold, silver, and copper shows a greenish colour, and this does not appear in any one of those metals singly, so that it is quite possible to produce an infinite number of shades by varying the proportion of the several ingredients used for alloying gold. Likewise, all the natural physical qualities of gold undergo a change by alloying it with other metals, sometimes for the better and sometimes for the worse. As a rule, the hardness in all cases increases, whilst the tenacity increases by judicious mixing. The ductility and malleability also undergo considerable change. The constitutional qualities of one metal, which may be nearly equal to another, are not always reproduced when the two are mixed together by fusion, but a much harder or softer metal may be the result, though in no one case are they softer than fine gold or fine silver, and the achievement of any particular object can only be brought about by selecting such definite parts of the several metals which experience in mixing and in manipulating the metal has taught to be absolutely essential to their production; no theorising will do this for you. It is common among authorities to give alloys for special purposes, containing many metals, which, it is claimed for them, greatly increases the properties desired in the alloy, yet such mixtures are in a high degree injurious to their working qualities in the production of the objects sought. In some alloys a greater proportion of silver will impart softness to the resulting metal, whilst in others the same metal will impart hardness; and the exact knowledge required in the preparation of a mixture possessing all the essentials necessary for the user of the metal to execute his work properly is only gained by close observation and extended experience, both in the preparation of the various mixtures and in the working of them up into the different kind of articles designed for commercial utility and artistic effect.

CHAPTER XIV

TABLES OF 22-CARAT GOLD ALLOYS

No. 1.—22-Carat Alloy for Transparent Enamelling

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·917	=	0	18	8	or	1	0	0
Fine Silver . .	·062	=	0	1	6	,,	0	1	8
Pure Copper . .	·021	=	0	0	10	,,	0	0	12
	1·000		1	0	0		1	1	20

No. 2.—22-Carat Alloy for Yellow Enamelling

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·917	=	0	18	8	or	1	0	0
Fine Silver . .	·050	=	0	1	0	,,	0	1	2
Pure Copper . .	·033	=	0	0	16	,,	0	0	18
	1·000		1	0	0		1	1	20

No. 3.—22-Carat Alloy for Red Enamelling

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·917	=	0	18	8	or	1	0	0
Fine Silver . .	·033	=	0	0	16	,,	0	0	18
Pure Copper . .	·050	=	0	1	0	,,	0	1	2
	1·000		1	0	0		1	1	20

No. 4.—22-Carat Alloy for Gold Coins and Wedding Rings

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·917	=	0	18	8	or	1	0	0
Pure Copper . .	·083	=	0	1	16	,,	0	1	20
	1·000		1	0	0		1	1	20

No. 5.—22-Carat Alloy for Deeper Red Enamelling

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·917	=	0	18	8	or	1	0	0
Fine Silver . .	·021	=	0	0	10	,,	0	0	12
Pure Copper . .	·062	=	0	1	6	,,	0	1	8
	1·000		1	0	0		1	1	20

No. 6.—22-Carat Beautiful Pale Yellow Alloy for Casting

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·917	=	0	18	8	or	1	0	0
Pure Spelter . .	·083	=	0	1	16	,,	0	1	20
	1·000		1	0	0		1	1	20

No. 7.—22-Carat Greenish-Yellow Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·917	=	0	18	8	or	1	0	0
Fine Silver . .	·083	=	0	1	16	,,	0	1	20
	1·000		1	0	0		1	1	20

No. 8.—22-Carat Guinea-Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·917	=	0	18	8	or	1	0	0
Fine Silver . .	·042	=	0	0	20	,,	0	0	22
Pure Copper . .	·041	=	0	0	20	,,	0	0	22
	1·000		1	0	0		1	1	20

No. 9.—22-Carat Greenish-Yellow Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·917	=	0	18	8	or	1	0	0
Pure Platinum .	·083	=	0	1	16	,,	0	1	20
	1·000		1	0	0		1	1	20

No. 10.—22-Carat Full Pale Yellow Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·917	=	0	18	8	or	1	0	0
Pure Iron . .	·083	=	0	1	16	,,	0	1	20
	1·000		1	0	0		1	1	20

No. 11.—22-Carat Pale Violet Alloy for Cast Work

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·917	=	0	18	8	or	1	0	0
Pure Aluminium .	·083	=	0	1	16	,,	0	1	20
	1·000		1	0	0		1	1	20

No. 12.—22-Carat Brownish-Yellow Gold for Fancy Work

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·917	=	0	18	8	or	1	0	0
Pure Palladium .	·083	=	0	1	16	,,	0	1	20
	1·000		1	0	0		1	1	20

No. 13.—22-Carat Pale Yellowish-Grey Alloy for Casting

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·917	=	0	18	8	or	1	0	0
Manganese . .	·083	=	0	1	16	,,	0	1	20
	1·000		1	0	0		1	1	20

Platinum was discovered by Wood in 1741, and appears in my researches to be the most effective in changing the colour of fine gold. One-seventeenth part of platinum so alters the colour of pure gold as to give it a very pale appearance, whilst the gold alloy No. 9, containing $\frac{1}{2}$ part platinum, will impart to it a peculiar yellowish-grey tint, the deep yellow colour of fine gold being entirely overpowered by mixing the metal with small quantities of platinum. It is superior to silver for this purpose, although

$\frac{1}{20}$ part of the latter is sufficient to change the colour of gold. The gold-platinum mixture is difficult to work, and is only melted at a very high heat. Platinum is of a greyish-white colour, very ductile, but highly infusible.

The gold alloy No. 6, containing $\frac{1}{11}$ part zinc, is a rich pale yellow, resembling a colour like pale yellow brass with excess of zinc, but possessing high lustre, and does not tarnish. It is a very brittle alloy, and can only be used for casting purposes as it is without malleability and ductility, being in fact as brittle as glass if subjected to pressure by the rolls. It cannot, therefore, be altered in shape by mechanical means, but must be cast, when melted, into moulds of the required form. This alloy is capable of receiving a brilliant polish of very rich appearance.

The gold alloy No. 13, containing $\frac{1}{11}$ part manganese, is brittle, and forms a hard alloy of light yellowish-grey colour with a coarse-grained fracture. It is difficult to melt, and possesses bad workable qualities. A fine lustre, however, can be imparted to it by polishing. Manganese is not obtained in a pure state, being often found combined with certain kinds of pig iron, in which state it is brittle and difficult to file, and is less fusible than the former. Metallic manganese, when extracted from its natural associates, has a greyish-white colour resembling that of white pig iron, with a fracture fine grained, and is much harder than wrought iron. Few experiments with alloys of gold and manganese have been made, on account of their not being rendered workable enough for the purposes of utility. The black oxide of manganese, MnO_2, the most common compound of manganese, is frequently taken for alloying purposes, and metallic manganese may be obtained by reducing this oxide to the metallic state. Manganese was discovered by Gahn in the year 1774 by reducing the above oxide. Its symbol or chemical name is Mn, its specific gravity or density is 8·00, its atomic weight is 54·80, and it melts at 1,900° C., or 3,452° F. Manganese readily unites with several of the base metals, and forms some important alloys, the principal of which are manganese copper, manganese brass, and manganese German silver.

The gold alloy No. 10, containing $\frac{1}{11}$ part iron to $\frac{11}{12}$ part gold, is of a pale yellowish colour of a very rich tint. It is both malleable and ductile, slightly harder than 22-carat ordinary gold, but can, without any particular special preparation, be rolled into thin plates and manipulated into

any desired form. Iron has an affinity for gold, and will enter into fusion with it in all its states, whether as malleable iron, cast iron, or steel. The preponderance of the gold in this alloy facilitates the fusion of the iron, which should be added in small quantities at a time, bit by bit. Almost all alloys of gold take up a small quantity of iron if stirred with an iron rod when in a state of fusion, on account of the iron dissolving in small quantity into the molten mass. The alloys of gold and iron in which the former predominates serve to make gold of different colours, and are employed by goldsmiths for giving an artistic effect to some of their wares; but these will be dealt with more fully when I come to speak of other standards of gold in which it produces a far more distinguishing effect. The alloys of gold and iron take a very high polish, and I may here remark that the colour of gold alloys is made to vary according to the proportions of copper or silver or of any of the other rare metals used in their preparation, and manufacturers of a certain class of gold-ware make extensive use of the various colours of gold, some of the articles being composed wholly in parts of the different colours, the specific colours being used as far as possible in reproduction of the works of Nature, and these colours are selected according to the purpose for which they are to be used.

The gold alloy No. 11, containing $\frac{1}{2}$ part aluminium to $\frac{11}{2}$ part gold, forms an alloy of pale violet colour, hard and brittle in substance, without malleability. Although aluminium in its fine state is one of the foremost metals in point of malleability, yet when alloyed with fine gold—the most malleable of all metals—in the manner stated it gives as the result an exceedingly fragile compound which cannot easily be worked. Its peculiar colour, however, which is different from all others, makes the alloy very suitable for purposes of decoration, and it can with that view be prepared in a manner in accordance with the object engaged upon, either by casting the parts required and filing to the shapes needed, or by melting on the charcoal and flattening whilst in the liquid state, subsequently attaching the parts to the article being wrought, when, after dressing it up with sundry files and polishing, an artistic effect will be produced not possible with most other alloys. This alloy does not tarnish, and keeps its polish well under all ordinary atmospheric influences. In using the aluminium great attention must be paid to the quality; only the very purest must be used for

alloying, and it is best introduced into the molten gold bit by bit at a time. Previously to doing this, well warm the aluminium so that it will not chill the gold when the addition is made. The physical constants of this metal have already been given in the table describing those of the most known metals.

The gold alloy No. 12, containing $\frac{1}{12}$ part palladium to $\frac{11}{12}$ part fine gold, has a brownish-yellow hue. Palladium readily unites with gold, and makes the latter pale in colour. The alloy in the table is hard and difficult to work, and is therefore very little used as an alloy for gold of this standard. When the proportion of palladium used is small, the alloy is still hard, but ductile and workable. In the lower gold standards it does not present the same difficulties in working as it does in the higher ones. Pure palladium is but little used on account of its price. It is sometimes employed in dentistry, and in the preparation of alloys used for the bearings of arbors in high-class watches, which cause little friction and never rust in atmospheric air. It is also made an addition to the metal used for some kinds of mirrors and mathematical instruments. Palladium occurs associated with platinum, and is obtained as a by-product in refining the latter. It is a greyish-white metal resembling platinum, or steel-grey colour, not so white as silver, and is soluble in hot dilute nitric acid; but in hot concentrated sulphuric acid, and in hot hydrochloric acid it is, if at all, slowly attacked. Its specific gravity is 11·50, its atomic weight is 106·20, its melting-point is 1,500° C., or 2,732° F., and its symbol is Pd. It has been used in alloying gold for the purpose of detecting crime in the workshop and in tracing the particular metal to the hands of the receiver. With silver it forms a series of useful alloys, but as an adulterant for gold it is rarely resorted to in the manufacture of jewellery. The pure metal is less ductile than platinum, and when rolled is apt to crack. It is difficult of fusion, as will be seen by the scale given above of the degrees of heat necessary for effecting that purpose. Palladium was discovered by Wollaston in the year 1803.

The gold alloys Nos. 1 to 5, with varying proportions of silver and copper, are all readily formed, and are easily made workable if the alloying metals are selected free from impurity. Gold and silver, gold and copper, and gold, silver, and copper, may be easily mixed together, and may be alloyed in all proportions. They become harder and more

fusible than fine gold, but these features are presented in accordance to the definite proportions of the two metals taken to alloy the gold with. Just in proportion as these metals are varied in alloying, the resulting compounds are rendered more ductile, harder, more elastic, and become possessed of far more sound than gold or silver taken singly in their purer state, for these metals increase the toughness of gold, and it is principally for that reason that these alloys are used for the coinage and for the manufacture of jewellery.

The alloys of gold with other metals have no corresponding practical utility, and need not, therefore, be enlarged upon further. The principal alloys of gold in use at the present are those with silver and copper, or, in rare cases, with either of these metals singly.

The merest fraction of lead, tin, antimony, bismuth, arsenic, and zinc will destroy the workable qualities of all these alloys, rendering them brittle and inductible, and of no possible use in the industrial arts, one part of either metal in $\frac{1}{1000}$ part of 22-carat gold being sufficient to entirely destroy the gold so that it cannot be worked by the most skilful hands.

CHAPTER XV

TABLES OF 20-CARAT GOLD ALLOYS

No. 1.—20-Carat Extra Red Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·833	=	0	16	16	or	1	0	0
Fine Silver . .	·042	=	0	0	20	,,	0	1	0
Pure Copper . .	·125	=	0	2	12	,,	0	3	0
	1·000		1	0	0		1	4	0

No. 2.—20-Carat Red Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·833	=	0	16	16	or	1	0	0
Fine Silver . .	·050	=	0	1	0	,,	0	1	6
Pure Copper . .	·117	=	0	2	8	,,	0	2	18
	1·000		1	0	0		1	4	0

No. 3.—20-Carat Pale Red Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·833	=	0	16	16	or	1	0	0
Fine Silver . .	·063	=	0	1	6	,,	0	1	12
Pure Copper . .	·104	=	0	2	2	,,	0	2	12
	1·000		1	0	0		1	4	0

No. 4.—20-Carat Yellow Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·834	=	0	16	16	or	1	0	0
Fine Silver . .	·083	=	0	1	16	,,	0	2	0
Pure Copper . .	·083	=	0	1	16	,,	0	2	0
	1·000		1	0	0		1	4	0

No. 5.—20-Carat Pale Yellow Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·833	=	0	16	16	or	1	0	0
Fine Silver . .	·104	=	0	2	2	,,	0	2	12
Pure Copper . .	·063	=	0	1	6	,,	0	1	12
	1·000		1	0	0		1	4	0

No. 6.—20-Carat Extra Pale Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·833	=	0	16	16	or	1	0	0
Fine Silver . .	·125	=	0	2	12	,,	0	3	0
Pure Copper . .	·042	=	0	0	20	,,	0	1	0
	1·000		1	0	0		1	4	0

No. 7.—20-Carat Greenish Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·833	=	0	16	16	or	1	0	0
Fine Silver . .	·157	=	0	3	3	,,	0	3	18
Pure Copper . .	·010	=	0	0	5	,,	0	0	6
	1·000		1	0	0		1	4	0

No. 8.—20-Carat Green Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·833	=	0	16	16	or	1	0	0
Fine Silver . .	·167	=	0	3	8	,,	0	4	0
	1·000		1	0	0		1	4	0

No. 9.—20-Carat Ring Gold Alloy and for Setting

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·833	=	0	16	16	or	1	0	0
Fine Silver . .	·092	=	0	1	20	,,	0	2	6
Pure Copper . .	·075	=	0	1	12	,,	0	1	18
	1·000		1	0	0		1	4	0

No. 10.—20-Carat Red Enamelling Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·833	=	0	16	16	or	1	0	0
Fine Silver . .	·033	=	0	0	16	,,	0	0	18
Pure Copper . .	·134	=	0	2	16	,,	0	3	6
	1·000		1	0	0		1	4	0

No. 11.—20-Carat Yellow Enamelling Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·833	=	0	16	16	or	1	0	0
Fine Silver . .	·134	=	0	2	16	,,	0	3	6
Pure Copper . .	·033	=	0	0	16	,,	0	0	18
	1·000		1	0	0		1	4	0

No. 12. 20-Carat Green Enamelling Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·833	=	0	16	16	or	1	0	0
Fine Silver . .	·157	=	0	3	3	,,	0	3	18
Pure Copper . .	·010	=	0	0	5	,,	0	0	6
	1·000		1	0	0		1	4	0

No. 13.—20-Carat Yellowish-Grey Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·833	=	0	16	16	or	1	0	0
Fine Silver . .	·117	=	0	2	8	,,	0	2	18
Iron or Steel . .	·050	=	0	1	0	,,	0	1	6
	1·000		1	0	0		1	4	0

No. 14.—20-Carat Light Grey Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·834	=	0	16	16	or	1	0	0
Fine Silver . .	·083	=	0	1	16	,,	0	2	0
Platinum or Palladium	·083	=	0	1	16	,,	0	2	0
	1·000		1	0	0		1	4	0

No. 15.—20-Carat Green Gold Alloy for Cast Work

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·833	=	0	16	16	or	1	0	0
Fine Silver . .	·104	=	0	2	2	,,	0	2	12
Cadmium . .	·063	=	0	1	6	,,	0	1	12
	1·000		1	0	0		1	4	0

No. 16.—20-Carat Setting Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·833	=	0	16	16	or	1	0	0
Fine Silver . .	·075	=	0	1	12	,,	0	1	18
Pure Copper . .	·092	=	0	1	20	,,	0	2	6
	1·000		1	0	0		1	4	0

No. 17.—20-Carat Light Grey Gold Alloy for Casting

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·833	=	0	16	6	or	1	0	0
Cadmium . .	·067	=	0	3	8	,,	0	4	0
	1·000		1	0	0		1	4	0

Iron may be substituted for the steel in the steel-gold alloys, and in whichever form it is preferred, either as cast iron or as wrought iron, extra care will have to be observed in the working of the metal. Gold alloyed with any of the different forms of iron should not be quenched in pickle or water immediately after annealing, but allowed to become quite cool—and this is best done gradually—before the manipulations with the metal are commenced, or it will become hard and brittle.

The foregoing alloys will be all that are needed to show how the different colours are produced, for, as previously remarked in the manufacture of jewellery, alloys of gold with copper and silver are the principal ones used on account of their great facility for working, the rare metals being only occasionally brought in for service, and then only for the manufacture of ornamental articles. The latter alloys are,

all of them, much more difficult of manipulation, and are not, as a consequence, very much resorted to; but for certain wares which are to be distinguished by their peculiar colour, a little diversion from the beaten track is sometimes indulged in for the production of specific colours. It is, however, quite possible to provide all the necessary colours by means of varying proportions of copper and silver; and this may be done without losing any of their manipulative properties, which is not the case with the rare metals, for, by varying the standard fineness of the gold and by adopting the correct method of mixing, almost any colour can be effected with copper and silver, from the deep red of copper to the pale white of silver, running through yellow, green, blue, grey, puce, and citron, whilst each tint can be intensified by using discriminating powers in the respective quantities of these two metals which are taken for mixing with the gold.

Cadmium imparts a beautiful green colour to gold. It is a metal of recent discovery, being made known in the year 1817 by Stromeyer. The colour of cadmium is of a silvery-white shade, somewhat between tin and zinc, and it possesses one of the characteristics of the former metal—that of giving out a crackling sound when bent. It is harder than that metal, but more tenacious; it is ductile, and can be rolled and beaten into leaf; it readily dissolves in the three principal mineral acids—nitric, hydrochloric, and sulphuric—but more quickly in nitric acid. Cadmium is found associated with zinc ores, although differing from that metal in many properties, being more volatile for one thing, and it lowers the melting-point of alloys formed with it in union with other metals for another. Cadmium can be rolled cold, whereas zinc rolls best when heated. Cadmium is employed in the preparation of gold and silver solders to enable them to fuse easily.

Its specific gravity is 8·60, its atomic weight is 112·00, its melting-point is 320° C., or 608° F., and its symbol is Cd. With gold of high standard cadmium yields brittle alloys which require great care being exercised in their general treatment, and it is of the utmost importance, when experimenting with new alloys, to see that each metal taken to form a part of the mixture is possessed of a high degree of purity, otherwise failure may attend the result in conducting experiments for the union of new metals, which might have very different properties were it not that the

purity of one or other of the metals selected to form the preparation had been neglected to be ascertained.

The alloys of gold with cadmium are said by some authorities to be both malleable and ductile, but I have by no means found this to be the case in preparing alloys to be used in the manufacture of jewellery.

The general results of my researches are that cadmium imparts to all high-class gold alloys the same properties as "spelter" does. That is, a brittle mixture is compounded which is difficult to work under normal conditions, and for those reasons such constituted alloys have not found their way into the general trade; but for experimental work, and for purposes of special design, where time and trouble are of very little consequence to the financial well-being of the business, such indulgence in experimental research cannot but help to advance metallurgical knowledge and be a distinct gain to science.

To prepare alloys of gold with the addition of a little cadmium it will be found much the best plan to melt the more infusible metals first, such as the gold, copper, silver, etc., and when these are well fused in a plumbago crucible, under a thin layer of charcoal powder, the cadmium—previously heating it nearly to the melting-point—is added; and on account of the great volatilising power of the cadmium it is advisable to force it with the tongs below the charcoal covering as a precaution against any considerable part of it being lost in vapour, for, like spelter, however careful the operative at the furnace may have performed his work, some portion of cadmium will be lost in the process. It will be found best, to save a remelting of the mixture, when this loss is found to be too great, to add an excess of cadmium to the original alloy to allow for loss and to bring it up again to the percentage of cadmium the mixture is desired to contain when in ingot form, and thus avoid the risk of having to perform the operation a second time in order to correct the deficiency with a further addition of cadmium. A little sal-ammoniac powder, or powdered cyanide, is a good flux to prevent oxidation of the cadmium in the melting. It is not wise to raise the heat too high in preparing these mixtures; a moderate heat is much the best, and saves loss of cadmium from volatilisation. The ingot mould should also be much thinner for casting the metal into, as a precaution against liquation and for promoting rapid cooling.

The alloys of gold with cadmium can be used for casting purposes with very satisfactory results. Indeed, for cast rings, and for anodes for gilding in colours, whereby any specially desired colour can be achieved and made to appear on the surface of the work in full accord with the shade of colour the alloy of the article is supposed to have, these alloys can be used for such and similar purposes to advantage and with excellent effect.

CHAPTER XVI

TABLES OF 18-CARAT GOLD ALLOYS

No. 1.—18-Carat Deep Red Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·750	=	0	15	0	or	1	0	0
Pure Copper . .	·250	=	0	5	0	,,	0	6	16
	1·000		1	0	0		1	6	16

No. 2.—18-Carat Rose Red Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·750	=	0	15	0	or	1	0	0
Fine Silver . .	·025	=	0	0	12	,,	0	0	16
Pure Copper . .	·225	=	0	4	12	,,	0	6	0
	1·000		1	0	0		1	6	16

No. 3.—18-Carat Light Red Gold Alloy for Chasing

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·750	=	0	15	0	or	1	0	0
Fine Silver . .	·042	=	0	0	20	,,	0	1	3
Pure Copper . .	·208	=	0	4	4	,,	0	5	13
	1·000		1	0	0		1	6	16

No. 4.—18-Carat Pale Red Gold Alloy (for Dry Colouring)

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·750	=	0	15	0	or	1	0	0
Fine Silver . .	·083	=	0	1	16	,,	0	2	6
Pure Copper . .	·167	=	0	3	8	,,	0	4	10
	1·000		1	0	0		1	6	16

No. 5.—18-Carat Deep Yellow Gold Alloy (very fine Colour)

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·750	=	0	15	0	or	1	0	0
Fine Silver . .	·094	=	0	1	21	,,	0	2	12
Pure Copper . .	·156	=	0	3	3	,,	0	4	4
	1·000		1	0	0		1	6	16

No. 6.—18-Carat Bright Gold Alloy (for Signet Rings)

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·750	=	0	15	0	or	1	0	0
Fine Silver . .	·125	=	0	2	12	,,	0	3	8
Pure Copper . .	·125	=	0	2	12	,,	0	3	8
	1·000		1	0	0		1	6	16

No. 7.—18-Carat Deep Yellow Gold Alloy (for Dry Colouring)

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·750	=	0	15	0	or	1	0	0
Fine Silver . .	·087	=	0	1	18	,,	0	2	8
Pure Copper . .	·163	=	0	3	6	,,	0	4	8
	1·000		1	0	0		1	6	16

No. 8. 18-Carat Pale Casting Gold Alloy, also for Pearl and Diamond Setting

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·750	=	0	15	0	or	1	0	0
Fine Silver . .	·150	=	0	3	0	,,	0	4	0
Pure Copper . .	·100	=	0	2	0	,,	0	2	16
	1·000		1	0	0		1	6	16

No. 9.—18-Carat Wet Colouring Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·750	=	0	15	0	or	1	0	0
Fine Silver . .	·100	=	0	2	0	,,	0	2	16
Pure Copper . .	·150	=	0	3	0	,,	0	4	0
	1·000		1	0	0		1	6	16

No. 10.—18-Carat Extra Pale Yellow Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·750	=	0	15	0	or	1	0	0
Fine Silver . .	·167	=	0	3	8	,,	0	4	10
Pure Copper . .	·083	=	0	1	16	,,	0	2	6
	1·000		1	0	0		1	6	16

No. 11.—18-Carat Green Gold Alloy for Fancy Work

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·750	=	0	15	0	or	1	0	0
Fine Silver . .	·250	=	0	5	0	,,	0	6	16
	1·000		1	0	0		1	6	16

No. 12.—18-Carat Grey Gold Alloy (used for Blue Gold)

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·750	=	0	15	0	or	1	0	0
Steel or Iron . .	·250	=	0	5	0	,,	0	6	16
	1·000		1	0	0		1	6	16

No. 13.—18-Carat Blue or Black Enamelling Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·750	=	0	15	0	or	1	0	0
Fine Silver . .	·208	=	0	4	4	,,	0	5	13
Pure Copper . .	·042	=	0	0	20	,,	0	1	3
	1·000		1	0	0		1	6	16

No. 14.—18-Carat Yellow Enamelling Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·750	=	0	15	0	or	1	0	0
Fine Silver . .	·157	=	0	3	3	,,	0	4	4
Pure Copper . .	·093	=	0	1	21	,,	0	2	12
	1·000		1	0	0		1	6	16

No. 15.—18-Carat Green Enamelling Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·750	=	0	15	0	or	1	0	0
Fine Silver . .	·212	=	0	4	6	,,	0	5	16
Pure Copper . .	·038	=	0	0	18	,,	0	1	0
	1·000		1	0	0		1	6	16

No. 16.—18-Carat Red Enamelling Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·750	=	0	15	0	or	1	0	0
Fine Silver . .	·050	=	0	1	0	,,	0	1	8
Pure Copper . .	·200	=	0	4	0	,,	0	5	8
	1·000		1	0	0		1	6	16

No. 17. 18-Carat Chasing Gold Alloy (Red Gold)

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·750	=	0	15	0	or	1	0	0
Fine Silver . .	·025	=	0	0	12	,,	0	0	16
Pure Copper . .	·225	=	0	4	12	,,	0	6	0
	1·000		1	0	0		1	6	16

No. 18.—18-Carat Brownish Gold Alloy (Hard Alloy)

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·750	=	0	15	0	or	1	0	0
Fine Silver . .	·062	=	0	1	6	,,	0	1	16
Pure Palladium .	·188	=	0	3	18	,,	0	5	0
	1·000		1	0	0		1	6	16

No. 19.—18-Carat Very Soft Stamping Gold Alloy (good for Tube)

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·750	=	0	15	0	or	1	0	0
Fine Silver . .	·162	=	0	3	6	,,	0	4	8
Pure Copper . .	·088	=	0	1	18	,,	0	2	8
	1·000		1	0	0		1	6	16

No. 20.—18-Carat Polishing Gold Alloy, or for Wet Colouring

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·750	=	0	15	0	or	1	0	0
Fine Silver . .	·120	=	0	2	9	,,	0	3	4
Copper . . .	·130	=	0	2	15	,,	0	3	12
	1·000		1	0	0		1	6	16

No. 21.—18-Carat Yellow Gold Alloy for Rings and Colouring

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·750	=	0	15	0	or	1	0	0
Fine Silver . .	·112	=	0	2	6	,,	0	3	0
Pure Copper . .	·138	=	0	2	18	,,	0	3	16
	1·000		1	0	0		1	6	16

It is the practice of manufacturers of jewellery and other gold wares to make use of a number of different coloured alloys for purposes of shading the same article in distinguishing colours. For example, red, yellow, blue, and white are employed for flowers, green for leaves, yellow for stems, grey for backgrounds, and so forth. For white, in high-quality grades of gold, silver, platinum, and sometimes palladium are used. I have given a number of formulas in the above table of 18-carat alloys and of their peculiar composition for all the purposes required, and naming also their special colours, any one of which can be selected in conformity with the specific object in view. As previously remarked, the colour of alloyed gold varies in shade according to the proportions of silver and copper, or of those of other metals, taken in preparing the alloys, care being exercised

in selecting the shade of gold nearest to that desired for the special class of work being wrought, when a much better effect will be obtained than will be the case where this precaution is neglected. The little differently coloured ornaments employed in embellishing the work can be made solid and hard soldered to the articles in course of construction, or used in other ways, according to the demands of the market for which the goods are intended. The different colours may be deposited electrically upon made-up articles of ordinary gold, the various parts not deposited upon being protected from receiving the deposit by a resisting varnish whilst deposition is going on. The solution is made from the required shade of gold, and an anode of the same colour is employed to keep the solution at the right strength for depositing purposes. In fact, there is no end to the purposes to which some of these alloys may be put in the industrial and artistic arts.

I have only mentioned the alloys of 18-carat gold compounded from those metals which give them a real practical utility. Most of the alloys used in the industrial establishments are nothing more than mere mechanical mixtures of the different metals used in compounding the various preparations; they are not made according to any fixed law of chemical combination, but are simply "mixtures of metals," and as such are readily separated into their integral parts again. Gold and copper may be alloyed in all proportions, but the physical or working properties undergo considerable change in accordance with the proportions of each metal as they are taken for alloying or mixing together. The colour also may be made to vary from a light red to a deep red, according to the state of purity of the selected copper. Copper has a tendency to harden some alloys of gold, and the more impure it is, the harder is the mixture formed, especially with high-grade alloys. It may not only alter the malleability and ductility of these mixtures, but render them so brittle as to be workable with difficulty. Gold and silver may likewise be alloyed in all proportions. These compound mixtures are generally pale, extending to a greenish hue, and, further, to a greenish white according to the more silver there is put in the alloy and the less copper; one-twentieth of silver is sufficient to alter the colour of fine gold by rendering it much paler. Silver is used to soften gold in some alloys, while in others it is used to harden them. This knowledge is highly valuable

to a worker in metals, as it can only be acquired from a very extended experience, and, therefore, can only be written about with accuracy by those having had such an experience. The silver-gold alloys are known under the names of pale gold, green gold, and yellow gold. Gold-copper alloys, after annealing red-hot, should not be quenched at a red heat, but allowed to become black before the quenching is performed, otherwise they invariably crack and part asunder in some of the subsequent stages of working. Gold-silver alloys do not present this appearance when treated to immediate quenching.

Gold alloyed with iron or steel forms grey and blue mixtures of a hard nature, some of which are brittle and magnetic and require exceptional treatment to be worked to the best advantage. They are not much used in the jewellery trade.

Gold alloyed with palladium forms hard alloys, almost as hard as iron, even if the palladium be used in small quantities. When, therefore, it is necessary to provide a very hard alloy, this metal may be used for effecting the desired object. For general purposes, however, it is not a part of the stock-in-trade of a jeweller or goldsmith. Palladium has lately been employed for gem setting.

It is sometimes stated by those responsible for a great deal of matter which appears in print that "the ordinary gold of trade jewellery is 18 carat, and if alloyed with copper only, is not pleasant in colour, is much harder to work, and is liable to crack if used for repoussé work. If it is alloyed with silver only, the alloy is paler in colour than gold, but it is very pleasant to work and is very ductile." Such writers do not appear to know the practice adopted in the workshops allied to the jewellery trade, and that while neither of these mixtures would conform to the requirements of buyers of jewellery as regards colour for their general jewellery wares, 18-carat quality of gold can be so proportioned in its composition as to make it capable of being worked up into almost any article by a judicious blending of both silver and copper with the gold, with the certain result following of a richness and beauty of colouring being imparted to the metal, which, when finished into saleable objects, at once takes the commercial eye as being far more acceptable for disposal in the various trading markets of the world. The above is very much akin to the man who said, "there was only 'one alloy,' and everybody knew it,

and used it." Such information is of no real value to the practical jeweller, either as a workman or as a manufacturer, if it is intended as a practical guide to some of the more simple processes of the art of manufacturing up-to-date jewellery, and is such that would not be advanced by any thoroughly experienced craftsman who had received his training direct from the workshop. The object of this treatise is, therefore, to supply really practical information, acquired from the right sources, so that when put to the test there will be no doubt about its usefulness and advantage.

CHAPTER XVII

TABLES OF 16-CARAT GOLD ALLOYS

No. 1.—16-Carat Red Gold Alloy for Chasing

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·667	=	0	13	8	or	1	0	0
Fine Silver . .	·062	=	0	1	6	,,	0	1	21
Pure Copper . .	·271	=	0	5	10	,,	0	8	3
	1·000		1	0	0		1	10	0

No. 2.—16-Carat Extra Red Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·667	=	0	13	8	or	1	0	0
Fine Silver . .	·042	=	0	0	20	,,	0	1	6
Pure Copper . .	·291	=	0	5	20	,,	0	8	18
	1·000		1	0	0		1	10	0

No. 3.—16-Carat Full Red Alloy for Leaf Work

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·667	=	0	13	8	or	1	0	0
Pure Copper . .	·333	=	0	6	16	,,	0	10	0
	1·000		1	0	0		1	10	0

No. 4.—16-Carat Ordinary Gold Alloy (Ring Gold)

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·667	=	0	13	8	or	1	0	0
Fine Silver . .	·125	=	0	2	12	,,	0	3	18
Pure Copper . .	·208	=	0	4	4	,,	0	6	6
	1·000		1	0	0		1	10	0

No. 5.—16-Carat Wet-Coloured Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·667	=	0	13	8	or	1	0	0
Fine Silver . .	·117	=	0	2	8	,,	0	3	12
Pure Copper . .	·216	=	0	4	8	,,	0	6	12
	1·000		1	0	0		1	10	0

No. 6.—16-Carat Yellow Gold Alloy (Bright Gold)

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·667	=	0	13	8	or	1	0	0
Fine Silver . .	·167	=	0	3	8	,,	0	5	0
Pure Copper . .	·166	=	0	3	8	,,	0	5	0
	1·000		1	0	0		1	10	0

No. 7.—16-Carat Deep Yellow Gold Alloy (Polishing Gold)

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·667	=	0	13	8	or	1	0	0
Fine Silver . .	·200	=	0	4	0	,,	0	6	0
Pure Copper . .	·133	=	0	2	16	,,	0	4	0
	1·000		1	0	0		1	10	0

No. 8.—16-Carat Pale Yellow Polishing Gold Alloy and Yellow Enamelling

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·667	=	0	13	8	or	1	0	0
Fine Silver . .	·250	=	0	5	0	,,	0	7	12
Pure Copper . .	·083	=	0	1	16	,,	0	2	12
	1·000		1	0	0		1	10	0

No. 9.—16-Carat Ordinary Yellow Gold Alloy for Polishing

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·667	=	0	13	8	or	1	0	0
Fine Silver . .	·150	=	0	3	0	,,	0	4	12
Pure Copper . .	·183	=	0	3	16	,,	0	5	12
	1·000		1	0	0		1	10	0

No. 10.—16-Carat Full Yellow Gold Alloy for Cases

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·667	=	0	13	8	or	1	0	0
Fine Silver . .	·183	=	0	3	16	,,	0	5	12
Pure Copper . .	·150	=	0	3	0	,,	0	4	12
	1·000		1	0	0		1	10	0

No. 11.—16-Carat Wet-Colouring Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·667	=	0	13	8	or	1	0	0
Fine Silver . .	·100	=	0	2	0	,,	0	3	0
Pure Copper . .	·233	=	0	4	16	,,	0	7	0
	1·000		1	0	0		1	10	0

No. 12.—16-Carat Green Gold Alloy for Blue Enamelling

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·667	=	0	13	8	or	1	0	0
Fine Silver . .	·300	=	0	6	0	,,	0	9	0
Pure Copper . .	·033	=	0	0	16	,,	0	1	0
	1·000		1	0	0		1	10	0

No. 13.—16-Carat Pale Green Gold Alloy for Green Enamelling

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·667	=	0	13	8	or	1	0	0
Fine Silver . .	·333	=	0	6	16	,,	0	10	0
	1·000		1	0	0		1	10	0

No. 14.—16-Carat Orange Red Gold Alloy (Red Enamelling)

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·667	=	0	13	8	or	1	0	0
Fine Silver . .	·083	=	0	1	16	,,	0	2	12
Pure Copper . .	·250	=	0	5	0	,,	0	7	12
	1·000		1	0	0		1	10	0

No. 15.—16-Carat Red Chasing Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold	·667	=	0	13	8	or	1	0	0
Fine Silver	·025	=	0	0	12	,,	0	0	18
Pure Copper	·308	=	0	6	4	,,	0	9	6
	1·000		1	0	0		1	10	0

No. 16.—16-Carat Polishing Gold Alloy (Rich Yellow)

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold	·667	=	0	13	8	or	1	0	0
Fine Silver	·133	=	0	2	16	,,	0	4	0
Pure Copper	·200	=	0	4	0	,,	0	6	0
	1·000		1	0	0		1	10	0

No. 17. 16-Carat Greenish Yellow Gold Alloy (Setting Gold)

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold	·667	=	0	13	8	or	1	0	0
Fine Silver	·267	=	0	5	8	,,	0	8	0
Pure Copper	·066	=	0	1	8	,,	0	2	0
	1·000		1	0	0		1	10	0

No. 18.—16-Carat Grey Gold Alloy (for Blue Gold)

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold	·667	=	0	13	8	or	1	0	0
Iron or Steel	·333	=	0	6	16	,,	0	10	0
	1·000		1	0	0		1	10	0

No. 19.—16-Carat Dentist Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold	·667	=	0	13	8	or	1	0	0
Pure Palladium	·250	=	0	5	0	,,	0	7	12
Fine Silver	·083	=	0	1	16	,,	0	2	12
	1·000		1	0	0		1	10	0

This quality of gold is, at the present time, not much used in the manufacture of gold articles, and since the demand for wares bearing the hall-marks has become so popular with the general public, its use has become almost obsolete. It is a useful standard of gold, and I give it a place among the standards now current because it forms a rich-looking metal of great capacity for withstanding the various manipulations employed in manufacturing, and may still be adapted to the wants of some of the persons engaged in the sectional departments of the precious metal industries.

The 16-carat alloy was greatly used by a former generation of goldsmiths, when what was called *filigree* jewellery came into fashion. Its commencement dates from the latter part of the second decade of the last century, when the colouring of gold first began to be practised, previous to which polished gold was the staple trade article. The method of colouring gold jewellery had been introduced into England by some French emigrants at the beginning of the last century, but the process—which is a chemical one—met with little success until after the peace of 1815 (Waterloo), when it came into general use; and the 16-carat alloy, by the greater inequality in the proportions of the materials used in alloying, could be made to possess a special aptitude for "colouring" over and above those in previous use; and with the then limited knowledge of colouring it was a great inducement for employing it, because the particular colour wanted could be produced so much more easily and quickly when alloyed to that quality than in using richer metal, for in the 16-carat alloy more scope was given for mixing the copper and the silver with the gold in a variety of proportions, by which the surface of gold may be changed into different shadings to suit the object intended, than was the case with the 18-carat and 20-carat alloys. With the introduction of the former alloy for filigree (the original filigree work was made of fine gold, or fine silver, and was necessarily very costly), the resulting work required little or no polishing, or other artificial finish, except colouring, and could be made exceedingly light and graceful in appearance. In consequence of the great facilities it gave for working, it was largely used for brooches of ornamental design, for earrings, and also for the light wire-work which came into fashion at the period, and answered for all the requirements of modern universal wear, both in cheapness and durability. It was also manufactured into chains, bracelets, and, indeed,

into any other of the numerous articles which the new fashion brought into universal demand. There was, in fact, a similarity between the work of the then period and that which arose half a century later in the manufacture of gold jewellery, when 14-carat gold became the rage, and when the younger generation of goldsmiths were wont to display upon their signboards the distinguishing words: "Manufacturers of 'coloured gold jewellery'"; but with other changes following, this notification is now very much more the exception than the rule in the jeweller's quarter. The change from bright work only to coloured work was great indeed, for while the finished gold work which came from the hands of the former worker was very much like bright pale copper, that of the latter possessed that peculiar dead yellow colour on its surface by which anybody was able to distinguish it. The finish and beauty of the bright work was due entirely to the "polisher," whereas that of the coloured work was due to the "colourer" alone. The change of fashion in gold work is chiefly due to the taste of individual wearers, and gold workers have also been subject occasionally to periods of fluctuations in the continuity of their trade. Political disturbances, strikes of the workmen in the general trades of the country, and hard times of most other descriptions always tell first on the journeyman goldsmith and jeweller. At the period to which I have been referring it was a custom with the trade that gold should not be worked less in quality than 16-carat, and this was, therefore, adopted as the lowest alloy for trade jewellery in general by the workers.

For blue enamelling the alloy No. 12 is to be recommended; for green enamelling, the alloy No. 13; for red enamelling, the alloy No. 14; and for yellow enamelling the alloy No. 8 is an excellent one; and the same alloy, when used for "polished" gold, gives out a peculiar rich greeny-yellow tint of great brilliancy and lustre.

Iron or steel can be used as one of the substances in compounding those alloys when it is desirable to procure such shades as blue and grey, as described under 18-carat alloys; but extra care will have to be used in treating the resulting metal to the various manipulations of craftsmanship incidental to the manufacture of artistic jewellery, to prevent difficulties and failures from arising from their use. The addition of either iron or steel to gold makes the mixtures hard and less workable to the ordinary craftsman. Such

alloys are best cooled gradually after they have been annealed, and not quenched in water or other liquid to facilitate cooling, as this helps to increase the hardness. The melting of the metals constituting these alloys is also a matter of some importance, since the iron is much more difficult of fusion than the gold. The gold should in all cases be first melted, and, as it does not in its pure state become oxidised, the heat of the furnace may be raised to its utmost capacity, and the iron or steel previously converted into small pieces then added, piece by piece at a time, until each piece is entirely melted. This object is promoted by stirring the mixture with a dried stick of poplar or fir wood, which causes rapid circulation to take place within the intumescent mass in the crucible, for the combination takes place only at a very high temperature, and unless the operation is conducted into the homogeneous state, the result will leave an injurious effect upon the ductility of the alloy. The stirring may be performed with a clean iron rod sharpened a little at the point, and made red-hot before it is introduced into the fusing mass of metal, if that is preferred by some workmen to the use of a wooden stirrer. The alloys of gold and iron, in which the gold predominates in definite proportions, serve to make gold of different colours, from pale yellow, yellowish-grey, blue, grey, greyish-white, and white, and these are employed by jewellers to give artistic effect to works of art in which the floral designs of Nature are to form a conspicuous part of the ornamentation.

CHAPTER XVIII

TABLES OF 15-CARAT GOLD ALLOYS

No. 1.—15-Carat Extra Red Gold Alloy for Leaf Work

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·625	=	0	12	12	or	1	0	0
Pure Copper . .	·375	=	0	7	12	,,	0	12	0
	1·000		1	0	0		1	12	0

No. 2.—15-Carat Red Gold Alloy for Chasing

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·625	=	0	12	12	or	1	0	0
Fine Silver . .	·062	=	0	1	6	,,	0	2	0
Pure Copper . .	·313	=	0	6	6	,,	0	10	0
	1·000		1	0	0		1	12	0

No. 3.—15-Carat Medium Red Gold Alloy for Colouring

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·625	=	0	12	12	or	1	0	0
Fine Silver . .	·100	=	0	2	0	,,	0	3	6
Pure Copper . .	·275	=	0	5	12	,,	0	8	18
	1·000		1	0	0		1	12	0

No. 4.—15-Carat Colouring Gold Alloy (Good Bright Alloy)

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·625	=	0	12	12	or	1	0	0
Fine Silver . .	·125	=	0	2	12	,,	0	4	0
Pure Copper . .	·250	=	0	5	0	,,	0	8	0
	1·000		1	0	0		1	12	0

No. 5.—15-Carat Rich Bright Alloy for Polishing

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·625	=	0	12	12	or	1	0	0
Fine Silver . .	·137	=	0	2	18	,,	0	4	9
Pure Copper . .	·238	=	0	4	18	,,	0	7	15
	1·000		1	0	0		1	12	0

No. 6.—15-Carat Pale Yellow Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·625	=	0	12	12	or	1	0	0
Fine Silver . .	·250	=	0	5	0	,,	0	8	0
Pure Copper . .	·125	=	0	2	12	,,	0	4	0
	1·000		1	0	0		1	12	0

No. 7.—15-Carat Yellow Gold Alloy (Bright) for Lockets

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·625	=	0	12	12	or	1	0	0
Fine Silver . .	·150	=	0	3	0	,,	0	4	20
Pure Copper . .	·225	=	0	4	12	,,	0	7	4
	1·000		1	0	0		1	12	0

No. 8.—15-Carat Red Gold Alloy for Chasing

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·625	=	0	12	12	or	1	0	0
Fine Silver . .	·037	=	0	0	18	,,	0	1	6
Pure Copper . .	·338	=	0	6	18	,,	0	10	18
	1·000		1	0	0		1	12	0

No. 9.—15-Carat Green Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·625	=	0	12	12	or	1	0	0
Fine Silver . .	·337	=	0	6	18	,,	0	10	18
Pure Copper . .	·038	=	0	0	18	,,	0	1	6
	1·000		1	0	0		1	12	0

No. 10.—15-Carat Greenish-Grey Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold	·625	=	0	12	12	or	1	0	0
Fine Silver	·375	=	0	7	12	,,	0	12	0
	1·000		1	0	0		1	12	0

No. 11.—15-Carat Pale Yellow Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold	·625	=	0	12	12	or	1	0	0
Fine Silver	·167	=	0	3	8	,,	0	5	8
Pure Copper	·208	=	0	4	4	,,	0	6	16
	1·000		1	0	0		1	12	0

No. 12.—15-Carat Very Soft Working Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold	·625	=	0	12	12	or	1	0	0
Fine Silver	·075	=	0	1	12	,,	0	2	9
Pure Copper	·300	=	0	6	0	,,	0	9	15
	1·000		1	0	0		1	12	0

No. 13.—15-Carat Extra Soft Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold	·625	=	0	12	12	or	1	0	0
Fine Silver	·050	=	0	1	0	,,	0	1	15
Pure Copper	·325	=	0	6	12	,,	0	10	9
	1·000		1	0	0		1	12	0

No. 14.—15-Carat Gold Alloy for Setting (Very Good Colour)

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold	·625	=	0	12	12	or	1	0	0
Fine Silver	·275	=	0	5	12	,,	0	8	18
Pure Copper	·100	=	0	2	0	,,	0	3	6
	1·000		1	0	0		1	12	0

No. 15.—15-Carat Gold Alloy for Stamping and Tube

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·625	=	0	12	12	or	1	0	0
Fine Silver . .	·087	=	0	1	18	,,	0	2	18
Pure Copper . .	·288	=	0	5	18	,,	0	9	6
	1·000		1	0	0		1	12	0

No. 16.—15-Carat Grey Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·625	=	0	12	12	or	1	0	0
Fine Silver . .	·225	=	0	4	12	,,	0	7	6
Charcoal Iron . .	·150	=	0	3	0	,,	0	4	18
	1·000		1	0	0		1	12	0

No. 17.—15-Carat Dark Grey Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·625	=	0	12	12	or	1	0	0
Fine Silver . .	·333	=	0	6	16	,,	0	10	16
Pure Copper . .	·042	=	0	0	20	,,	0	1	8
	1·000		1	0	0		1	12	0

No. 18.—15-Carat Hard Gold Pen Alloy (Very Elastic)

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·625	=	0	12	12	or	1	0	0
Fine Silver . .	·288	=	0	5	18	,,	0	9	6
Pure Copper . .	·087	=	0	1	18	,,	0	2	18
	1·000		1	0	0		1	12	0

No. 19.—15-Carat Gold Alloy for Blue Gold

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·625	=	0	12	12	or	1	0	0
Fine Silver . .	·250	=	0	5	0	,,	0	8	0
Pure Nickel . .	·125	=	0	2	12	,,	0	4	0
	1·000		1	0	0		1	12	0

No. 20.—15-Carat Green Gold Alloy for Cast Work

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold	·625	=	0	12	12	or	1	0	0
Fine Silver	·125	=	0	2	12	,,	0	4	0
Pure Copper	·125	=	0	2	12	,,	0	4	0
Cadmium	·125	=	0	2	12	,,	0	4	0
	1·000		1	0	0		1	12	0

No. 21.—15-Carat Paler Green Gold Alloy for Colour Gilding

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold	·625	=	0	12	12	or	1	0	0
Fine Silver	·187	=	0	3	18	,,	0	6	0
Pure Copper	·100	=	0	2	0	,,	0	3	6
Cadmium	·088	=	0	1	18	,,	0	2	18
	1·000		1	0	0		1	12	0

No. 22.—15-Carat Casting Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold	·625	=	0	12	12	or	1	0	0
Fine Silver	·200	=	0	4	0	,,	0	6	12
Pure Copper	·175	=	0	3	12	,,	0	5	12
	1·000		1	0	0		1	12	0

No. 23.—15-Carat Straw Yellow Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold	·625	=	0	12	12	or	1	0	0
Fine Silver	·275	=	0	5	12	,,	0	8	18
Pure Copper	·100	=	0	2	0	,,	0	3	6
	1·000		1	0	0		1	12	0

No. 24.—15-Carat Bright Yellow Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·625	=	0	12	12	or	1	0	0
Fine Silver . .	·130	=	0	2	15	,,	0	4	6
Pure Copper . .	·245	=	0	4	21	,,	0	7	18
	1·000		1	0	0		1	12	0

No. 25.—15-Carat Soft Stamping Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·625	=	0	12	12	or	1	0	0
Fine Silver . .	·108	=	0	2	4	,,	0	3	12
Pure Copper . .	·267	=	0	5	8	,,	0	8	12
	1·000		1	0	0		1	12	0

I have given my readers a very comprehensive table of these alloys, because the standard is the lowest alloy which can be "chemically coloured" if need be, and also hall-marked as well, and because at the present time it is the most popular standard with the general public for gold articles of a high degree of fineness. It is largely employed in the manufacture of coloured gold jewellery of every description of the best class, having taken the place of the 16-carat alloy, firstly, because it carries with it, when hall-marked, an independent guarantee besides that of the maker or the individual seller; and, secondly, because articles fabricated from it are generally harder, which makes them wear a much longer time than when made of a softer material, as it gives them strength and durability, and thus they retain their shape better during wear. Alloys for the use of every section of the gold-working trades are given in the table, from which a mixture can be selected to suit any special branch or any kind of work.

I have purposely provided the gold worker with a very comprehensive table of 15-carat alloys because it is a standard largely used in the many different branches of manufacture associated with the precious-metal industries in the various parts of the world, although in compounding mixtures of metals few alloys are made use of by individual persons, for the reason that their physical or working pro-

perties are chiefly taken into consideration before artistic effect. But in special branches of goldsmithing bearing a direction relative to the ornamentation of finished articles something more is required than the rule of thumb knowledge of mixing of the ordinary manufactory. As a guide, therefore, to some of the latter processes it is necessary to devote here a brief space to the intensification of colour, to the classification of alloys, and to their behaviour towards artistic effect.

Gold alloys which are intended to be ornamented with enamel should be specially prepared to harmonise with the particular kind of enamel used, to produce the best and richest effect. For translucent enamellings, the alloys should always be prepared paler than those intended for red or black enamelling. Several of the alloys given in the preceding table may be selected at will for enamelling, any one of which will be found to serve the purpose admirably for the different coloured enamels to which attention is now directed. The alloy No. 2 may be chosen with good results for red enamelling; the alloy No. 8, for black enamelling; the alloy No. 9, for green enamelling; the alloys Nos. 3 and 4, for blue enamelling; also the alloy No. 6, for transparent blue enamelling; the alloys Nos. 11 and 24, for yellow enamelling; and for white enamelling any of the palest alloys may be used with advantage and success by an experienced person.

The various enamel colours on gold articles are made more effective by adopting various processes preparatory to the work of enamelling—that is to say, before the enamel is applied to the work intended for ornamentation. For instance, for black enamelling, if the object is heated to a dull red so as to darken the ground, the colour is much heightened in effect. But the heating must not be such as to oxidise the copper into a loose scale, or the effect will be spoiled; the heating must only be slight—just sufficient to darken the ground for the enamel. For transparent enamel the brighter is the ground prepared for receiving the enamel, the better is the clearness of the enamel colour shown, and the greater is its power of transmitting light. For blue enamel, when an alloy of gold and iron is used, heat the object till a blue shade appears, and this will act as the ground for the enamel. There are numerous other little devices resorted to by practical men working in this art, but enough has been said to show the reader how to

proceed with the work after the primary stage has been passed. Studious practice soon enables an operative to pick up a wrinkle or two in his work.

The alloy No. 18 is very hard, and may be used for gold pens, which, for purposes of general wear, require to be hard and springy. The alloy No. 14 is a good setting alloy when the shades to be reflected are wanted to throw light into the stones and set them off to the best advantage. It possesses a light yellow tint of fine lustre.

The alloy No. 5 is a hard one, and is very suitable for pin stems, brooch tongues, hairpins, and other similar accessories, being very elastic, and finishes a rich mellow colour. The alloy No. 7 is a good one for bright finishing, as it is capable of receiving a very lustrous surface, which lasts considerably longer in brilliancy than do some other alloys which are prepared without any regard for the purposes they are intended to serve.

Any one of these alloys, if submitted to the chemical process of colouring, will leave the colour pot a golden yellow, with a deeper tinge than is usually to be seen in pure gold; the colouring salts and the mixture of alloy have something to do with this. When the article contains any special colours of gold, in order to show these to the fullest advantage, the surface colour is generally stoned off those parts after colouring which are to exhibit distinguishing colours. The green tint is given to gold of that colour by means of the graver, so also is the same practice adopted to produce most of the other colours, but with the blue it is best to heat the object to a given temperature afterwards to produce the highest effect; of course, it will depend on the nature of the article whether this plan can be adopted with success or not. The present demand for gold work is for the red tint in the general trade, but some masters carry this too far, and, after a certain period of wear, the work resulting from such alloys looks like dirty copper instead of the noble metal it represents.

CHAPTER XIX

TABLES OF 14-CARAT GOLD ALLOYS

No. 1.—14-Carat Very Red Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·583	=	0	11	16	or	1	0	0
Pure Copper . .	·417	=	0	8	8	,,	0	14	6
	1·000		1	0	0		1	14	6

No. 2.—14-Carat Ordinary Red Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·583	=	0	11	16	or	1	0	0
Fine Silver . .	·067	=	0	1	8	,,	0	2	6
Pure Copper . .	·350	=	0	7	0	,,	0	12	0
	1·000		1	0	0		1	14	6

No. 3.—14-Carat Pale Red Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·583	=	0	11	16	or	1	0	0
Fine Silver . .	·100	=	0	2	0	,,	0	3	12
Pure Copper . .	·317	=	0	6	8	,,	0	10	18
	1·000		1	0	0		1	14	6

No. 4.—14-Carat Deep Yellow Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·583	=	0	11	16	or	1	0	0
Fine Silver . .	·125	=	0	2	12	,,	0	4	6
Pure Copper . .	·292	=	0	5	20	,,	0	10	0
	1·000		1	0	0		1	14	6

No. 5.—14-Carat Rich Fine Yellow Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·583	=	0	11	16	or	1	0	0
Fine Silver . .	·150	=	0	3	0	,,	0	5	0
Pure Copper . .	·267	=	0	5	8	,,	0	9	6
	1·000		1	0	0		1	14	6

No. 6.—14-Carat Pale Yellow Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·583	=	0	11	16	or	1	0	0
Fine Silver . .	·208	=	0	4	4	,,	0	7	0
Pure Copper . .	·209	=	0	4	4	,,	0	7	6
	1·000		1	0	0		1	14	6

No. 7.—14-Carat Yellow Casting Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·583	=	0	11	16	or	1	0	0
Fine Silver . .	·175	=	0	3	12	,,	0	6	0
Pure Copper . .	·242	=	0	4	20	,,	0	8	6
	1·000		1	0	0		1	14	6

No. 8.—14-Carat Dark Green Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·583	=	0	11	16	or	1	0	0
Fine Silver . .	·334	=	0	6	16	,,	0	11	12
Pure Copper . .	·083	=	0	1	16	,,	0	2	18
	1·000		1	0	0		1	14	6

No. 9.—14-Carat Pale Green Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·583	=	0	11	16	or	1	0	0
Fine Silver . .	·417	=	0	8	8	,,	0	14	6
	1·000		1	0	0		1	14	6

No. 10.—14-Carat Green Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·583	=	0	11	16	or	1	0	0
Fine Silver . .	·375	=	0	7	12	,,	0	12	18
Pure Copper . .	·042	=	0	0	20	,,	0	1	12
	1·000		1	0	0		1	14	6

No. 11.—14-Carat Yellow Polishing Gold Alloy for Watch Cases

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·583	=	0	11	16	or	1	0	0
Fine Silver . .	·250	=	0	5	0	,,	0	8	12
Pure Copper . .	·167	=	0	3	8	,,	0	5	18
	1·000		1	0	0		1	14	6

No. 12.—14-Carat Pale Yellow Polishing Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·583	=	0	11	16	or	1	0	0
Fine Silver . .	·284	=	0	5	16	,,	0	9	18
Pure Copper . .	·133	=	0	2	16	,,	0	4	12
	1·000		1	0	0		1	14	6

No. 13.—14-Carat Red Gold Polishing Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·583	=	0	11	16	or	1	0	0
Fine Silver . .	·075	=	0	1	12	,,	0	2	12
Pure Copper . .	·342	=	0	6	20	,,	0	11	18
	1·000		1	0	0		1	14	6

No. 14.—14-Carat Chasing Gold Alloy (Red)

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·583	=	0	11	16	or	1	0	0
Fine Silver . .	·050	=	0	1	0	,,	0	1	18
Pure Copper . .	·367	=	0	7	8	,,	0	12	12
	1·000		1	0	0		1	14	6

No. 15.—14-Carat Wet Colouring Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·583	=	0	11	16	or	1	0	0
Fine Silver . .	·100	=	0	2	0	,,	0	3	12
Pure Copper . .	·317	=	0	6	8	,,	0	10	18
	1·000		1	0	0		1	14	6

No. 16.—14-Carat Wet Colouring Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·583	=	0	11	16	or	1	0	0
Fine Silver . .	·117	=	0	2	8	,,	0	4	0
Pure Copper . .	·300	=	0	6	0	,,	0	10	6
	1·000		1	0	0		1	14	6

No. 17.—14-Carat Yellow Enamelling Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·583	=	0	11	16	or	1	0	0
Fine Silver . .	·275	=	0	5	12	,,	0	9	6
Pure Copper . .	·142	=	0	2	20	,,	0	5	0
	1·000		1	0	0		1	14	6

No. 18.—14-Carat Red Enamelling Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·583	=	0	11	16	or	1	0	0
Fine Silver . .	·087	=	0	1	18	,,	0	3	0
Pure Copper . .	·330	=	0	6	14	,,	0	11	6
	1·000		1	0	0		1	14	6

No. 19.—14-Carat Green Enamelling Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·583	=	0	11	16	or	1	0	0
Fine Silver . .	·417	=	0	8	8	,,	0	14	6
	1·000		1	0	0		1	14	6

No. 20.—14-Carat Black or Blue Enamelling Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·583	=	0	11	16	or	1	0	0
Fine Silver . .	·083	=	0	1	16	,,	0	2	21
Pure Copper . .	·334	=	0	6	16	,,	0	11	9
	1·000		1	0	0		1	14	6

No. 21.—14-Carat Grey Gold Alloy for Floral Work

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·583	=	0	11	16	or	1	0	0
Fine Silver . .	·317	=	0	6	8	,,	0	10	18
Pure Copper . .	·100	=	0	2	0	,,	0	3	12
	1·000		1	0	0		1	14	6

No. 22. 14-Carat Gold Pen Alloy (Very Pale, but Springy)

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·583	=	0	11	16	or	1	0	0
Fine Silver . .	·300	=	0	6	0	,,	0	10	6
Pure Copper . .	·117	=	0	2	8	,,	0	4	0
	1·000		1	0	0		1	14	6

No. 23.—14-Carat Gold Pen Alloy (Commonly Used)

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·583	=	0	11	16	or	1	0	0
Fine Silver . .	·175	=	0	3	12	,,	0	6	0
Pure Copper . .	·242	=	0	4	20	,,	0	8	6
	1·000		1	0	0		1	14	6

No. 24. 14-Carat Gold Pen Alloy, *very elastic* (by the Author)

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·583	=	0	11	16	or	1	0	0
Fine Silver . .	·150	=	0	3	0	,,	0	5	0
Pure Copper . .	·230	=	0	4	14	,,	0	8	0
Pure Nickel . .	·037	=	0	0	18	,,	0	1	6
	1·000		1	0	0		1	14	6

The chief characteristics of these mixtures will be well understood by the workers from the descriptive matter supplied with the tables of former standards; suffice it to say that this table includes alloys for all the purposes of utility in commerce. Sometimes hard alloys are required for special work, such as pin stems, brooch tongues, etc., and for such purposes the alloy No. 5 forms an excellent one, as it is hard, elastic, and possesses a steel-like springiness after drawing, which admirably fits it for use where strength and toughness are essential requisites for objects having to be worn as personal ornaments. A very soft alloy, on the other hand, suitable for drawing-through purposes (a process adoptable in the manufacture of gold pencil-cases, tubes, and other kindred work), is very readily provided by mixing the different ingredients in the proportions stated in the alloy No. 13.

Both hardness and softness may be imparted to gold alloys in other ways than by simply taking definite proportions of the three metals which are invariably selected to form the different mixtures for different purposes. The hardness may be increased by using the common bean-shot copper in place of the best refined copper. The ingot of gold, if rolled with less frequent annealings during the breaking down stages, will so harden the metal that it seldom loses that property in subsequent working. Again, only partially annealing the metal—that is, not heating up to a red heat—and continuing the rolling from that condition will so harden the atomical properties of the compound mixture as to make it very much harder and more springy. Overheating in the melting operation has a like tendency to increase the hardness. So also has the melting of the bar twice over if the mixture contains spelter as one of the ingredients of alloy; in the double process of melting the spelter generally becomes overheated or burned, and that causes the metal to become hard, and diffusion taking place throughout the mass, a certain hardness is imparted to the resulting mixture not generally accounted for by the majority of those who manipulate the melting.

Softness in a mixture may also be facilitated in the melting. By carefully selecting the best refined copper, seeing that it is quite free from all oxide, not continuing the heat after the copper has run down, stirring the mixture with a charcoal stick, keeping the surface of the metal covered with fine charcoal powder free from grit or other

foreign substances, and pouring into a *very hot* ingot mould, the result will be surprisingly good and soft working metal, if the manipulations are carried out consistently. The overheating of many mixtures and the long-continued stirring with an iron rod are the cause of most of the " difficulties " which arise subsequently in the working processes related to the craftsman, and from which many " failures " in the execution of good work are often to be attributed. Fluxing with ferrocyanide of potassium gives hardness to all gold mixtures.

CHAPTER XX

TABLES OF 13-CARAT GOLD ALLOYS

THIRTEEN carat is the next quality of gold, and it is about the lowest alloy employed in the manufacture of articles which are to be "coloured," a trade term applied to a chemical process which leaves the surface of the articles with a colour like that of fine gold, but without changing the internal substance of the material itself, the surface only being affected by removing the copper and the silver, or any other base element of alloy existing in the gold mixture. The 13-carat alloy is about the lowest standard which can with commercial safety be used for this purpose, for below that fineness a sufficiently taking colour with purchasers is hardly possible to procure without incurring difficulties in the process, and these would far outweigh any imaginary gain derived by the manufacturer by further debasing the standard. What is wanted is a rich and uniform appearance without showing any irregularities on the surface, and to effect this in the best manner possible, the fine gold must predominate in the mixture of alloy. Formerly, a very large quantity of gold of this standard was worked up into trinkets of every description for colouring purposes. Now, however, the 15-carat alloy has taken its place, and has become more generally popular with the public—no doubt because it can be hall-marked, which the 13 carat could not be, it not being a standard authorised by Act of Parliament. Different results in regard to the fine gold surface are produced by varying the proportions of the ingredients of alloy and also those of the colouring mixtures used. And when any special tint is wanted, both of these details will have to be taken into particular account in order to achieve the fullest measure of success.

The 13-carat standard can be prepared for "bright finishing" by properly proportioning the metals used for alloying the gold, and, in fact, so can any of the higher standards I have given, if treated in the same way—that is, by adopting a little variation in the mixture of alloy. It

is a usual custom to put a little more silver and a little less copper, and sometimes a limited quantity of spelter is added, or, on the other hand, a kind of brass, generally termed "compo," is employed, and these produce different shades of brightness, according to the different metals used and to their constituent proportions. The principal mixtures are as follows :—

No. 1.—13-Carat Deep Red Gold Alloy for Chasing

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·542	=	0	10	20	or	1	0	0
Fine Silver . .	·042	=	0	0	20	,,	0	1	12
Pure Copper . .	·416	=	0	8	8	,,	0	15	10
	1·000		1	0	0		1	16	22

No. 2.—13-Carat Ordinary Red Gold Alloy for Red Enamelling

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·542	=	0	10	20	or	1	0	0
Fine Silver . .	·100	=	0	2	0	,,	0	3	16
Pure Copper . .	·358	=	0	7	4	,,	0	13	6
	1·000		1	0	0		1	16	22

No. 3.—13-Carat Gold Alloy for Transparent Enamelling

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·542	=	0	10	20	or	1	0	0
Fine Silver . .	·400	=	0	8	0	,,	0	14	18
Pure Copper . .	·058	=	0	1	4	,,	0	2	4
	1·000		1	0	0		1	16	22

No. 4.—13-Carat Gold Alloy for Wet Colouring

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·542	=	0	10	20	or	1	0	0
Fine Silver . .	·108	=	0	2	4	,,	0	4	0
Pure Copper . .	·350	=	0	7	0	,,	0	13	0
	1·000		1	0	0		1	17	0

No. 5.—13-Carat Gold Alloy for Wet Colouring

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·542	=	0	10	20	or	1	0	0
Fine Silver . .	·125	=	0	2	12	,,	0	4	15
Pure Copper . .	·333	=	0	6	16	,,	0	12	9
	1·000		1	0	0		1	17	0

No. 6.—13-Carat Gold Alloy for Stamping and Tube

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·542	=	0	10	20	or	1	0	0
Fine Silver . .	·083	=	0	1	16	,,	0	3	0
Pure Copper . .	·375	=	0	7	12	,,	0	13	22
	1·000		1	0	0		1	16	22

No. 7.—13-Carat Deep Yellow Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·542	=	0	10	20	or	1	0	0
Fine Silver . .	·150	=	0	3	0	,,	0	5	12
Pure Copper . .	·308	=	0	6	4	,,	0	11	10
	1·000		1	0	0		1	16	22

No. 8.—13-Carat Rich Yellow Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·542	=	0	10	20	or	1	0	0
Fine Silver . .	·166	=	0	3	8	,,	0	6	0
Pure Copper . .	·292	=	0	5	20	,,	0	10	22
	1·000		1	0	0		1	16	22

No. 9.—13-Carat Pale Yellow Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·542	=	0	10	20	or	1	0	0
Fine Silver . .	·225	=	0	4	12	,,	0	8	6
Pure Copper . .	·233	=	0	4	16	,,	0	8	16
	1·000		1	0	0		1	16	22

No. 10.—13-Carat Bright Gold Alloy for Polishing

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·542	=	0	10	20	or	1	0	0
Fine Silver . .	·137	=	0	2	18	,,	0	5	0
Pure Copper . .	·321	=	0	6	10	,,	0	11	22
	1·000		1	0	0		1	16	22

No. 11.—13-Carat Pale Bright Polishing Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·542	=	0	10	20	or	1	0	0
Fine Silver . .	·300	=	0	6	0	,,	0	11	0
Pure Copper . .	·158	=	0	3	4	,,	0	5	22
	1·000		1	0	0		1	16	22

No. 12.—13-Carat Bright Polishing Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·542	=	0	10	20	or	1	0	0
Fine Silver . .	·250	=	0	5	0	,,	0	9	0
Pure Copper . .	·208	=	0	4	4	,,	0	7	22
	1·000		1	0	0		1	16	22

No. 13.—13-Carat Hard Gold Pen Alloy (Bright Pale Yellow)

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·542	=	0	10	20	or	1	0	0
Fine Silver . .	·200	=	0	4	0	,,	0	7	12
Pure Copper . .	·258	=	0	5	4	,,	0	9	10
	1·000		1	0	0		1	16	22

No. 14.—13-Carat Very Elastic Gold Pen Alloy (by the Author)

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·542	=	0	10	20	or	1	0	0
Fine Silver . .	·133	=	0	2	16	,,	0	5	0
Pure Copper . .	·292	=	0	5	20	,,	0	10	16
Pure Nickel . .	·033	=	0	0	16	,,	0	1	6
	1·000		1	0	0		1	16	22

No. 15.—13-Carat Rich Yellow Gold Pen Alloy (by the Author)

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold	·542	=	0	10	20	or	1	0	0
Fine Silver	·150	=	0	3	0	,,	0	5	12
Pure Copper	·266	=	0	5	8	,,	0	10	0
Pure Spelter	·042	=	0	0	20	,,	0	1	12
	1·000		1	0	0		1	17	0

No. 16.—13-Carat Green Gold Alloy for Leaf Work

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold	·542	=	0	10	20	or	1	0	0
Fine Silver	·400	=	0	8	0	,,	0	14	18
Pure Copper	·058	=	0	1	4	,,	0	2	4
	1·000		1	0	0		1	16	22

No. 17.—13-Carat Blue Gold Alloy for Leaf Work

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold	·542	=	0	10	20	or	1	0	0
Fine Silver	·250	=	0	5	0	,,	0	9	0
Iron or Steel	·208	=	0	4	4	,,	0	7	22
	1·000		1	0	0		1	16	22

No. 18.—13-Carat Grey Gold Alloy for Fancy Work

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold	·542	=	0	10	20	or	1	0	0
Fine Silver	·333	=	0	6	16	,,	0	12	8
Iron or Steel	·125	=	0	2	12	,,	0	4	16
	1·000		1	0	0		1	16	22

No. 19.—13-Carat Casting Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold	·542	=	0	10	20	or	1	0	0
Fine Silver	·187	=	0	3	18	,,	0	7	0
Pure Copper	·271	=	0	5	10	,,	0	10	0
	1·000		1	0	0		1	17	0

No. 20.—13-Carat White Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold	·542	=	0	10	20	or	1	0	0
Fine Silver	·383	=	0	7	16	,,	0	14	4
Pure Cadmium	·075	=	0	1	12	,,	0	2	18
	1·000		1	0	0		1	16	22

No. 21.—13-Carat Bright Bright Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold	·542	=	0	10	20	or	1	0	0
Fine Silver	·150	=	0	3	0	,,	0	5	12
Pure Copper	·275	=	0	5	12	,,	0	10	4
Pure Spelter	·033	=	0	0	16	,,	0	1	6
	1·000		1	0	0		1	16	22

No. 22.—13-Carat Bright Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold	·542	=	0	10	20	or	1	0	0
Fine Silver	·150	=	0	3	0	,,	0	5	12
Pure Copper	·208	=	0	4	4	,,	0	7	16
Citron Compo	·100	=	0	2	0	,,	0	3	18
	1·000		1	0	0		1	16	22

No. 23.—13-Carat Pale Wet Coloured Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold	·542	=	0	10	20	or	1	0	0
Fine Silver	·175	=	0	3	12	,,	0	6	12
Pure Copper	·283	=	0	5	16	,,	0	10	10
	1·000		1	0	0		1	16	22

The colouring gold mixtures are invariably prepared from a preponderance of copper alloy, and different quantities

are shown in the table of alloys to meet every ordinary purpose—such, at least, as are likely to fall to the share of the common craftsman. To the ordinary person, probably, an article with a fine gold surface would take the first place, because it looks more costly to the uneducated mind, in that it closely represents pure gold in outward appearance, whereas bright golds show the natural colour of the mixture of alloy, but they are just as valuable from a monetary point of view, and, moreover, they present a fine sparkling brightness, when properly finished, which is very taking to the eye of a connoisseur. This quality of gold will retain its lustrous brightness for a considerable time without change of colour by using sufficient silver in the compounding of the mixture. There are no hall-marks for this quality of gold, but large quantities of wares were made from it formerly; but it is now nearly run out of the market by the 15-carat standard, which carries with it an independent guarantee of its absolute fineness, by certain cabalistic signs of authoritative control which all articles bear, and which mean much to the general public nowadays.

I am still often asked to give an opinion regarding the heat it is necessary to give to a mixture in melting it to render it homogeneous. I now repeat what I have already written—that it is not a wise proceeding to make the charge unnecessarily hot, and particularly is this the case with mixtures containing "spelter," or any other of the easily fusible metals. Further, the more liable the predominant metal—copper—in those taken for mixing together, is to oxidisation, the more carefully should the process be guarded. Overheating makes the copper brittle, less adhesive, and more apt to break asunder in some of the subsequent working stages of manufacturing the material into commercial wares; but the right heat makes the mixture more coherent, enables its particles to hold more firmly together, and improves its working properties in every direction. Of the three metals commonly taken for mixing into jewellers' alloys, copper is the most liable to oxidisation, and it is this metal which suffers first by overheating; therefore, the difficulties of this nature, which are constantly being brought to my notice, are, as a consequence, more pronounced in the lower standards of gold than in those richer in the noble metal, for the reason that, in the latter, the copper has more protection from the fine gold

in the mixture, when that metal is in excess, than it has in low standards like 9-carat golds.

With regard to the melting-point of an alloy, something ought to be said here, although I shall defer the general details until I come to treat of 9-carat golds and their subordinates. All alloys, however, fuse at a lower degree than that at which the most infusible of any one of the alloying ingredients melts. Copper is the most infusible of the three metals named, its melting-point being 1,050° C., although such a high degree of heat in melting it as that is not required when in union with more readily fusible metals like gold and silver, as the metals one after the other, according to their degree of fusibility, melt or dissolve one into the other, and this tends to lower the melting-point of the most refractory metal. The possession of this knowledge should act as a guide to the operator at the furnace not to prolong the heat after the copper has run down and the requisite fluidity has been obtained. Prolonged heating deteriorates the quality of the melting charge, and the fused mass should be withdrawn as soon as possible after the mixed metals have assumed the liquid condition, which is much facilitated by stirring with a charcoal stirrer. Overheated metal is doubly defective in physical properties after the scrap is remelted to be worked over a second time, unless subjected to a special process of treatment which I have found during some of my researches into the subject upon which I now write. When spelter, compo metal, or brass enter into composition as a feature in the alloy, the fire should not be too brisk, or much of the zinc will be wasted; and it will be found an advantage to partially close the damper of the chimney whilst adding the latter metal, for, whilst the boiling-point of zinc is 1,040° C. and the melting-point of copper 1,050° C., it would naturally be supposed that the reaching of the former point could not be well obviated; but this is readily guarded against, for, as I have shown, when the mixture is in the fluid state and ready to receive the zinc, its melting-point (if the operation is well performed) is lower than that of the most obstinate constituent of alloy. The covering of the fused mixture with charcoal powder keeps in sufficient heat to liquefy the zinc, if the latter is first heated nearly to its melting-point before the addition is made. The charcoal also protects the metal from oxidisation by the air, and helps to absorb the gases produced in reducing the metals to the molten

state, particularly when the mechanical agitation of the mixture is indulged in by vigorous stirring, which should be done immediately after the addition is made of the zinc, to prevent loss of zinc, and to guard against its being overheated, which experience has proved to be one of the greatest obstacles to the production of sound metal free from spilliness.

CHAPTER XXI

TABLES OF 12-CARAT GOLD ALLOYS

THE next standard of alloys to be considered is the 12 carat. Although there are intermediate alloys occasionally used in jewellery manufacture between 12 and 13 carat, both for colouring and bright gold finishing, they do not call for any special remark that would necessitate their being given a place in the current tables of alloys which up to the present have been familiarised by a distinct caratage.

Articles made from the 12-carat alloys are nearly always finished bright by polishing or "bobbing" the surface with rouge powder mixed with a small quantity of water into a paste, and they are not coloured, like some of the other alloys of higher caratage already described. This method of finishing shows the natural colours of the compound mixture of metals, as prepared from their several constituent parts, and is altogether different from the artificial finish of coloured gold work. Each alloy for bright finishing is prepared in accordance with the object to be wrought, that is, to the taste and requirements of the manufacturer, so that it may display that peculiar tint or shade of colour best adapted to set off the work to the fullest advantage without in any way destroying the physical properties of the mixture and thus rendering it less useful for manufacturing purposes.

No. 1.—12-Carat Deep Red Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·500	=	0	10	0	or	1	0	0
Pure Copper . .	·500	=	0	10	0	,,	1	0	0
	1·000		1	0	0		2	0	0

No. 2.—12-Carat White Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·500	=	0	10	0	or	1	0	0
Fine Silver . .	·500	=	0	10	0	,,	1	0	0
	1·000		1	0	0		2	0	0

No. 3.—12-Carat Green Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·500	=	0	10	0	or	1	0	0
Fine Silver . .	·438	=	0	8	18	,,	0	17	12
Pure Copper . .	·062	=	0	1	6	,,	0	2	12
	1·000		1	0	0		2	0	0

No. 4.—12-Carat Dark Green Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·500	=	0	10	0	or	1	0	0
Fine Silver . .	·400	=	0	8	0	,,	0	16	0
Pure Copper . .	·100	=	0	2	0	,,	0	4	0
	1·000		1	0	0		2	0	0

No. 5. 12-Carat Light Green Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·500	=	0	10	0	or	1	0	0
Fine Silver . .	·450	=	0	9	0	,,	0	18	0
Pure Copper . .	·050	=	0	1	0	,,	0	2	0
	1·000		1	0	0		2	0	0

No. 6.—12-Carat Old Time Bright Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·500	=	0	10	0	or	1	0	0
Fine Silver . .	·138	=	0	2	18	,,	0	5	12
Pure Copper . .	·325	=	0	6	12	,,	0	13	0
Pure Spelter . .	·037	=	0	0	18	,,	0	1	12
	1·000		1	0	0		2	0	0

No. 7.—12-Carat Yellow Gold Alloy for Wedding Rings

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·500	=	0	10	0	or	1	0	0
Fine Silver . .	·162	=	0	3	6	,,	0	6	12
Pure Copper . .	·338	=	0	6	18	,,	0	13	12
	1·000		1	0	0		2	0	0

No. 8.—12-Carat Bright Polishing Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·500	=	0	10	0	or	1	0	0
Fine Silver . .	·200	=	0	4	0	,,	0	8	0
Pure Copper . .	·300	=	0	6	0	,,	0	12	0
	1·000		1	0	0		2	0	0

No. 9.—12-Carat Pale Bright Polishing Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·500	=	0	10	0	or	1	0	0
Fine Silver . .	·300	=	0	6	0	,,	0	12	0
Pure Copper . .	·200	=	0	4	0	,,	0	8	0
	1·000		1	0	0		2	0	0

No. 10.—12-Carat Very Soft Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·500	=	0	10	0	or	1	0	0
Fine Silver . .	·094	=	0	1	21	,,	0	3	18
Pure Copper . .	·406	=	0	8	3	,,	0	16	6
	1·000		1	0	0		2	0	0

No. 11.—12-Carat Hard Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·500	=	0	10	0	or	1	0	0
Fine Silver . .	·250	=	0	5	0	,,	0	10	0
Pure Copper . .	·250	=	0	5	0	,,	0	10	0
	1·000		1	0	0		2	0	0

No. 12.—12-Carat Ordinary Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold	·500	=	0	10	0	or	1	0	0
Fine Silver	·125	=	0	2	12	,,	0	5	0
Pure Copper	·375	=	0	7	12	,,	0	15	0
	1·000		1	0	0		2	0	0

No. 13.—12-Carat Enamelling Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold	·500	=	0	10	0	or	1	0	0
Fine Silver	·325	=	0	6	12	,,	0	13	0
Pure Copper	·175	=	0	3	12	,,	0	7	0
	1·000		1	0	0		2	0	0

No. 14. 12-Carat Transparent Enamelling Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold	·500	=	0	10	0	or	1	0	0
Fine Silver	·350	=	0	7	0	,,	0	14	0
Pure Copper	·150	=	0	3	0	,,	0	6	0
	1·000		1	0	0		2	0	0

No. 15.—12-Carat Red or Black Enamelling Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold	·500	=	0	10	0	or	1	0	0
Fine Silver	·088	=	0	1	18	,,	0	3	12
Pure Copper	·412	=	0	8	6	,,	0	16	12
	1·000		1	0	0		2	0	0

No. 16.—12-Carat Tube Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold	·500	=	0	10	0	or	1	0	0
Fine Silver	·083	=	0	1	16	,,	0	3	8
Pure Copper	·367	=	0	7	8	,,	0	14	16
Compo No. 4	·050	=	0	1	0	,,	0	2	0
	1·000		1	0	0		2	0	0

No. 17.—12-Carat Fine Yellow Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·500	=	0	10	0	or	1	0	0
Fine Silver . .	·075	=	0	1	12	,,	0	3	0
Pure Copper . .	·275	=	0	5	12	,,	0	11	0
Compo No. 4 . .	·150	=	0	3	0	,,	0	6	0
	1·000		1	0	0		2	0	0

No. 18.—12-Carat Gold Alloy that can be Coloured

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·500	=	0	10	0	or	1	0	0
Fine Silver . .	·067	=	0	1	8	,,	0	2	16
Pure Copper . .	·333	=	0	6	16	,,	0	13	8
Compo No. 4 . .	·100	=	0	2	0	,,	0	4	0
	1·000		1	0	0		2	0	0

No. 19.—12-Carat Hard Spring Alloy for Expanding Bracelets

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·500	=	0	10	0	or	1	0	0
Fine Silver . .	·312	=	0	6	6	,,	0	12	12
Pure Copper . .	·188	=	0	3	18	,,	0	7	12
	1·000		1	0	0		2	0	0

No. 20.—12-Carat Red Chasing Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·500	=	0	10	0	or	1	0	0
Fine Silver . .	·075	=	0	1	12	,,	0	3	0
Pure Copper . .	·388	=	0	7	18	,,	0	15	12
Compo No. 4 . .	·037	=	0	0	18	,,	0	1	12
	1·000		1	0	0		2	0	0

No. 21.—12-Carat Yellow Chasing Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·500	=	0	10	0	or	1	0	0
Fine Silver . .	·100	=	0	2	0	,,	0	4	0
Pure Copper . .	·312	=	0	6	6	,,	0	12	12
Compo No. 4 . .	·088	=	0	1	18	,,	0	3	12
	1·000		1	0	0		2	0	0

No. 22.—12-Carat Gold Alloy for Expanding Bracelets, as Hard as Steel

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·500	=	0	10	0	or	1	0	0
Fine Silver . .	·156	=	0	3	3	,,	0	6	6
Pure Copper . .	·300	=	0	6	0	,,	0	12	0
Pure Nickel . .	·044	=	0	0	21	,,	0	1	18
	1·000		1	0	0		2	0	0

No. 23.—12-Carat Gold Setting Alloy for Pearl Work

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·500	=	0	10	0	or	1	0	0
Fine Silver . .	·375	=	0	7	12	,,	0	15	0
Pure Copper . .	·125	=	0	2	12	,,	0	5	0
	1·000		1	0	0		2	0	0

No. 24.—12-Carat Green Gold Alloy for Leaf Work

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·500	=	0	10	0	or	1	0	0
Fine Silver . .	·388	=	0	7	18	,,	0	15	12
Compo No. 4 . .	·112	=	0	2	6	,,	0	4	12
	1·000		1	0	0		2	0	0

The 12-carat alloys prepared with compo or spelter as one of the constituents require some care in the melting, and also in the working, to guard against "difficulties." In the working processes the metal must be oftener annealed,

and not quenched in water immediately after annealing, but allowed to cool gradually. It must not be heated too hot nor shaken on the annealing pan whilst still hot, for, if it is, it is liable to crack and split in a peculiar manner. This is owing to the zinc in the compo metal used in the alloying. When, however, only a small portion of that metal is used, the characteristic feature is not so pronounced, and these precautions need not be so strictly observed. The alloys Nos. 17, 18, and 24 are the most difficult ones to work, their special feature being their handsome colour, which is equal to one of 14 carat, or even of higher standard. In melting these mixtures to the best advantage some experience at the work is necessary to overcome the many "failures" which often beset the inexperienced craftsman in producing good working metal. Many workmen heat the metal too hot, and this may be brought about in two ways: firstly, by applying the heat so rapidly that the spelter sweats out of the compo and becomes oxidised, or burned, before the other metals, which melt at a higher temperature, become fluid; and this causes a dross to rise to the surface of the molten metal, and unless very great care be then exercised, it may become mixed with the contents of the crucible in pouring the mixture of alloy into the ingot mould, and this prevents uniform cohesion of the particles of the several metals from taking place; and, secondly, by prolonged heating, the result being that, after the ingot of gold is rolled and comes to be worked up into articles of jewellery, fissures varying in size will be met with, having all the appearance of layers of dirt, apparently existing between the disintegrated portions of metal. Sometimes it will be found, on removing the firebrick from the mouth of the furnace to inspect the progress of the melting, that the compo swims on the surface of the fluid mass in the crucible in the same form (to all outward appearance) in which it was put in the crucible at the start; and if you touch this with the tongs or stirring iron, it will at once disseminate, and break up into fragments and enter the liquid metal, but not in the liquid form. Now this is the oxide of zinc reduced to that condition by the action of the air exerting its influence on the top of the fused metal and causing the zinc in the compo metal to leave the copper, which is dissolved into the gold and silver, leaving the zinc like a burnt piece of paper floating on the surface of the liquid in an oxidised condition, to subsequently show itself later in various forms

and places in the gold alloy when under the manipulative treatment of the operative workmen. Good metal cannot be accomplished through such prevailing obstacles. In melting, when a blue flame is observable, this oxidising process is always going on. To prevent this from happening, the surface of the melted metal should be kept covered with fine charcoal powder, which will prevent oxidisation by keeping the air from it. A small quantity of sal-ammoniac should also occasionally be added, and the metal stirred quickly before pouring, otherwise a constantly varying quality of metal may result from the omission. By placing the compo metal at the bottom of the crucible, melting slowly, and keeping the liquid when in a pasty condition properly covered with charcoal, as described previously, it will fuse clear, be of equal hardness, and the ingots of gold cast will present a uniform quality throughout. It is always more difficult to melt the precious metals in contact with atmospheric air than is the case when all traces of air are absent, and this applies to the degree of heat necessary for the purpose as well as to the soundness of the work resulting. When I mention slow melting, of course I do not mean roasting. The trade will, I think, quite understand my meaning; it is this—the heat should be sufficient to begin steadily and thus continue without relapse until the metal becomes thinly fluid, and not be urged so fiercely as to overheat one or more of the ingredients of alloy before those more refractory have attained an adequate temperature to form a proper union. It is perhaps best to have the fire burned well up and clear before putting on the crucible with its contents, which will save a too prolonged heating. Melting is more quickly performed when the air is well driven from the furnace, and it also requires a far less degree of heat to effect the object in view. For further particulars and more descriptive details relating to this work of the goldsmith, see earlier chapters of this treatise.

The compo metal I used in these mixtures was prepared from the No. 4 recipe in the table of composition metals for alloying gold, consisting of $33\frac{1}{3}$ per cent. of spelter and $66\frac{2}{3}$ per cent. of copper. The 12-carat alloys are all workable in the ordinary way when the spelter does not exceed $4\frac{1}{2}$ per cent., or the compo 13 per cent., of the compound mixture being formed; about those proportions extra care will have to be taken in working the resulting metal, otherwise it may fall to pieces and have to be returned to the melting-

pot as scrap for remelting. There is no reason, however, why all these alloys should not be worked with ease and advantage if placed in the hands of thoughtful and experienced workmen, most of them being the special preparations of the writer, who, through a very extended experience, has naturally worked them with his own hands, and can, therefore, speak with a certain degree of authority as to their capabilities of being successfully manipulated.

Before proceeding with the next table of alloys it is advisable to state that the 12-carat standard is not at the present time much used in the manufacture of jewellery, but I think it a pity it is not more cultivated, as it is a mixture containing one-half of its weight of fine gold in its composition, no matter what the weight of the object may be, and it may be adjudged to be the best of the bright golds, because the 15 carat is more commonly coloured. A very high and lustrous surface finish can be imparted to the 12-carat alloys, which is of more lasting duration than that given to some other alloys, and from which the great bulk of bright gold jewellery is now manufactured. But, as a rule, it appears to be the fashion to patronise more largely the lowest standards for trading purposes in all the leading countries of the world, whether for bright or coloured gold finishing, and no doubt the present prevailing feature of cheapness is the potent reason which causes this demand, and sets the fashion; hence the innumerable articles now to be seen in the market of inferior standards to the 12 carat.

CHAPTER XXII

TABLES OF 10-CARAT GOLD ALLOYS

THE next alloys are the 10 carats, and these, like those just named, are sometimes used for a better quality, as a larger article can be manufactured for less money on account of the lower specific gravity and, therefore, lightness as regards size of the metal being wrought. Most of these alloys are very soft, ductile, and easily worked into wares of jewellery. Previously they formed the standard for the manufacture of many articles of jewellery, the principal of which were gold seals and long curb guards. Now, however, they have been supplanted by the 9-carat standard, to which ample reference will be made in due course. Generally speaking, each alloy of gold is selected for the purpose which its peculiar nature and physical properties will answer best for the requirements needed in the execution of the work.

No. 1.—10-Carat Red Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·416	=	0	8	8	or	1	0	0
Fine Silver . .	·042	=	0	0	20	,,	0	2	0
Pure Copper . .	·542	=	0	10	20	,,	1	6	0
	1·000		1	0	0		2	8	0

No. 2.—10-Carat Red Chasing Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·416	=	0	8	8	or	1	0	0
Fine Silver . .	·062	=	0	1	6	,,	0	3	0
Pure Copper . .	·522	=	0	10	10	,,	1	5	0
	1·000		1	0	0		2	8	0

No. 3.—10-Carat Yellow Gold Alloy (Polishing)

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold	·416	=	0	8	8	or	1	0	0
Fine Silver	·167	=	0	3	8	,,	0	8	0
Pure Copper	·417	=	0	8	8	,,	1	0	0
	1·000		1	0	0		2	8	0

No. 4.—10-Carat Setting Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold	·416	=	0	8	8	or	1	0	0
Fine Silver	·416	=	0	8	8	,,	1	0	0
Pure Copper	·168	=	0	3	8	,,	0	8	0
	1·000		1	0	0		2	8	0

No. 5.—10-Carat Bright Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold	·416	=	0	8	8	or	1	0	0
Fine Silver	·125	=	0	2	12	,,	0	6	0
Pure Copper	·434	=	0	8	16	,,	1	0	18
Pure Spelter	·025	=	0	0	12	,,	0	1	6
	1·000		1	0	0		2	8	0

No. 6.—10-Carat Pale Gold Bright Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold	·416	=	0	8	8	or	1	0	0
Fine Silver	·292	=	0	5	20	,,	0	14	0
Pure Copper	·292	=	0	5	20	,,	0	14	0
	1·000		1	0	0		2	8	0

No. 7.—10-Carat Green Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold	·416	=	0	8	8	or	1	0	0
Fine Silver	·450	=	0	9	0	,,	1	1	12
Compo No. 4	·134	=	0	2	16	,,	0	6	12
	1·000		1	0	0		2	8	0

No. 8.—10-Carat White Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·416	=	0	8	8	or	1	0	0
Fine Silver . .	·584	=	0	11	16	,,	1	8	0
	1·000		1	0	0		2	8	0

No. 9.—10-Carat Bluish-White Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·416	=	0	8	8	or	1	0	0
Fine Silver . .	·521	=	0	10	10	,,	1	5	0
Pure Spelter . .	·063	=	0	1	6	,,	0	3	0
	1·000		1	0	0		2	8	0

No. 10.—10-Carat Gold Alloy for Curb Guards

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·416	=	0	8	8	or	1	0	0
Fine Silver . .	·084	=	0	1	16	,,	0	4	0
Pure Copper . .	·437	=	0	8	18	,,	1	1	0
Pure Spelter . .	·063	=	0	1	6	,,	0	3	0
	1·000		1	0	0		2	8	0

No. 11.—10-Carat Gold Alloy for Transparent Enamelling

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·416	=	0	8	8	or	1	0	0
Fine Silver . .	·434	=	0	8	16	,,	1	1	18
Pure Copper . .	·150	=	0	3	0	,,	0	6	6
	1·000		1	0	0		2	8	0

No. 12.—10-Carat Gold Alloy for Green Enamelling

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·416	=	0	8	8	or	1	0	0
Fine Silver . .	·375	=	0	7	12	,,	0	18	0
Pure Copper . .	·209	=	0	4	4	,,	0	10	0
	1·000		1	0	0		2	8	0

No. 13.—10-Carat Gold Alloy for Red Enamelling

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·416	=	0	8	8	or	1	0	0
Fine Silver . .	·084	=	0	1	16	,,	0	4	0
Pure Copper . .	·500	=	0	10	0	,,	1	4	0
	1·000		1	0	0		2	8	0

No. 14.—10-Carat Gold Alloy for Yellow Enamelling

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·416	=	0	8	8	or	1	0	0
Fine Silver . .	·250	=	0	5	0	,,	0	12	0
Pure Copper . .	·334	=	0	6	16	,,	0	16	0
	1·000		1	0	0		2	8	0

No. 15.—10-Carat Fine Yellow Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·416	=	0	8	8	or	1	0	0
Fine Silver . .	·109	=	0	2	4	,,	0	5	0
Pure Copper . .	·350	=	0	7	0	,,	0	17	0
Compo No. 4 . .	·125	=	0	2	12	,,	0	6	0
	1·000		1	0	0		2	8	0

No. 16. 10-Carat Watch Arbor Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·416	=	0	8	8	or	1	0	0
Fine Silver . .	·167	=	0	3	8	,,	0	8	0
Pure Copper . .	·317	=	0	6	8	,,	0	15	6
Pure Palladium .	·100	=	0	2	0	,,	0	4	18
	1·000		1	0	0		2	8	0

No. 17. 10-Carat Pale Polishing Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·416	=	0	8	8	or	1	0	0
Fine Silver . .	·312	=	0	6	6	,,	0	15	0
Pure Copper . .	·272	=	0	5	10	,,	0	13	0
	1·000		1	0	0		2	8	0

I have given in the above table of alloys the necessary proportions of the several metals whereby a mixture can be compounded to suit every description of work which is likely to arise in the jewellery and kindred trades, and, as it is not a popular standard, very few descriptive remarks are necessary in pointing out their physical qualities regarding manipulation, particularly after what has been said in the introductory paragraph leading up to these alloys. The alloy No. 16 is a rich light brown colour, and is used sometimes for bearings of the arbors in fine watches, as little friction is caused on the steel by their use (less than the jewels used for the same purpose), and they never rust on exposure to atmospheric air. The alloy is as hard as iron, and it may be used for other purposes where great hardness and strength are necessary requisites in the metal, notably as the mixture for employment in the manufacture of gold pens, and it also may be of service in other of the precious metal industries.

The enamelling alloys given under that name are the best for displaying the respective colours to their best advantage; but for some of the ordinary trade purposes, where most of the gold colour of the metal is to be shown without enamel, they may be considered too pale to meet the public taste, in which case the alloys Nos. 3, 6, 14, and 15 can be utilised with almost equal success, and the same directions must guide other workers in the different branches of the precious metal crafts in procuring the particular shades of gold likely to set the work off to the very best advantage, always remembering that silver renders the gold paler in colour, and that copper makes it redder. Platinum makes it whiter, and compo metal yellower, provided the necessary proportions of the respective metals which actually produce those results are not exceeded.

When copper and silver only are used along with the gold, the tint of the gold will incline to red, or to yellow, in the 10-carat alloys, as the proportions of the former or of the latter are increased. Gold alloyed with cadmium gives a greenish tint; an addition of iron or steel gives a gold colour of grey, and by certain definite proportions a blue colour, which is heightened by heating at a low temperature after the article is manufactured. Palladium gives a brown colour, spelter yellow to green, according to the quantity used in the mixture, and by varying the proportions of these several metals the goldsmith is placed in the position

of manufacturing very handsome gold ornaments to adorn his work, without the use of enamel colours, or other colorants, by using an underlay of pure yellow, or one of white, or of any other distinguishing colour as a backing for the opposite shades of gold. The compo used in all these alloys was prepared from recipe No. 4 in the table of alloying metals.

The bluing of separate parts or ornaments manufactured from blue gold alloys is easily effected by placing the parts (after polishing them thoroughly bright) in a pan filled with Calais sand, and after the parts are well covered with the sand, submit them to the heat of a Bunsen burner flame applied from below, the parts being uncovered occasionally, and then re-covered again until it is seen that they are of the desired colour all over, when the heat is turned off, the parts removed and dipped in water or oil—whichever preferred—to cool them. They may then be secured to the piece of work for which they are designed by any one of the many devices known to the workmen engaged in the manufacture of artistic work of an ornamental character. The art of obtaining a fine blue shade which is so pleasing to the eye is, in a great measure, due to the operator being able to judge of the exact quantity of heat to give to the metal, and not wholly, as generally assumed, to the mixture of alloy, even if not quite correctly prepared, which, I may mention, should contain a good percentage of iron or steel for either a dark blue or grey colour to be given to the parts when finished.

The following is another process for turning the colour of the alloy of iron or steel, after the work has been completed, to blue. Place the parts (bright polished) upon a perfectly clear fire and gradually heat them. When at the point of changing colour, the work is immediately taken off, and some oil applied to the surface, and well rubbed all over with a piece of soft flannel or chamois leather so as to obtain a uniform colour as well as to give it a bright appearance. Then the work is again put on the fire and gently heated until the desired tint is secured, when it is at once removed, the oil again applied with the flannel and rubbed until dry, and when cold, the process of bluing is completed.

For turning the colour of the iron or steel alloyed gold into grey, the process is as follows: the alloyed parts are, after being completed, heated over a spirit lamp, the work

being moved about so as to distribute the heat equally all over the surface. When sufficiently hot, which can be ascertained by the least experienced by water not resting on the surface, put some oil of vitriol over the front parts by means of a small piece of linen tied on to the end of a thin piece of stick no larger than a penholder; that object, in fact, will answer the purpose admirably. Let the acid remain on the work for at least half a minute. The work should then be wiped dry, and a little oil put over it and then again be held over the lamp for the oil to penetrate into the pores of the alloy. It is not always that the correct colour is produced with the first attempt, in which case the operations of polishing and heating must be repeated, until the necessary uniform colour is obtained. These and similar devices are only in request in the execution of the highest artistic productions for decorative purposes, where excellence of craftsmanship is essential to the display of beauty and design in real art work in the precious metals, and which effect is much enhanced by the wonderful variety of form and substance of material to which artistic hand-made jewellery of the highest class can be now represented to give embellishments of colour and contrast to surfaces.

CHAPTER XXIII

TABLES OF 9-CARAT GOLD ALLOYS

I SHALL now proceed to provide the reader with a most comprehensive table of 9-carat mixtures, the most popular standard of the present day, for it is used for manufacturing purposes in every description of wares of the cheaper class.

No. 1.—9-Carat Gold Alloy for Curb Work. Very Soft

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·056	=	0	1	3	,,	0	3	0
Pure Copper . .	·532	=	0	10	15	,,	1	8	8
Compo No. 4 . .	·037	=	0	0	18	,,	0	2	0
	1·000		1	0	0		2	13	8

No. 2.—9-Carat Gold Alloy for Stamped Brooches. Fine Colour

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·084	=	0	1	16	,,	0	4	12
Pure Copper . .	·475	=	0	9	12	,,	1	5	8
Compo No. 4 . .	·066	=	0	1	8	,,	0	3	12
	1·000		1	0	0		2	13	8

No. 3.—9-Carat Gold Alloy. Good Soft Tube Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·033	=	0	0	16	,,	0	1	18
Pure Copper . .	·512	=	0	10	6	,,	1	7	8
Compo No. 4 . .	·080	=	0	1	14	,,	0	4	6
	1·000		1	0	0		2	13	8

No. 4.—9-Carat Gold Alloy. Rich Yellow Bracelet Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·175	=	0	3	12	,,	0	9	8
Pure Copper . .	·350	=	0	7	0	,,	0	18	16
Compo No. 4 . .	·100	=	0	2	0	,,	0	5	8
	1·000		1	0	0		2	13	8

No. 5.—9-Carat Gold Alloy for Hollow Curb Bracelets

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·094	=	0	1	21	,,	0	5	0
Pure Copper . .	·100	=	0	8	0	,,	1	1	8
Compo No. 4 . .	·131	=	0	2	15	,,	0	7	0
	1·000		1	0	0		2	13	8

No. 6.—9-Carat Gold Alloy for Cast Signet Rings

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·132	=	0	2	15	,,	0	7	0
Pure Copper . .	·437	=	0	8	18	,,	1	3	8
Compo No. 4 . .	·056	=	0	1	3	,,	0	3	0
	1·000		1	0	0		2	13	8

No. 7.—9-Carat Gold Alloy for Cast Signet Rings

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·150	=	0	3	0	,,	0	8	0
Pure Copper . .	·475	=	0	9	12	,,	1	5	8
	1·000		1	0	0		2	13	8

No. 8.—9-Carat Gold Alloy for Solid Curb Chains. Works Excellent

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·056	=	0	1	3	,,	0	3	0
Pure Copper . .	·513	=	0	10	6	,,	1	7	8
Compo No. 4 . .	·056	=	0	1	3	,,	0	3	0
	1·000		1	0	0		2	13	8

No. 9.—9-Carat Gold Alloy for Same. Rather Paler Colour

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·062	=	0	1	6	,,	0	3	8
Pure Copper . .	·500	=	0	10	0	,,	1	6	16
Compo No. 4 . .	·063	=	0	1	6	,,	0	3	8
	1·000		1	0	0		2	13	8

No. 10.—9-Carat Gold Alloy without Silver. Good Colour

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Pure Copper . .	·100	=	0	8	0	,,	1	1	8
Compo No. 4 . .	·225	=	0	1	12	,,	0	12	0
	1·000		1	0	0		2	13	8

No. 11.—9-Carat Gold Alloy. Rich Browny Colour. Very Soft

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·056	=	0	1	3	,,	0	3	0
Pure Copper . .	·186	=	0	9	17	,,	1	5	20
Compo No. 4 . .	·083	=	0	1	16	,,	0	4	12
	1·000		1	0	0		2	13	8

No. 12.—9-Carat Gold Alloy for Cigarette and Card Cases

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·175	=	0	3	12	,,	0	9	8
Pure Copper . .	·300	=	0	6	0	,,	0	16	0
Compo No. 4 . .	·150	=	0	3	0	,,	0	8	0
	1·000		1	0	0		2	13	8

No. 13.—9-Carat Gold Alloy. Rich Yellow for Match-Boxes

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·200	=	0	4	0	,,	0	10	16
Pure Copper . .	·275	=	0	5	12	,,	0	14	16
Compo No. 4 . .	·150	=	0	3	0	,,	0	8	0
	1·000		1	0	0		2	13	8

No. 14.—9-Carat Gold Yellow Alloy for Cigarette Cases

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·158	=	0	3	4	,,	0	8	12
Pure Copper . .	·292	=	0	5	20	,,	0	15	12
Compo No. 4 . .	·175	=	0	3	12	,,	0	9	8
	1·000		1	0	0		2	13	8

No. 15.—9-Carat Gold Yellow Alloy for Watch Cases

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·170	=	0	3	9	,,	0	9	0
Pure Copper . .	·325	=	0	6	12	,,	0	17	8
Compo No. 4 . .	·130	=	0	2	15	,,	0	7	0
	1·000		1	0	0		2	13	8

No. 16.—9-Carat Gold Alloy. Hard for Springs for Expanding Bracelets

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·187	=	0	3	18	,,	0	10	0
Pure Copper . .	·344	=	0	6	21	,,	0	18	8
Compo No. 4 . .	·094	=	0	1	21	,,	0	5	0
	1·000		1	0	0		2	13	8

No. 17.—9-Carat Gold Alloy for Keeper Rings

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·104	=	0	2	2	,,	0	5	12
Pure Copper . .	·465	=	0	9	7	,,	1	4	20
Compo No. 4 . .	·056	=	0	1	3	,,	0	3	0
	1·000		1	0	0		2	13	8

No. 18.—9-Carat Gold Alloy for Springs for Expanding Bracelets, Resilient as Steel

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·170	=	0	3	9	,,	0	9	0
Pure Copper . .	·399	=	0	8	0	,,	1	1	8
Pure Nickel . .	·056	=	0	1	3	,,	0	3	0
	1·000		1	0	0		2	13	8

No. 19.—9-Carat Gold Alloy. Hard for Springs without Nickel

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·375	=	0	7	12	,,	1	0	0
Bean Shot Copper .	·250	=	0	5	0	,,	0	13	8
	1·000		1	0	0		2	13	8

No. 20.—9-Carat Gold Alloy for Springs. Very Elastic

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·150	=	0	3	0	,,	0	8	0
Pure Copper . .	·450	=	0	9	0	,,	1	4	0
Pure Nickel . .	·025	=	0	0	12	,,	0	1	8
	1·000		1	0	0		2	13	8

No. 21.—9-Carat Gold Alloy. Used Fifty Years Ago for Bright Lockets

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·250	=	0	5	0	,,	0	13	8
Pure Copper . .	·200	=	0	4	0	,,	0	10	16
Compo No. 3 . .	·175	=	0	3	12	,,	0	9	8
	1·000		1	0	0		2	13	8

No. 22.—9-Carat Bluish-White Gold Alloy in Imitation of Platinum

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·562	=	0	11	6	,,	1	10	0
Pure Spelter . .	·063	=	0	1	6	,,	0	3	8
	1·000		1	0	0		2	13	8

No. 23.—9-Carat Bluish-White Gold Alloy to Imitate Platinum

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·550	=	0	11	0	,,	1	9	8
Pure Spelter . .	·075	=	0	1	12	,,	0	4	0
	1·000		1	0	0		2	13	8

No. 24.—9-Carat Bright Gold Chain Alloy. Rich Colour

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·150	=	0	3	0	,,	0	8	0
Pure Copper . .	·419	=	0	8	9	,,	1	2	8
Pure Spelter . .	·056	=	0	1	3	,,	0	3	0
	1·000		1	0	0		2	13	8

No. 25.—9-Carat Hard Gold Alloy for Double Expanding Bracelets

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·130	=	0	2	15	,,	0	7	0
Pure Copper . .	·458	=	0	9	3	,,	1	4	8
Pure Nickel . .	·037	=	0	0	18	,,	0	2	0
	1·000		1	0	0		2	13	8

No. 26.—9-Carat Alloy with B.B. Nickel Silver in Place of Pure Nickel

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·125	=	0	2	12	,,	0	6	16
Pure Copper . .	·350	=	0	7	0	,,	0	18	16
B.B. Nickel Silver .	·150	=	0	3	0	,,	0	8	0
	1·000		1	0	0		2	13	8

No. 27.—9-Carat Gold Alloy. Beautiful Colour for Lapped Work

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·150	=	0	3	0	,,	0	8	0
Pure Copper . .	·425	=	0	8	12	,,	1	2	16
Compo No. 4 . .	·050	=	0	1	0	,,	0	2	16
	1·000		1	0	0		2	13	8

No. 28.—9-Carat Gold Soft Setting Alloy for Pearl Work

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·412	=	0	8	6	,,	1	2	0
Pure Copper . .	·213	=	0	4	6	,,	0	11	8
	1·000		1	0	0		2	13	8

No. 29.—9-Carat Gold Hard Alloy for Spectacles and Ear-Wires

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·200	=	0	4	0	,,	0	10	16
Pure Copper . .	·425	=	0	8	12	,,	1	2	16
	1·000		1	0	0		2	13	8

No. 30.—9-Carat Gold Alloy for Signet Rings. Good Colour

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·087	=	0	1	18	,,	0	4	16
Pure Copper . .	·163	=	0	9	6	,,	1	4	16
Compo No. 4 . .	·075	=	0	1	12	,,	0	4	0
	1·000		1	0	0		2	13	8

No. 30a.—9-Carat Green Gold Alloy for Leaves

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·542	=	0	10	20	,,	1	8	20
Pure Copper . .	·083	=	0	1	16	,,	0	4	12
	1·000		1	0	0		2	13	8

No. 31.—9-Carat Yellow Gold Alloy for Gem Setting

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·400	=	0	8	0	,,	1	1	8
Pure Copper . .	·225	=	0	4	12	,,	0	12	0
	1·000		1	0	0		2	13	8

No. 31a.—9-Carat Pale Yellow Gold Alloy for Diamond Setting

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Copper . .	·425	=	0	8	12	,,	1	2	16
Pure Copper . .	·200	=	0	4	0	,,	0	10	16
	1·000		1	0	0		2	13	8

No. 32.—9-Carat Pale Pale Yellow Gold Alloy for Pearl Setting

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·450	=	0	9	0	,,	1	4	0
Pure Copper . .	·175	=	0	3	12	,,	0	9	8
	1·000		1	0	0		2	13	8

No. 32a.—9-Carat Gold *Soft Ductile Alloy* for Tubes

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·088	=	0	1	18	,,	0	4	16
Pure Copper . .	·450	=	0	9	0	,,	1	4	0
Compo No. 4 . .	·087	=	0	1	18	,,	0	4	16
	1·000		1	0	0		2	13	8

No. 33.—9-Carat Gold Alloy for Spinning. Rich Colour

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·091	=	0	1	21	,,	0	5	0
Pure Copper . .	·437	=	0	8	18	,,	1	3	8
Compo No. 4 . .	·091	=	0	1	21	,,	0	5	0
	1·000		1	0	0		2	13	8

No. 33a.—9-Carat Rich Yellow Gold Alloy, for all Kinds of Cases

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·150	=	0	3	0	,,	0	8	0
Pure Copper . .	·325	=	0	6	12	,,	0	17	8
Compo No. 4 . .	·150	=	0	3	0	,,	0	8	0
	1·000		1	0	0		2	13	8

No. 34.—9-Carat Gold Alloy for Translucent Enamelling

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·200	=	0	4	0	,,	0	10	16
Pure Copper . .	·425	=	0	8	12	,,	1	2	16
	1·000		1	0	0		2	13	8

No. 35.—9-Carat Gold Springy Alloy for Stamped Brooches

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·104	=	0	2	2	,,	0	5	12
Pure Copper . .	·521	=	0	10	10	,,	1	7	20
	1·000		1	0	0		2	13	8

No. 36.—9-Carat Gold Alloy for Ordinary Enamelling

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·170	=	0	3	9	,,	0	9	0
Pure Copper . .	·455	=	0	9	3	,,	1	4	8
	1·000		1	0	0		2	13	8

No. 37.—9-Carat Gold Alloy for Stamping and Spinning

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·150	=	0	3	0	,,	0	8	0
Pure Copper . .	·375	=	0	7	12	,,	1	0	0
Compo No. 4 . .	·100	=	0	2	0	,,	0	5	8
	1·000		1	0	0		2	13	8

No. 38.—9-Carat Gold Soft Alloy for Claw Work and Twisting

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold	·375	=	0	7	12	or	1	0	0
Fine Silver	·080	=	0	1	15	,,	0	4	8
Pure Copper	·465	=	0	9	6	,,	1	4	16
Compo No. 4	·080	=	0	1	15	,,	0	4	8
	1·000		1	0	0		2	13	8

No. 38a.—9-Carat Cheap Yellow Gold Alloy for Cases

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold	·375	=	0	7	12	or	1	0	0
Fine Silver	·075	=	0	1	12	,,	0	4	0
Pure Copper	·325	=	0	6	12	,,	0	17	8
Compo No. 4	·225	=	0	4	12	,,	0	12	0
	1·000		1	0	0		2	13	8

No. 39.—9-Carat Pale Stamping Alloy for Watch Cases, etc.

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold	·375	=	0	7	12	or	1	0	0
Fine Silver	·187	=	0	3	18	,,	0	10	0
Pure Copper	·363	=	0	7	6	,,	0	19	8
Compo No. 4	·075	=	0	1	12	,,	0	4	0
	1·000		1	0	0		2	13	8

No. 40.—9-Carat Gold Alloy for Pendants and Brooches. Good Colour

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold	·375	=	0	7	12	or	1	0	0
Fine Silver	·125	=	0	2	12	,,	0	6	16
Pure Copper	·437	=	0	8	18	,,	1	3	8
Compo No. 4	·063	=	0	1	6	,,	0	3	8
	1·000		1	0	0		2	13	8

No. 41.—9-Carat Gold Alloy for Pens. Very Elastic

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·150	=	0	3	0	,,	0	8	0
Pure Copper . .	·412	=	0	8	6	,,	1	2	0
Pure Spelter . .	·063	=	0	1	6	,,	0	3	8
	1·000		1	0	0		2	13	8

No. 42.—9-Carat Gold Alloy for Engine-Turned Work

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·100	=	0	2	0	,,	0	5	8
Pure Copper . .	·425	=	0	8	12	,,	1	2	16
Compo No. 4 . .	·100	=	0	2	0	,,	0	5	8
	1·000		1	0	0		2	13	8

No. 43.—9-Carat Gold Alloy for Collar Studs in One Piece of Metal

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·092	=	0	1	21	,,	0	5	0
Pure Copper . .	·496	=	0	9	21	,,	1	6	8
Compo No. 4 . .	·037	=	0	0	18	,,	0	2	0
	1·000		1	0	0		2	13	8

No. 44.—9-Carat White Gold Alloy for Diamond Setting

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·625	=	0	12	12	,,	1	13	8
	1·000		1	0	0		2	13	8

No. 45.—9-Carat Gold Alloy for Rich Yellow Colour

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·250	=	0	5	0	,,	0	13	8
Pure Copper . .	·225	=	0	4	12	,,	0	12	0
Compo No. 4 . .	·150	=	0	3	0	,,	0	8	0
	1·000		1	0	0		2	13	8

No. 46.—9-Carat Gold Alloy for Cheap Stamped Rings

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·100	=	0	2	0	,,	0	5	8
Pure Copper . .	·500	=	0	10	0	,,	1	6	16
Pure Spelter . .	·025	=	0	0	12	,,	0	1	8
	1·000		1	0	0		2	13	8

No. 47.—9-Carat Gold Brooch Alloy. Good Colour

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·113	=	0	2	6	,,	0	6	16
Pure Copper . .	·512	=	0	10	6	,,	1	7	8
	1·000		1	0	0		2	13	8

No. 48.—9-Carat Red Gold Alloy. Very Soft Working

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·075	=	0	1	12	,,	0	4	0
Pure Copper . .	·550	=	0	11	0	,,	1	9	8
	1·000		1	0	0		2	13	8

No. 49.—9-Carat Red Gold Alloy. Used for Fancy Work along with No. 23

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Pure Copper . .	·625	=	0	12	12	,,	1	13	8
	1·000		1	0	0		2	13	8

No. 50.—9-Carat Gold Alloy. Old Pencil-Case Alloy. Very Hard

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·225	=	0	4	12	,,	0	12	0
Pure Copper . .	·400	=	0	8	0	,,	1	1	8
	1·000		1	0	0		2	13	8

No. 51.—9-Carat Gold Alloy. Another Old Alloy for Pencil Cases

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·225	=	0	4	12	,,	0	12	0
Pure Copper . .	·363	=	0	7	6	,,	0	19	8
Compo No. 4 . .	·037	=	0	0	18	,,	0	2	0
	1·000		1	0	0		2	13	8

No. 52.—9-Carat Gold Alloy. Red for Ornamenting Silver Brooches

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·050	=	0	1	0	,,	0	2	16
Pure Copper . .	·575	=	0	11	12	,,	1	10	16
	1·000		1	0	0		2	13	8

No. 53.—9-Carat Gold Alloy for Stamping in Series

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·094	=	0	1	21	,,	0	5	0
Pure Copper . .	·531	=	0	10	15	,,	1	8	8
	1·000		1	0	0		2	13	8

No. 54.—9-Carat Gold Alloy for Transparent Enamelling

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold	·375	=	0	7	12	or	1	0	0
Fine Silver	·206	=	0	4	3	,,	0	11	0
Pure Copper	·406	=	0	8	3	,,	1	1	16
Pure Spelter	·013	=	0	0	6	,,	0	0	16
	1·000		1	0	0		2	13	8

No. 54a.—9-Carat Pale Gold Alloy for Transparent Enamelling

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold	·375	=	0	7	12	or	1	0	0
Fine Silver	·337	=	0	6	18	,,	0	18	0
Pure Copper	·288	=	0	5	18	,,	0	15	8
	1·000		1	0	0		2	13	8

No. 55.—9-Carat Gold Alloy used for Transparent Enamelling Fifty Years Ago

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold	·375	=	0	7	12	or	1	0	0
Fine Silver	·292	=	0	5	20	,,	0	15	12
Pure Copper	·292	=	0	5	20	,,	0	15	12
Compo No. 4	·041	=	0	0	20	,,	0	2	8
	1·000		1	0	0		2	13	8

No. 56.—9-Carat Gold Alloy for Thin Stampings. Not Easily Dented

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold	·375	=	0	7	12	or	1	0	0
Fine Silver	·120	=	0	2	9	,,	0	6	8
Pure Copper	·468	=	0	9	9	,,	1	5	0
Compo No. 4	·037	=	0	0	18	,,	0	2	0
	1·000		1	0	0		2	13	8

No. 57.—9-Carat Gold Drawing Through Tube Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold	·375	=	0	7	12	or	1	0	0
Fine Silver	·094	=	0	1	21	,,	0	5	0
Pure Copper	·475	=	0	9	12	,,	1	5	8
Compo No. 4	·056	=	0	1	3	,,	0	3	0
	1·000		1	0	0		2	13	8

No. 58.—9-Carat Gold Yellow Alloy for Fine Bright Lustre

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold	·375	=	0	7	12	or	1	0	0
Fine Silver	·170	=	0	3	9	,,	0	9	0
Pure Copper	·280	=	0	5	15	,,	0	15	0
Compo No. 4	·175	=	0	3	12	,,	0	9	8
	1·000		1	0	0		2	13	8

No. 59.—9-Carat Green Gold Alloy for Leaves

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold	·375	=	0	7	12	or	1	0	0
Fine Silver	·475	=	0	9	12	,,	1	5	8
Compo No. 4	·150	=	0	3	0	,,	0	8	0
	1·000		1	0	0		2	13	8

No. 60.—9-Carat Full Yellow Gold Alloy for Bright Finishing

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold	·375	=	0	7	12	or	1	0	0
Fine Silver	·150	=	0	3	0	,,	0	8	0
Pure Copper	·225	=	0	4	12	,,	0	12	0
Compo No. 4	·250	=	0	5	0	,,	0	13	8
	1·000		1	0	0		2	13	8

No. 61.—9-Carat Gold Alloy for Ordinary Enamelling

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·282	=	0	5	15	,,	0	15	0
Pure Copper . .	·306	=	0	6	3	,,	0	16	8
Compo No. 4 . .	·037	=	0	0	18	,,	0	2	0
	1·000		1	0	0		2	13	8

No. 62.—9-Carat Gold Alloy for Transparent Enamelling Green

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·500	=	0	10	0	,,	1	6	16
Pure Copper . .	·125	=	0	2	12	,,	0	6	16
	1·000		1	0	0		2	13	8

No. 63.—9-Carat Gold Alloy for Transparent Enamelling Yellow

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·312	=	0	6	6	,,	0	16	16
Pure Copper . .	·313	=	0	6	6	,,	0	16	16
	1·000		1	0	0		2	13	8

No. 64.—9-Carat Gold Alloy for Transparent Enamelling Red

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·100	=	0	2	0	,,	0	5	8
Pure Copper . .	·525	=	0	10	12	,,	1	8	0
	1·000		1	0	0		2	13	8

No. 64a.—9-Carat Hard Gold Alloy for Springs for Expanding Bracelets

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·437	=	0	8	18	,,	1	3	0
Shot Copper . .	·188	=	0	3	18	,,	0	10	8
	1·000		1	0	0		2	13	8

No. 65.—9-Carat Gold Alloy for General Enamelling

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·262	=	0	5	6	,,	0	14	0
Pure Copper . .	·344	=	0	6	21	,,	0	18	8
Pure Spelter . .	·019	=	0	0	9	,,	0	1	0
	1·000		1	0	0		2	13	8

No. 66.—9-Carat Gold Alloy for Drawn Through Tube

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·100	=	0	2	0	,,	0	5	8
Pure Copper . .	·450	=	0	9	0	,,	1	4	0
Compo No. 4 . .	·075	=	0	1	12	,,	0	4	0
	1·000		1	0	0		2	13	8

No. 67.—9-Carat Gold Alloy. Very Tenacious

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·175	=	0	3	12	,,	0	9	8
Pure Copper . .	·450	=	0	9	0	,,	1	4	0
	1·000		1	0	0		2	13	8

No. 68.—9-Carat Pale Green Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·512	=	0	10	6	,,	1	7	8
Pure Copper . .	·113	=	0	2	6	,,	0	6	0
	1·000		1	0	0		2	13	8

No. 69.—9-Carat Water Green Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·475	=	0	9	12	,,	1	5	8
Pure Copper . .	·150	=	0	3	0	,,	0	8	0
	1·000		1	0	0		2	13	8

No. 69a.—9-Carat Deep Yellow Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·062	=	0	1	6	,,	0	3	6
Pure Copper . .	·313	=	0	6	6	,,	0	16	18
Compo No. 4 . .	·250	=	0	5	0	,,	0	13	8
	1·000		1	0	0		2	13	8

No. 70.—9-Carat Dark Green Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·438	=	0	8	18	,,	1	3	8
Pure Copper . .	·187	=	0	3	18	,,	0	10	0
	1·000		1	0	0		2	13	8

No. 71.—9-Carat Gold Alloy. Very Soft. Good Curb Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·100	=	0	2	0	,,	0	5	8
Pure Copper . .	·500	=	0	10	0	,,	1	6	16
Pure Spelter . .	·025	=	0	0	12	,,	0	1	8
	1·000		1	0	0		2	13	8

No. 72.—9-Carat Gold Alloy to Imitate Palladium

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·425	=	0	8	12	,,	1	2	16
Palladium . .	·200	=	0	4	0	,,	0	10	16
	1·000		1	0	0		2	13	8

No. 73.—9-Carat Gold Alloy. Colour like Palladium

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·450	=	0	9	0	,,	1	4	0
Palladium . .	·175	=	0	3	12	,,	0	9	8
	1·000		1	0	0		2	13	8

No. 74.—9-Carat Yellow Gold Alloy

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·170	=	0	3	9	,,	0	9	0
Pure Copper . .	·305	=	0	6	3	,,	0	16	8
Compo No. 4 . .	·150	=	0	3	0	,,	0	8	0
	1·000		1	0	0		2	13	8

No. 75.—9-Carat Gold Alloy for Pens

	Decimal.		Oz.	Dwt.	Gr.		Oz.	Dwt.	Gr.
Fine Gold . .	·375	=	0	7	12	or	1	0	0
Fine Silver . .	·133	=	0	2	16	,,	0	7	0
Pure Copper . .	·425	=	0	8	12	,,	1	2	20
Pure Spelter . .	·067	=	0	1	8	,,	0	3	12
	1·000		1	0	0		2	13	8

The great majority of these alloys are the special preparations of the writer, and have been designed to supply the wants of numerous workers who have consulted him in times of perplexity regarding the productions of their businesses. With very few exceptions, the whole of the mixtures are available for all the ordinary exigencies of manufacturers engaged in the different branches of goldsmiths' work, and may be worked with ease and rapidity. The most difficult to work are those prepared with iron or steel, as these metals do not appear to unite well with silver and copper in the preparation of low-grade alloys, but with a great preponderance of gold are much easier to mix together, as fine gold and iron readily unite, the latter metal having great affinity for gold. Iron and nickel will combine, and in special cases nickel may be used to replace the silver and copper alloy in compounding the mixture, or even German silver may be taken, if preferred, in place of the nickel.

In melting iron or steel with gold, a more homogeneous mixture is formed by first fusing these metals together, then adding the nickel, German, or other desired metals afterwards, under a layer of fine charcoal powder, to prevent a scoria from arising to the surface of the molten mass in

the crucible. Where these mixed metals are found difficult to combine, all iron or steel may be used with the gold to make up the mixture. When German silver is used as one of the ingredients in these alloys, the best drawn wire should be chosen. By doing this you will know that that metal is properly ductile, otherwise it could not have been drawn into wire without sundry breakages. Particular attention must be given to these alloys in annealing. It will also much facilitate the working qualities of the metal if slow cooling is allowed to take place; this can be assisted by plunging the objects beneath the hot ashes of the furnace, when the metal will be found much softer by adopting this method of slow cooling. Nickel is very unworkable unless of the highest purity; for that reason I have usually chosen German silver as the better metal to work from. The next most difficult alloys to work are those prepared with a large proportion of brass or compo metal—a mixture of copper and zinc—which is generally the metal chosen. The chief difficulty is their brittleness if heated too hot in the melting, and also in the annealing if overheated; and, further, these alloys will not stand shaking when being drawn from the annealing furnace, or any other rough treatment whilst still hot, without breaking more or less into fragments, the extent of the damage done to the work by the treatment indicated depending entirely on the amount of zinc used in the mixed metal.

Palladium in union with the other metals I have named forms very hard alloys, which are useful for some purposes in the artistic crafts, but it is not much resorted to as an alloying metal along with or in place of those commonly used for the manufacture of jewellery.

In replying to numerous workers regarding the melting and working of 9-carat alloys, much will have to be said to show how their "difficulties" can be surmounted and also guarded against in the future, for there are modes of working the different alloys of gold which will have to be considered as well as the experienced knowledge of being able to mix and melt satisfactorily, for it is not always the cause of the melting that brings obstacles and difficulties to the paths of the workers: it is far oftener due to the latter's incompetency in not knowing how to manipulate the metal properly, and, when necessary, to move out of the beaten track; and this is more particularly the case with the younger men of the new school of workers who

presume to know everything, but yet cannot work with sufficient thoughtfulness and give proper attention to the exigencies of cases which demand alteration, no matter how slight that may be, from the usual methods which have been followed in the workshop. The consequence is that good metal has been destroyed through not knowing how to treat it and bring it properly through the various manipulations of working. These men have been always ready to cast the blame on to somebody else whose share in the transaction was a perfectly innocent one from the start. By giving certain descriptive matter relating to gold and silver manipulation, I hope and trust to be able to show from whom and how sundry difficulties arise in most of the gold working establishments engaged in the manufacture of jewellery to-day.

First, with regard to the melting, I desire it to be well understood that the metals used for alloying gold must be pure and free from oxide, or no melter can produce metal possessed of the highest working properties. The copper must be free from tin or lead to produce ductile metal; so also must the silver be free from galena (sulphuret of lead), which is the common ore of lead and is usually associated with silver in the bowels of the earth, and unless this is thoroughly removed from the silver in the process of refining the silver, it proves very destructive in some of the alloys of gold, more particularly those of the highest standards. It is also very objectionable to the enameller of silver wares, causing the enamel to crack and fly badly at times; this is owing to the contraction of the metal on cooling being more pronounced than it is when the silver is absolutely free from galena. Deposited copper is not good for use in forming alloys to be enamelled on, it being porous and nothing like so good as copper which has been manipulated before using as an alloy for mixing with gold into any of the different standards which are used for purposes of utility. In all cases of mixing gold to be enamelled upon, the poorer the quality of the copper taken for the alloying of the gold, the more difficult is it to enamel upon the preparations made from any of the mixtures in which it is employed.

CHAPTER XXIV

HOW DIFFICULTIES IN WORKING GOLD AND SILVER ARE MET WITH SIMPLE REMEDIES

BEFORE entering into descriptions of the lower alloys of gold, it will no doubt be advisable to make the reader's more intimate acquaintance with the nature and varying properties of the different 9-carat alloys used in the industrial crafts, for 9 carat, though the lowest hall-marking standard legalised in this country, is probably the most important of all the standards, because much larger employment is found for the workers in this standard than that of any other, but possibly that may be through its being the least costly as regards the capital outlay. Really practical information is much wanted, for the literature upon this subject is very meagre, and further knowledge is found to be necessary by practical men in the preparation and treatment of the various mixtures, for widely divergent opinions exist among the men in every department of the gold-working trades, not only as regards the mode of mixing the metals, the method of melting, but also as to the general manipulations or physical treatment to which the different admixtures should be subjected in the workshops of manufacturers. I have previously pointed out that it is not always the fault of the melter, or the component parts of the several metals which form the admixture of alloy, that causes difficulties to arise in the working of certain mixtures, but more often is it to be traced to the want of the requisite knowledge of the operative workers with regard to the physical properties of the different alloys, such as hardness, malleability, ductility, tenacity, elasticity, and general molecular constructions of the various mixtures which are placed in their hands to be made up into the general articles manufactured by particular firms, some of which require a variation of the ordinary mode of working. Metal may be malleable although not highly ductile, and yet the former quality may be admirably suited to the manufactures of some firms, where ductility is not an essential feature to the required manipulations in executing

their wares. Again, other workers require metal possessed of great ductility as well as great malleability, and it is these characteristics which it is absolutely of importance should be well understood by the mixer of metals in the preparation of his alloys, when aiming for the production of the highest physical or working capabilities to be combined in the mixture. I have known highly ductile metal to have this characteristic destroyed by the worker by giving too much hardening pressure in the rolling without an intermediate annealing, which entirely destroyed the molecular arrangement of the mixture, and so prevented it being drawn into wire, the fault in nine cases out of ten being laid to the melter's charge, such a thing as the inexperience of the worker never occurring to him for a moment.

That the physical qualities of a mixture may be retained in their highest forms or partially destroyed in the melting is also a true axiom. This result is largely influenced by the intellectual capacity of the operator at the furnace. The metal, or one of them composing the mixture, may be overheated, and this will cause brittleness. Again, it may be underheated, and this will cause the metal to break or part asunder under the least tensile strain when it comes to be drawn into wire.

The following are some of the chief causes of brittle and spilly gold: (*a*) Oxidisation of copper and absorption of some of the copper oxide by the molten metal in the crucible. (*b*) Burning of the copper or other easily oxidisable metal in the mixture and the closing in of the oxygen and other gases which are evolved by the overheating of the mixture. (*c*) Impurities in the alloying metals. (*d*) Adding of volatile metals under improper conditions. (*e*) Pouring the molten liquid in a pasty form (like the yolk of an egg) from the crucible to the ingot mould. (*f*) Absorption of impurity from some of the fluxes used in melting the mixture. (*g*) Melting in dirty pots containing impurities. (*h*) Alloying certain mixtures with too much spelter. There are other causes than these to be attributed to defective metal, and these will be dealt with in due order, the topics sketched above claiming prior attention as being the most important, if they are to be judged by the number of the problems I am constantly being requested to solve.

An important point in alloying copper with gold is, that the copper should be of the purest kind obtainable; and especially is this the case when the resulting metal is

required to possess those invaluable properties of ductility and tenacity.

It has been said by some authorities that electro-deposited copper is the best for alloying with gold. Now this is only partially true, and for the purpose of imparting the above-named physical qualities, is very objectionable in the formation of gold alloys of all standards. For metal to be rolled into flat, and worked up into wares from that form, its defects are not nearly so apparent. But when the metal is to be drawn into wire it is much inferior to the best selected double refined Swedish copper drawn into wire, and sold in wire coils. Wire-drawing tries a metal to its utmost limit, and it should, therefore, not only be endowed with malleability, but, more important still, it should be highly ductile, tough, and strongly tenacious, for great strength is an essential element in a metal which is to be used exclusively for wire-drawing purposes, and no one knows this better than gold chain makers and filigree workers. Deposited copper has a granular structure consisting of small grains, whilst ordinary native copper when freed from all impurity has a fibrous structure, consisting of small threads or a string-like fracture when broken, and this is commonly accompanied by high tenacity, whereas in the case of the former it is not, and by tenacity is understood the resistance offered by a substance in an attempt to sever or pull asunder its particles by the application of a stretching force, like that practised in wire-drawing. Overheated metal assumes a coarsely crystalline structure, and this causes inductility. Most highly crystalline metals have very little tenacity, and this is one of the reasons why the use of spelter should be limited in the preparation of gold alloys in which the principal manipulations are wire-drawing. Lead, tin, and zinc are all crystalline metals possessing little tenacity, and this is well known to physical science. It is through science that we come to know the cause of things nowadays. It is the result of exact and experimental knowledge; science finds the cause, and practical experience reduces it to successful commercial account, for there is always a cause, and the main thing is to find out that cause and supply the remedy, and the time is well spent in searching for it. For with a little science and expert practical knowledge the greatest difficulties may be surmounted, and it is in the interests of the industrial population that genuine work of this kind should be made public.

Nine-carat gold alloys are now principally prepared with copper as the alloying medium, and as the latter metal in 9 carat is the chief constituent, the mixture is much more liable to oxidisation, as it forms the base; but with the old alloys in use some forty years ago, when silver formed one of the principal ingredients of admixture, the difficulty of melting the compound mixture was not so great as regards oxidisation as it is now, when a portion of the silver is replaced with copper and spelter, as the latter metals give off more gases in the melting of them; and when in the least they are overheated, rapid oxidisation quickly commences in the molten mass, notwithstanding its surface being protected from the air, and this is a bad foe, producing, as it does, not only spilly and blistery gold, but blow-holes and other defects, when the ingot is rolled flat and thin, through the oxidised metal falling out from the mass and exhibiting holes and cracks, and the majority of the melters of the old school cannot account for these things happening. I have seen bars of 9-carat gold which have been remelted and remelted until the operators have become heartily sick of their work, and every known device in their possession had been resorted to, so I was informed, but with no better results. Now the remedy is very simple, when you know the cause. In the course of the subject-matter I am dealing with, I shall put the readers of this text-book into possession of the causes of their failures, so that they may guard against them in the future, as well as provide them with reliable remedies which will undoubtedly extricate them out of sundry difficulties inseparable from working the precious metals.

Oxidisation.—This is the result of the action of oxygen in melting metallic alloys, on inferior metals which are more susceptible to its influence, particularly when they are used in large quantities, as is usual in the preparation of 9-carat gold, and of all the lower standards. It is the operation or process of converting into an oxide a portion of the baser metals used, by causing them to combine with a certain portion of oxygen, and this is effected both by air and heat. It is generally known that more or less oxide is formed on the surface of copper, brass, compo, spelter, and all such metals as are capable of rapid oxidisation; and the presence of this in melting, if allowed to take place to any considerable extent, is very objectionable in the after-working of the metal, for the particles of oxide, if wrongly treated, will not combine with the fused metals in the crucible when once

having formed, but will continue floating on the surface of the fused mass in the form of dross, scurf, or of a scum-like film which covers the whole surface, and if very great care be not exercised in the pouring, will enter into the alloyed mixture in infusible molecules, and these may be disseminated throughout the entire bar when cast, and thereby not only offering a decided opposition to its ductility, but also causing the metal to be spilly and scaly, a preparation most unsuitable for the execution of sundry kinds of work, and frequent remeltings have to take place, which occasions not only the loss of valuable metal but also workmen's time in effecting the necessary work. If I can show how this kind of bad gold—which is the most prevalent—can be avoided in the first instance, I shall be rendering a service to gold workers generally, and I think I can do this for them. If the process of melting is frequently repeated under greater heat, and this is often the case with workmen each time the metal is remelted, it loses a part of its malleability and ductility, but with proper safeguards both these characteristics may be fully retained in the resulting metal.

The remelting of imperfect bars of gold and silver under pressure of greater heat adds considerably to the difficulty, for, as a general rule, more oxygen is taken up by the metal, and this addition of oxygen will not only cause further oxidisation, but render that portion which had previously been oxidised much less fusible by forming a higher oxide of the particular alloying metal most susceptible to the action of oxygen, the term oxidisation—so far as it relates to this subject—being applied to the union of any *metal* with *oxygen*, which then becomes *oxidised*, and the resulting compound is called an *oxide*.

With ordinary gold mixtures, copper is the metal the most likely to be affected by oxygen influences, and as there are several oxides of copper to contend with, the difficulty of melting perfect metal is increased unless the operator is in possession of certain knowledge which can be acquired only by close observation and experimental research. The highest oxide of copper is the peroxide, that oxide which contains the greatest quantity of oxygen, as CuO_2, signifying excess of oxygen and containing two proportions of oxygen and one of copper, whilst the ordinary oxide of copper, CuO, contains equal proportions of the two substances by volume. Sub-oxide of copper, Cu_2O, contains two proportions of copper to one of oxygen, and is called a sub-oxide,

as having less oxygen than the ordinary oxide, CuO. It is the ordinary oxide that the gold and silver workers have most to fear, for this is liable to cause difficulties to arise, more or less, in most of the departmental work incidental to ordinary manufacturing establishments, unless very great care be exercised at all times as regards cleanliness.

To avoid oxidisation and the formation of metallic oxides in melting gold mixtures, particularly 9 carat and under, to begin with, the copper should be quite clean and free from all oxide, and the mixture of metals should be covered with a layer of fine charcoal powder, free from gritty particles of other substances; no other flux will be necessary to the running down of the metal if these instructions are properly carried out. It is only when *oxidised* metal has to be contended with that fluxes are necessary in melting the pure elementary metals, and then those of a *de-oxidising* nature should be used in order to restore the metals to their former condition. The mixture should be melted at a moderate heat only, for copper, when its fusing-point is passed, becomes somewhat volatile, and absorbs oxygen and other gases within the compound mixture of a deleterious nature to its working properties, whilst, if the surface of the fused mixture is ever so little exposed to the action of the draught of the air currents playing within the furnace, it immediately becomes covered over with a scum-like film of oxidised metal, principally oxide of copper, but which unites with it some little silver and gold, and thus causes a loss of metal to take place. By allowing such a state of things to proceed, under the heat of the furnace and the exposure of the liquid to the air, further oxidisation takes place, and the copper oxide may become peroxidised; it is then as brittle as, and resembles, burnt cinders. Serious injury has then been done to a portion of the mixture, and great loss in weight will be the result when the cast bar comes to be weighed, the normal oxide having been converted into the peroxide by its absorption of more oxygen; but as long as the fused mixture is well covered with charcoal it is in a great measure protected from oxidisation, whilst such a covering will not exert any injurious influence on any of the metals forming the mixture. The carbon of the charcoal tends also to absorb any oxygen or other gases which are liberated from the mixed metals under fusion by forming a gas (by the oxidisation of the charcoal) called carbonic oxide, CO, which is a reducing agent and withdraws the gaseous oxygen from

the fusing metals (which combines with the carbon) as it is forming, thus preventing the baser metals from oxidisation; and when oxidisation has even taken place on the surface of the fused mixture in the crucible, the addition of a charcoal covering will by its reducing power withdraw the oxygen from the oxidised metal, causing the latter to take its place again in the mixture proper; and after the chemical action has ceased, a quantity of charcoal will remain on the surface of the mixture in a finely divided state, which covers the liquid metals and protects them from further oxidisation. The liberation of the gaseous oxygen arising through the heating and fusion of the basic metals beneath the surface is accomplished by adopting the following simple remedy. After the fusion is complete, take a thoroughly dried wooden rod and well stir the mixture with it; this will absorb the gaseous oxygen and eliminate it from the liquid metal. If the wooden stirrer is not well dried, free from sap or moisture, it will cause the metal to spit up in the crucible, and some of it may be lost in the fire. The burning of the wood in the liquid metal facilitates the object desired by its becoming carbonised, and by such reaction the gaseous matter within is removed. Poplar, fir, or willow wood is the best to use, because it burns slowly. This *modus operandi* produces beautifully soft and solid metal, free from flaws and blemishes of any kind. It is also an excellent method for silver melting of all standards, as these absorb gases freely on heating, and the charcoal stirrer will deprive them of their gaseous substances.

Burning.—This is caused by the overheating of the mixture in the crucible, and may result from either of the following causes: too great a heat within the furnace by having too strong a draught, or a too long fusion after the several metals have run down into the liquid state. Overheated metal is generally porous, somewhat brittle, and its working qualities are thus considerably impaired. It also assumes a crystalline structure, which becomes fixed through the burning; thus a deteriorating effect is produced in the compound mixture as to entirely alter its physical properties; it loses coherency, becomes far less tenacious, and is rendered much harder than would otherwise be the case had the melting been effected under proper conditions. Further, as all metals give off gases in melting them, the higher the temperature given, the more gases are evolved by the prolongation of the process; and as these are apt to be

enclosed by the surrounding liquid and conveyed with it to the ingot mould, two serious difficulties are likely to arise, though they may also occur from entirely different causes, these are *blow-holes* and *spillyness*. The prevention of these defects, and their correction after becoming present in a bar of metal, is a matter for entirely different treatment. Blow-holes and spillyness may easily be prevented by melting the mixture with moderate heat under a layer of charcoal powder, as recommended for the prevention of oxidisation, and stirring the fused mass with one of the sticks of wood, which will contribute to its ultimate mixture, and provide as homogeneous an alloy as possible. The wood greatly assists the fusion of the metals, and so great a furnace heat is not necessary as probably would otherwise be the case if an iron stirrer was used. Stirring with an iron stirrer has a tendency to produce dry alloys and also scaly metal. A wooden stirrer, which burns without spitting, makes the metal much softer and more tenacious, whilst iron has a tendency to cause a little scale to be detached, which enters the fused mixture and causes the imperfect cohesion of its particles. Escape of oxygen gas is greatly assisted by oiling the ingot mould and dusting evenly all over its inner surfaces with charcoal until a perfectly velvety face is produced. The gases, on pouring in the liquid metal, are withdrawn by the charcoal, assisted by its porous surface, and are thus enabled to escape from the solidifying metal into the pores of the charcoal. Old masters used the charcoal to prevent the liquid metal from adhering to the iron of which the moulds are made, and were not acquainted with its advantages in other respects, for it has since become almost abandoned. It has been through some of my researches into the subject for the prevention and cure of blistery metal that I have found, by adopting an old method, more uniformly sound ingots of gold and silver are obtained, and when used as a part of the process of casting with the other remedies narrated above, fewer difficulties and less failures to produce good solid metal will have to be chronicled than now, in the melting of gold and silver alloys.

Impurities.—These substances are principally found to exist in the alloying metals used in the preparation of the various mixtures of gold and silver, although the precious metals themselves are not always free from impurity. In ordinary copper the impurities, such as antimony, bismuth, tin, lead, and arsenic, have a very injurious effect on the alloys

of gold, particularly those of the higher standards, making them hard and brittle; therefore to safeguard the requisite properties of the mixture in its preparation, the best and purest copper should be taken, which is the double refined Swedish copper, and sold in wire coils, as a guarantee of its being ductile and tough. The melting together of gold, silver, and copper is not very difficult after a little practice, providing care be exercised in the selection of the materials and the right heat be given in the melting. The art of mixing gold alloys with brass, compo metal, gilding metal, and spelter is much more difficult to produce good metal, because in the latter the spelter volatilises so rapidly that a portion of it is liable to be lost in fumes, with considerable loss in the weight of the mixture, and a resulting uncertainty in regard to the colour and composition as to yield practically different results to those intended. Spelter is the name given to purified zinc. Zinc of commerce should not be used for alloying with gold and silver, because it contains as impurities traces of lead, iron, and arsenic, and these would have a very injurious action on the precious metals. Brass, unless its composition is known, should not be employed in alloying for goldsmiths' work, when the material is to be subjected to a variety of manipulative processes, for the same reason that some brass mixtures contain lead and tin. Compo metal is a preparation specially provided for the use of goldsmiths and jewellers, and consists of a compound mixture of pure copper and pure zinc in variable proportions (for which see Table in Chapter IV.), to take the place of brass in the preparation of bright gold alloys and without the usual impurities inherent in commercial brasses. Gilding metal, so called under that name, is a preparation of the same kind, but contains much less spelter than the ordinary compo metals employed in the mixing of certain standards for the manufacture of gold wares designed to serve special purposes. Compo metal is a pure mixture of copper and zinc, and serves (as a cheap medium to give colour) the place of both a portion of the necessary copper and silver which would otherwise be required to make up the desired mixture of alloy. Its constituents, when blended together, form a moderately hard but very tough body, admirably adapted to improve bright gold alloys by giving increased lustre to articles bright finished, and by its power being more superior in resisting chemical influences than copper.

VOLATILE METALS.—In compounding mixtures with volatile substances, care must be taken that the alloys, when formed, are uniform in their composition, and that as little loss as possible should occur from volatilisation by burning, otherwise the resulting product will be hard and dry in its molecular arrangement. Spelter is the most volatile in the series of metals used by precious metal workers in the preparation of their solid ingots, and the greatest care is necessary in the melting to avoid difficulties and failures being met with in working up the metal. Alloys in which spelter forms a part must not be heated too highly or the resulting metal will be blown, and one blow-hole is sufficient to entirely spoil it for some purposes. Gold spelter alloys, if cast at a high temperature, are also brittle and crystalline in structure; but when cast at a medium heat are soft, comparatively malleable, and possess great ductile powers. Such alloys require to be more frequently annealed in the processes of rolling and drawing into wire than gold copper alloys. Alloys also to be used in the construction of articles requiring much hammering and stretching are possessed of far superior working qualities by not casting them too hot, as that will not only prevent them acquiring a too coarsely crystalline structure, the first step to inductility, but will add toughness and strength to the resulting metal.

The melting-point of spelter is very much below that of any of the other ingredients used in the mixing of gold and silver alloys, and when an alloy containing this metal is strongly heated the spelter volatilises, while the other metals remain for the most part fixed, so that the loss of weight incurred may be great if the operation is unduly prolonged after the spelter is added. When compo metal or brass, however, is used instead of spelter, the loss does not appear to be nearly so large as it is when the spelter is used unalloyed and added as a simple element direct to the crucible. The character of these alloys is also altered by repeated melting of the scraps arising from the working of the original metal, and some workers have been unable to work over again the scrap resulting from the working up of the first mixture, if melted in a gas furnace by means of air currents, on account of the burning of the zinc, which causes the cast ingots to be brittle and crystalline through a modification of the structure, thus rendering them unsuitable for the manipulations required in the construction of some kind of gold wares. It is less difficult to maintain the uniform character-

istics of an alloy, when only gold, silver, and copper are mixed together, by repeated remelting, than when highly volatile substances are used as constituents of alloy along with the former, for the furnace loss of the latter is much greater, and it is necessary to ascertain what that loss approaches to in melting the different standards, so that it may be made good by the addition of the requisite quantity of the losing metal to make up the deficiency and to maintain the right composition. This loss should be provided for at the commencement of the melting operation. A little practice and careful observation will soon put the person in charge in possession of the required knowledge.

The method of introducing the unalloyed spelter into the crucible for the purpose of preparing mixed alloys is one of the principal secrets in the successful practice of the manufacture of good metal. When used with gold and silver, it is now almost needless to remark, the spelter must be pure and contain no lead. The presence of lead causes the resulting mixture to be brittle and partly unworkable, the chief defect being its inductility. The best way of introducing the spelter into mixed alloys is by first alloying it with copper, and this tends to prevent (on its subsequent fusion with the gold and silver) to a certain extent the burning or volatilising of the spelter, should the mixture become overheated, which is invariably the case with some operators, but with the best and most experienced among them it is never possible to weigh out of the crucible as much metal as has been put into it originally, if much spelter is being used as one of the ingredients of alloy. Those who know the secret of the method, and have secured advantages from its use suitable to their different requirements, keep the knowledge to themselves, and endeavour to reap the benefit where there is close competition.

When the spelter is used in its elementary form as a separate metal, as an addition to gold and silver alloys, in order to obtain the best and most satisfactory results it is absolutely necessary that it should be introduced into the molten metal in the crucible in the most careful manner. The method I shall now proceed to describe is one which has met with universal success. When it is considered that copper melts at 1,050° C. and zinc at 415° C., and that the respective gravities of the other metals used are: gold, 19·32; silver, 10·53; copper, 8·82; and zinc only 7·15, it must be assumed that when a small quantity of the last metal is

introduced into a large volume of the other metals in a careless way, it usually comes to the surface and is oxidised, and the result of that event happening means, besides producing an unusually hard and somewhat brittle alloy, spillyness will be sure to arise in the subsequent working up of such metal, and the full advantage to be effected by the adding of the spelter will not be existent in the tint of the gold either, when polished to a finish, the object and use of spelter being to represent to the eye a higher quality of metal than can otherwise be secured. It should be noted that if too much spelter be used, at the expense of the silver, it will produce a very brittle alloy, unless great care be exercised in working it, being liable to split and crack in a peculiar manner when heated. For the most desirable quantities for the different standards, see table of percentages descriptive of melting, in an earlier chapter.

The best form in using the spelter for goldsmiths' work is in lumps about as big as a walnut, and the mode of its introduction is as follows: When the other ingredients of the intended mixture have become melted into the fluid state, and are perfectly protected from the air currents within the furnace by a layer of fine charcoal *powder*, take the spelter (which you have previously heated almost up to its melting-point) and gently force it down towards the bottom of the crucible with the tongs, piece after piece, until the desired quantity has been introduced, then quickly stir the mass with a thoroughly dried wooden stirrer, and pour without delay into a not too thick ingot mould, when, if properly managed, you will have excellent working metal, as these 9-carat mixtures when properly prepared produce the softest material to work with. It is a decided advantage to give an even coating of charcoal powder to the inside of the ingot mould to absorb the hot air within the mould during the pouring of the metal.

Pouring Molten Metal.—This is an operation of some importance in the production of alloys possessing uniformity of composition throughout the entire mass, for as soon as the mixture of metals is perfectly fused into the liquid condition and well stirred up, the crucible should be quickly withdrawn from the furnace, and its contents poured at once into a suitable ingot mould, made of iron, and heated until water, if poured on to the outside, boils off at once with a hissing sound. This is quite indispensable, for were the mixture, when fused, to be poured into a cold ingot

mould, or even one not *sufficiently heated*, the metal would be rejected with violence, its particles flying about in all directions, to the imminent danger of the craftsman performing the work, and, moreover, causing some considerable loss or waste of material, a portion of which you would be unable afterwards to recover.

The overheating of the ingot mould is not of so great importance as the underheating, and I have prepared some very soft alloys of gold by using an ingot mould heated to redness. The chief objection to the use of a temperature so high is that with some mixtures, particularly those in which the volatile metals form a part, liquation may take place through the extra time they take to solidify, as the more fusible metals are the last to set, or solidify, being rejected by the more infusible metals, as these cool off first and become solid, so that the former hold the space more or less between the latter as the mass gradually becomes firm, and, as a result, the preparation may not possess uniformity of composition; a necessary requirement in most compound mixtures. The reason why the molten mass should be quickly poured after attaining to a watery thinness is, that when the volatile metals are used as ingredients of alloy, those metals are very quickly converted into vapour, and rapidly become dissipated in fumes if the heating is prolonged, causing the loss to be greater in every case, the exact amount of what that loss will be being entirely dependent on the duration of the time of fusion. The loss, however, may be approximately ascertained by individual craftsmen, by noting the average wastage in their work, when an allowance can be made for it in the preparation of the mixture to be melted, by the addition of more alloy, and by adopting this method of working the actual waste may be much reduced and equalised.

The pouring of the molten metal should be effected by holding the crucible with the fire-tongs in the right hand, the ends pointing to the right shoulder, so that when pouring you can see right into the crucible. The pouring should not be performed too quickly, or accidents may happen; a steady, regular, and continuous flow of liquid metal from the crucible into the mould is at all times the safest and best course to pursue. The thicker the ingot mould, the faster should be the pouring. The metal should not be pasty when being poured, neither should it be glutinous like the yolk of an egg (as sometimes stated by the inexperienced), but, on the

contrary, it should be quite fluid, like oil or milk, and run from the crucible in a bright liquid stream, similar to running water. The charcoal flux floating upon the surface of the mixture is prevented from coming out of the crucible with the metal (its proper place being at the end of the pouring after all the metal has left the crucible) by means of a piece of flat wood (thoroughly dried) held to the mouth of the crucible with the left hand, allowing of the metal to flow beneath the lower edge only; thus the charcoal and any other organic substance is held back till the last, and only clean metal is allowed to pass into the ingot mould. This method will also prevent the dross, which arises to the surface in melting mixed scrap or dirty metal, from leaving the lip of the crucible while the pouring is being effected.

The ingot moulds should be arranged in a vertical position, or nearly so, for pouring into, that position being found the most convenient for the use of goldsmiths and silversmiths in the preparation of their ingots of metal, as it enables the workman to see much better when the moulds are filled than if they were placed in a more slanting position. The loss incurred by spitting, when that event happens to take place, is better safeguarded, too, for the rejected metal, if it does not actually fall back again into the mouth of the mould, is received by the iron tray on which the ingot mould is placed as a source of safety against accidental leakage. The liquid metal as it is being poured should be clear and bright, for this has a material effect on the properties for working of the resulting alloy; on the other hand, should the flow of metal be interspersed with dry dull patches it is a sure sign of imperfect melting or of impurities existing in the mixture of some kind, and if the latter, these will have a very injurious tendency by changing the natural properties of the alloy, hard and brittle spots exhibiting themselves at irregular stages in the manipulatory processes, which interfere with the working, causing loss of workmen's time and much waste of material; therefore it is very important that the melting should be thoroughly performed into a liquid condition before the pouring takes place, and that the latter should almost immediately be effected after the mixture is complete, for, unlike iron and some other mixtures, gold and silver alloys soon become thick and set quickly. The metal, as soon as it becomes thoroughly liquid and is well stirred to promote an intimate union of its different constituents, should be at once poured, it should not be

allowed to bubble up, as that will cause defective working material, whilst its softness will be considerably impaired also. If a little of the charcoal covering does run into the ingot mould (providing it is quite free from impurity) along with the molten metal, it will be no disadvantage to the perfect working of the resulting metal if the writer's instructions are faithfully carried out throughout the melting operation. There may appear on the cast bars a slight roughness of surface at times, but that will not interfere with the working of the metal, and that disfigurement is often found to be an advantage, as it allows of the escape of sundry gases which arise during the pouring of molten compound mixtures. The molten metal will in no case stick to the sides of the ingot mould, when by accident the latter is heated too hot, if the given conditions of preparation are strictly followed.

Impurities in Fluxes.—Many defects arise in the physical properties of certain alloys by the frequent use of fluxes containing impurities; even from bad charcoal powder these difficulties not infrequently happen: it is sometimes adulterated with coal dust, and this is very injurious. The best and purest charcoal should therefore always be procured from a respectable establishment dealing in chemicals specially prepared for the use of goldsmiths and silversmiths. Bad charcoal powder is tested by putting a portion in water, when, if it contains coal dust, the water will become black, whilst water from good charcoal will be very little changed if filtered through it. Borax of commerce is adulterated with alum, and this is also injurious in the melting of sound ingots of new metal. The use of fluxes other than charcoal is not recommended in preparing new metal, as they sometimes alter, although the impurities may not be in sufficient quantities to produce a very deteriorating effect, yet they may be such as to cause some difficulty with the highest gold standards, and for that reason they are much better avoided altogether. In the melting of all new metal, fluxes are not necessary if all the different constituents which are taken to form the compound mixture are pure, and it was to further this end that I, some time since now, introduced the wooden stirring rod, in place of the iron one, as being the most effective instrument to promote admixture without introducing into the crucible any foreign substance, or substances, likely to contaminate the mixture and cause its properties to be made less perfect. When the commercial

metals are known to be impure, it may be advisable to use fluxes of different kinds to convert the impurities into oxides, and to cause them to be withdrawn from the liquid metal, and to enter into combination with the fluxes which soon come up to the surface and take the form of a slag; but of this I shall treat hereafter, when supplying the remedies for the correction of bad and imperfectly prepared bars of gold and silver. As long as new mixtures—both gold and silver—are kept covered with pure charcoal powder, they are effectively protected against oxidisation, the most dangerous evil to which they are commonly liable to be subjected from the draught and heat of the furnace.

Melting in Dirty Pots.—The presence of foreign substances, even in small quantities, in the crucibles used for melting certain standards is ofttimes highly injurious to the physical properties of the resulting mixture, which may be so affected as to render it unsuitable for the purpose for which it is required. These results may be brought about by using the same crucible for melting all kinds of standards, and that in itself is sometimes sufficient to destroy the workable qualities of the highest gold standards; for 18-carat gold, when melted in a 9-carat crucible in which spelter or composition has been used as one of the ingredients of alloy, will have its properties completely changed thereby, to such an extent that it loses its natural malleability, and may be rendered also absolutely brittle, without many operative craftsmen knowing the reason why. But the cause is not far to seek, the impurities from the 9-carat melting left in the crucible, although not visible to the naked eye, enter into combination with the 18-carat alloy, and thus destroys or takes away from what under fair conditions should be a very soft and ductile preparation, those essential physical features which are so conducive to its working. The crucible may appear quite clear after using for the 9 carat, free from shots and all that kind of thing, yet that which is not an impurity to 9-carat gold repeatedly exhibits a peculiar and opposite behaviour towards 18-carat gold. The fumes arising from the burning of the spelter in 9-carat gold, and some little of the white flaky substance arising therefrom, may adhere to the sides of the pot, and that alone is quite sufficient to destroy the desirable properties in 18-carat gold and to set up injurious ones. The best plan is to use a different crucible for each of the standards you are preparing, to safeguard any little obstacle from arising at the wrong

moment, for it is not possible to clean a pot, even by scraping the inside, which has been used for mixed melting, for the production of good work in the highest gold standards, and when the crucible employed for melting the best mixtures has been used for some little time, it is much better to pass it on for use in melting the next lower standard, and so on. By these means the craftsman will meet with more universal success as the reward of his labour, and fewer difficulties and less failures will be encountered in the preparation of good metal for use in the different workshops or hives of industry. It is not advisable to use a pot in which a lemel button has been melted, for melting any quality, not even scrap metal, if it is to be worked over again; it is better to keep it for that purpose only, when once having been so used, for in the most experienced hands it would be a difficult matter to avoid spilly and scaly metal from resulting by the adoption of such a method. The free oxygen present in the different gases, which would be produced in melting in a dirty pot of the kind named, would produce blow-holes and spilly metal to such an extent as to prove by the absorption in the fused mixture of these gases very undesirable working metal, when it in turn comes into the hands of the workmen to be manipulated in various ways, by exhibiting cracks and flaws of several descriptions.

Excess of Spelter.—The use of this metal is to be avoided in all standards higher than 14 carat, and even in admixture for that standard it must be sparingly used. With all the lower grades of gold it may be used with success, providing discriminating powers be exercised in its distribution. Some standards, 9 carat, for instance, will work with a much higher percentage of spelter than those immediately preceding it, when melted under proper conditions, its use being principally to give colour and lustre to bright gold alloys. It also, in most cases, gives tenacity and ductility; these features, however, are chiefly due to the low heat given in melting the mixture. If too great a heat be given it will be hard, brittle, and inductile. The melting of gold mixtures containing spelter requires more furnace experience than is generally supposed, by manufacturing goldsmiths, to produce correct metal. To avoid the many failures, which with the admission of this metal are commonly the result, it is more prevalent in the trade to employ in its place a mixture of copper and zinc previously melted together and rolled to a convenient size for use and sold in 1 lb. lots. It

is called " composition metal " for alloying gold, and is sold by bullion dealers who deal in the precious metals. The loss in using this metal in the compound state is not so great as it is when using the spelter in the simple state, for the burning of the spelter in the latter state is much greater on its addition to the fused metals in the crucible at nearly the end of the process, than by adding it in the compound state at the commencement, for it then appears to be somewhat protected by the other metals. The necessity for absolute purity in these metals has already been pointed out, and I will only add that when the spelter is used in the simple state, after the other metals are completely fused, this metal is heated as nearly as possible up to its fusing point (which is readily ascertained by its appearing soft to the heated tongs) and then added to the fused mass in the crucible. The cooling down of the mixture need not be feared by the addition in this manner, as the spelter gives increased heat to the components of the crucible by the reaction set up, and all that is wanted is vigorous stirring to distribute the spelter among the other ingredients into one uniform alloy of gold, silver, copper, and spelter, and then to remove the crucible from the furnace and pour out immediately its contents into a heated ingot mould prepared in the usual way ready for its reception, and of medium thickness. The precautionary measure of heating the spelter before putting it into the pot prevents the chilling of the already fused contents of the crucible, which will remain fluid after the spelter is added, and so dispense with a further prolongation of heat being given, which would not only cause the burning of the spelter and greater loss of material, but also interfere with the quality of the mixture as regards hardness, ductility, and colour. Great mistakes are often made by operatives in continuing the heat of mixtures, in which this metal forms a part, for some considerable time after the addition is made, under the impression that a uniform mixture cannot be effected otherwise. This practice cannot be commended, since it is not to the advantage of the alloy, but entirely to the contrary, that the heating should be conducted longer than is absolutely necessary to render the metals liquid, and that with the lowest heat possible to serve this purpose, for by intense heating a considerable portion of the spelter becomes wasted. The copper, at more than its melting-point, is liable also to volatilisation in accordance to the extent of the heat given in a strong furnace, and this fact is carried

much farther, for gold, when alloyed with much copper, as in the case of most 9-carat mixtures, is rendered slightly volatile, and you can never recover back again the same amount of the precious metals from the crucible as originally put in, when defective ingots of unworkable metal are assayed with the view of sale, or exchange for new metal, which is invariably the case with badly prepared mixtures, which have been oxidised and burned beyond correction through the melting being repeated several times under wrong conditions. Spelter gold can be made to represent a much higher standard than is actually the case, on account of the rich yellow colour it imparts to certain mixtures, and that is principally the secret of its use, but it is dangerous to use too much, for the resulting metal will crack in all parts if roughly treated whilst still hot from annealing. Finished work may be even broken into sundry fragments, past all repair, if shaken even while it is hot on the annealing pan. It is therefore imperative that the cooling should be complete before these mixtures are moved. Dipping must not be resorted to, either, while hot. The articles made of these alloys will not stand overheating, if of thin construction, when under repair, the metal being liable to crumble and perish after the heating necessary to hard soldering. Finally, these alloys require to be more frequently annealed (taking care not to move the metal whilst under heat) and must be allowed to cool off naturally or they will fall to pieces.

Some Simple Remedies.—The knowledge hitherto conveyed to the reader has been primarily to prevent failures in operative work. Now I will proceed to describe the remedies to be applied in the restoration of defective material and faulty work, and also in the removal of other difficulties which daily beset craftsmen engaged in the precious-metal industries. I shall give the best formulas which my long experience, close observation, and experimental research into all the technical difficulties incidental to the craft in which I am daily engaged have brought me into possession of; the information, therefore, will be thoroughly reliable and perfectly adaptable to the purposes named.

Remedy for Spongy or Matt Ended Ingot Bars.—Sometimes cast bars of gold and silver will exhibit on their ends nearest to the mouth of the mould, after the pouring is finished, a kind of spongy scoria or dross; this is oxidised metal, chiefly copper, in which is included portions of any other base substances forming the alloy to be melted.

Cyanide of potassium will liberate the metals from their union with oxygen and sulphur, and cause them to return to their natural state and take their place again (in union with the different essential bodies) in the crucible in the liquid form. It (the cyanide) may be admitted to the crucible in small portions—about as large as a horse bean—at a time, and continued until a clear bright surface is reflected from the surface of the molten metal in the crucible. The usual charcoal covering is employed to prevent undue access of air to the molten metal. Cyanide of potassium or common salt is the cure for all such technical difficulties of the kind above named. Boric acid and borax will effect the same object, that of liberating metals from their oxides. Some of these, by repeated meltings under the common belief that they will liquefy, increase in the amount of scoria or dross instead, and which then become more infusible under the ordinary conditions as practised by jewellers, and the spoiled metal has ultimately to be sold to the refiners as waste. I have had shown to me some dreadful specimens of the melter's art, being one mass of apparent dross of a porous or spongy nature for some considerable distance down from the top end of the bar. Some of these specimens, it was admitted, had been melted from half a dozen to a dozen times, and always with a worse result, the cause of failure being a mistaken idea of cause and effect, namely, that of the heat being considered insufficient to effect complete fusion. If the operator, instead of adding to the cause of his failure by further heating, burning, and oxidising his metal, had been possessed of a little scientific knowledge regarding the merits of the four chemical salts I have named, considerable trouble, annoyance, and loss of metal would have been saved, for a little of either of these salts will decompose the scoria and cause it to give up the metal therein contained to the contents of the crucible, and with that addition will restore the original mixture to its proper condition again as a malleable and thoroughly workable alloy, if the copper and the other base metals have not been too badly burnt and oxidised, yet if the latter is the case, it may still be restored to good condition again, and thus the loss which would occur through the sale to the refiner as waste metal would be saved. The remedy for restoring the latter kind of metal is rather more complicated in the method of treatment, but, nevertheless, so simple that little practical experience is required to be successful. I

will now give the details of the process: Procure a clay crucible, "London round" is the best, break the gold or silver bar into pieces, so that it can be admitted to the crucible, and when the metal is in the crucible, flux down into a button with common salt, in the following proportions:—

Alloyed gold	20 oz. or 100 oz.
Common salt	1 „ „ 5 „

When thoroughly fused into the liquid form, all the deleterious substances will have been withdrawn from the metal into the flux; the crucible is then withdrawn from the fire, the contents allowed to cool, and when this is effected the crucible is broken and the lump of metal recovered. It is then remelted in a clean plumbago pot with a little charcoal, and you will have as good metal again as it is possible for anybody to prepare. The loss of metal incurred by this process is very small, and that can be made good by the necessary addition of alloy being made when remelting the lump of metal into ingot form. The metal is freed by this process of all oxygen and other bodies with which it had become contaminated by the burning of the base alloy to excess in an endeavour to melt the partly infusible scoria formed in the crucible by a continued repetition of fusing the mixture without the assistance of the proper fluxes, which are in such cases absolutely essential to reduce its scoriaceous condition. It will not be necessary to put this process into effect except for very badly overheated metal. It will be sufficient to correct most of the imperfectly melted bars if they are run down again without charcoal, but in its place take from $\frac{1}{4}$ to 1 oz., according to the quantity of metal under treatment, or sufficient to well cover the surface when melted, or better, say, 5 per cent. of either common salt or cyanide of potassium, and after a trial or two, finally adopt the one found to answer the best for your own particular work. I have had numerous bars of this description brought to me for treatment when all hope had been abandoned of ever being able to restore them for commercial uses, and in no single instance has failure resulted in the endeavour to bring back their physical properties.

Cyanide of potassium is easily fusible and somewhat volatile, but when fused forms a cover to the molten metal, protecting it from the oxidising action of the air currents within the furnace, and readily removed oxygen and sulphur

(two destructive elements in combination with alloyed gold and silver) from most metallic compound mixtures. It is the union of these gases with the commoner alloys of gold which causes so many difficulties to be set up, and when the theoretical conditions of mixing and melting are not properly understood, matters are so much more difficult to contend with. Very thin scrap gold and scrap from hollow work prepared on iron wire, from which the latter has been removed with acid, require care and experience in dealing with such material a second time in the crucible, for the destructive elements above named are inclined to be most evident. The cyanide, however, will cause these scraps, which easily become oxidised metal, to return to its natural state, enabling it to take its place again amongst the fused metal in the crucible in proper workable form. Potassium cyanide contains carbon, and this is an excellent reducing agent for both metallic oxides and dirty metal difficult of fusion. It is a deadly poison, and should not be left carelessly about. A small lump or two added to a melting charge occasionally to clear the surface, will be all that is necessary to ordinary scrap to be effective. But when the metal has previously been wrongly treated, the best method to pursue will be to run the metal down in a clay pot, for which the following formula is recommended :—

Alloyed gold	20 oz. or 100 oz.
Potassium cyanide . . .	1 „ „ 5 „

Follow the same directions as those laid down for the common salt treatment. The action of this formula is that the cyanogen of the potassium cyanide is set free, and this unites with oxygen and most other non-metallic bodies and removes them from the melting charge, whilst a portion of the contained carbon reduces the metal to the metallic state, the free carbon uniting with the other gases and escaping as carbonic acid gas, the potassium serving as a cover to the molten metal.

Remedy for Blow-Holes and Spillyness in Silver Ingot Bars.—This is a subject on which I am frequently consulted. After the metal has been melted over and over again, without any better results, then my help is requested for the cure of the series of holes and hollow places which the ingots present all over their entire surfaces. I am sometimes informed that extra heat has been given to a second melting. Pouring the liquid metal quickly and pouring it

slowly has been tried, but all to no effect, the hollows having increased rather than decreased. To save any misunderstanding on this matter I must point out that the hollow places or blow-holes in ingots of gold and silver are very different to bulbs or blisters ; the former are depressions or cavities, whereas the latter are projections of a half-spherical form filled with oxygen and other gases which have not broken through the outside crust of metal. But with the appearance of holes and hollows these gases have been liberated during the solidification of the metal in the iron ingot mould, and, as a consequence, there appear holes and sunken places, sometimes with a little crack extending along their surfaces of disunited metal, which, when the bars are rolled (if performed in that state) a slit appears at all those places, thus rendering a portion of the preparation imperfect, and only fit for remelting as scrap metal. The remedy for blow-holes, which subsequently bring a certain form of spillyness, is to remelt the bar in a new plumbago crucible, using a little fine charcoal powder as a covering to protect the fused metal from the air, and also the draught of the chimney, and to add a pinch or two of dried common salt to the fused metal in the crucible, just before pouring. This is an excellent remedy against the absorption of oxygen gas by the precious metals during their fusion, and will entirely remove the oft-occurring nuisance of blow-holes when other methods have failed. Well stir the molten metal, immediately before pouring, with a dried willow stick, but be sure that it is thoroughly dried before putting it into the molten metal, or the metal will spit up on coming in contact with the least moisture, and serious consequences may result if this information is not regarded. In heating for the restoration of imperfect bars of gold and silver of the kind I have described, it is advisable to make the ingot mould very hot, which should be of regular temperature throughout its entire length (as the condition of the mould has something to do with the production of hollows in cast metal) for, unless this is done, the cold air within is not expelled, and this is an additional obstacle to contend with, for if this air is not driven upwards before the rising of the molten metal in the ingot mould, as it is being poured into it, it will cause cavities to appear in the castings. The pouring should not be performed too quickly, as that would enclose the hot air in the mould instead of driving it before the molten metal out of the mouth of the ingot mould,

neither should the pouring be done too slowly, but in a clear, regular, and uninterrupted stream, and, as some air is carried into the mould during the act of pouring, the better chance has this air to escape again by adopting a medium speed of pouring. Overheated metal causes blow-holes and porosity, therefore, when melting a bar over again, take particular care not to get the metal so hot a second time. Do not use borax, but if any flux is necessary use chloride of ammonia (sal-ammoniac), this volatilises, leaving no substance behind, whilst toughening the gold or silver mixture in the crucible. Melting the precious metal in gas furnaces causes larger volumes of gases to be generated, which are more injurious to the physical properties of certain alloys than if they had been prepared from a good coke fire freed from sulphur and other fumes. The use of a little dried common salt for remedying blow-holes has always been successful, with myself and others who have had cause to use it, that little more need be said regarding it, except, perhaps, explaining the cause of its usefulness. Common salt, when heated above its fusing point, becomes decomposed, liberates its chlorine or hydrochloric acid, and this seizes upon any base substance existing in the metallic mixture, converting it into chloride, which either escapes or is retained in the charcoal covering, leaving the sodium behind, which by its strong attraction for oxygen unites with that gas and withdraws it from the mixture, leaving the latter to fill up every part of the mould, when a sound compact bar of either gold or silver will be found on turning it out of the mould, and all blow-holes and other kindred impediments to the preparation of good working metal will be found removed.

Remedy for Blistery and Scaly Metal.—These defects in ingots of gold and silver are liable to occur partly from the above causes and partly from a certain amount of air entering the metal during its fusion. Blisters, for the purpose of this paragraph, will be treated as being different to blow-holes. The former present themselves as little bulbs all over the surface, at different stages of working; more particularly are they apparent after the annealing process has been performed. They are little blisters of undischarged air or gases, such as hydrogen and carbonic oxide, which are generated by the heat which is necessary to cause fusion of the mixture of metals in the crucible, and by pouring at too high a temperature into the ingot mould

will cause these gases to be retained in the metal, and when the metal is rapidly cooled the means of their escape is prevented from taking place. When, however, the metal is well stirred with a wooden stirrer previous to pouring, their escape is greatly facilitated. In the different stages of manipulating the metal the blisters break, showing a dirty undersurface of oxide, and scaly metal is the result. Scaly metal is sometimes caused through impurities in the alloying metals used in the preparation, preventing perfect cohesion of the molecules to take place in the mass. Dirty scrap metal will also cause the same thing to frequently happen. Great care, therefore, should always be given to the matter of cleanliness in these operations in every detail if you want the resultant mixture to turn out without flaws and defects of any kind. Silver melting is very prone to blisters. Melting with gas is one source of the cause, heating the metal too hot is another cause, allowing it to remain in a fierce fire too long after fusion has been effected, as well as pouring it too quickly, are also contributory causes, and every kind of blistery metal can be traced to one or other, or to all of these causes. In very badly melted bars of the description to which I am alluding, a great amount of oxide is created, which in remelting sometimes obstinately refuses to become liquid. A little boric acid or borax will dissolve this oxide and remove all the deleterious substances from the melting charge, and restore it to its proper condition again, if the directions I have given are followed throughout ; and when pouring the liquid metal into the ingot mould do it at a uniform rate to avoid taking in too much air during the operation.

The remedy for blistery metal which has been melted in an old crucible containing old fluxes, or through remnants of rough mixtures having been left behind, is to remelt the defective metal in a new crucible, and add either a little cyanide of potassium, common salt, or bicarbonate of potassium, and give the mixture a vigorous stirring with a dried wooden stirrer ; pour into an extra hot mould and see that it is of uniform heat all down. Do not use borax if there is no oxidised metal to be dealt with, as this will prevent the gases from escaping by spreading over the entire surface of the molten metal, if used in quantity. A little sal-ammoniac and charcoal will be all that is necessary if the metal is not very bad ; if very bad it will have to be run down in the manner directed for badly oxidised stuff,

and afterwards remelted according to these directions. The sal-ammoniac is a volatile substance and partly escapes, the ammonia evaporating, whilst the chlorine unites with any deleterious substances of the mixture, converting them into chlorides, which, when sub-volatile, enter the charcoal and are prevented from going into the ingot mould with the liquid metal by the application of a piece of dried wood held against the mouth of the crucible. The sal-ammoniac is not a liquid flux to promote fluidity, as has been stated by a writer on goldsmithing, but one which burns entirely away, leaving nothing behind.

Remedy for Cracky Edges in Rolled Ingot Bars of Gold and Silver.—This is a matter of serious importance, not only to the worker, but also to the employer, for it always causes an excessive amount of scrap to be made in the course of the different manipulations to which the metal is subjected in working, and that not only means a loss of valuable time of the workers, but is one even of more serious import to the employers, and it is sometimes difficult to ascertain exactly what their losses amount to, for there is not only the loss of workmen's time, the time taken to remelt the waste, the loss of metal incurred during a second fusion, a repetition of the charges for rolling, and sundry other little expenses, which need not be enumerated here, but which are well known to all keen business men, thoroughly conversant with the cost of manufacturing articles of gold and silver jewellery and domestic wares of plate. Suffice it to say, that every worker in precious metals will have experienced at times the jagged, ragged, or uneven edges of some gold and silver bars after rolling, for this appearance can be seen daily in the streets of Birmingham in the jewellery quarter, as they are being carried from the rolling mills to the various manufactories. Now, this breaking out at the edges has been attributed by theory to various causes, and I regret to say, by the results of practical experience, mostly to wrong ones. True it is that there are several causes which will bring about the mischievous occurrence, and if I put on record the result of my researches into the subject, it will probably do something to improve matters in the future. Now, it is evident to my mind the *chief* cause exists in the rolling and annealing of the stock bars, for I have tested different compound mixtures of nearly all the standards in the course of my investigations during a long number of years in accordance

with the various rules of melting temperature, cooling, rolling, annealing, and other conditions as set down by some goldsmiths and scientific men, and I have had my directions conducted at different rolling mills, with the result that I have come to the conclusion that the principal causes which lead to three-fourths of the ragged-edged bars of gold and silver spring from the rolling and annealing by too much hardening pressure being employed and continued too far; they are put through the rolls too many times, between the first and subsequent periods of annealing. This unduly stretches the molecules of the mixture nearest to the edges of the bars being rolled, for the greatest pressure is there primarily bestowed by the rollers employed in the breaking-down process. The greatest strain is therefore on the two outside edges of the stock bars, and the molecules in these parts are unable to return to their normal condition after annealing, like those in the other parts, owing to overstraining; the overstrained molecules, being unable to contract equally with the normal ones, are displaced from their original position, become much less cohesive and easily part asunder; and in support of this testimony I have only to mention the habit which operatives at the rolls have of drawing their thumb and fingers down the edges of the bars they are rolling, as a test of condition for the requirements of annealing; and the rolling is ofttimes continued until a slight roughness is apparent to the thumb and fingers before transferring the bar of metal to the annealing furnace. This, then, is how most of the damage is started, so far as it relates to ragged and broken out edges. Of course, it must be assumed that the mixture of gold or silver was of a thoroughly workable condition, as regards the proportions of its ingredients, the correctness of the melting, and the purity of the alloy used, before the blame can be justly thrown on to the rollers. The rollers are not supposed to know what special treatment the different compound mixtures require at their hands, and it is a usual practice of theirs to form an opinion by the aforesaid means, of thumb and fingers, and unless you have a very malleable alloy, excellently melted, you must not at any time be surprised to have returned from rolling, rough-edged metal entailing an extra amount of scrap. Some mixtures will stand much more rolling than others before it is actually necessary to anneal them, that depending principally upon their composition, and on the care with which they have

been melted. It is a good plan to anneal the bars before sending them to the rolling mill, and to give directions, when sent, for them to be more frequently annealed than is the usual custom, for by these simple means harder and badly melted alloys may have their edges preserved and unnecessary scrap avoided. Do not pickle or quench gold copper alloys at too high a temperature, or they may sometimes crack by so doing, especially if they had absorbed gases in the melting.

The theory of the cause of gold and silver ingot bars cracking in rolling is due to their being prepared with a crystalline structure, a fine or a coarse grain is produced, it is said, by cold, or by hot, pouring. By pouring the molten metal at the lowest possible temperature of the requisite liquidity, a fine grain will be imparted to the mass of fibrous structure capable of great rolling strain without injury, while hot poured metal will have a coarse grain imparted to the mass of a crystalline structure when broken, and capable of far less tension. Again, it is urged, that gold and silver slowly cooled is crystalline in structure, but when quickly cooled, in a slightly warmed thick-walled iron mould, the grain is fine and free from crystalline structure. Overheated metal in a fierce fire, and quickly poured at a very high temperature, will naturally crack in rolling or breaking down.

Overheated gold and silver usually solidifies with a rough coarse grain into the crystalline condition, and when bars of the respective metal crack in rolling, the question of temperature should be inquired into. Neither alloyed gold or silver, more especially the latter, should be given a too high degree of heat in their compounding by fusion, for in many instances on totally disregarding this axiom will rest the cause of cracky bars, for usually all bars are treated alike when they get into the hands of the rollers. An important point in melting is to see that the fire heat is retained in the metal or nearly so, until poured, and not allow it to become thick or pasty in condition, for the latter state produces an element of incohesiveness which then bears much less tensile strain.

The question of temperature in the melting of gold and silver alloys is one of the first order of things, and is of paramount importance in manufacturing processes, as it generally brings about the first difficulties of precious-metal workers if the material upon which they are engaged is

carelessly prepared, for no art can be practised with complete success unless the theory on which it is founded be thoroughly inquired into and properly understood. It is a fact that operative melters were for a long time in considerable ignorance as to the principles of their art, for it was imagined that the presence of a piece of tool steel in a melting charge, and allowing it to float on the top of the melted metal in the crucible until it began to spark, indicated the proper pouring temperature, and not until then was the pouring temperature supposed to have been reached. This was certainly a primitive method, and indicated that a rather high temperature should be used, whereas the very opposite is required in melting most of the alloys in which the precious metals form a conspicuous part. The mass of metal under such a method would become liable to be filled with miniature specks of steel, for some of the steel becomes dissolved into the mixture in the crucible by the heat required to cause sparks to be emitted, and exists in the metal when it comes to be worked up, and is therefore highly injurious, creating difficulties and failures of an almost insurmountable nature on manufacturing the multitudinous fragile articles which the present-day fashion demands. There is still evident great misconception and an utter confliction of ideas among the different classes of goldsmiths and silversmiths regarding the principles which govern this branch of their craft, but notwithstanding all that is said, I still affirm that much depends upon the rolling, given heavy strains in the rolls, but not rolling so much before annealing will generally remove the cause of ragged edges. Many good bars have been condemned in the melting, while the trouble has sprung from the rolling.

Remedy for Dog's Ears in Casting Gold and Silver Ingots.—These make their appearance on the top ends of the cast bars of metal, and may consist of one or two projections, the number depending on the method pursued in pouring the molten mass into the cast-iron mould prepared for receiving it. If poured from the broad side of the mould into the centre, there will probably be two horns or ears, while if poured from the narrow side or endwise, which is sometimes done, there will be only one; these are caused by pouring the metal into a thick-walled under-heated iron mould, much too rapidly at the finish. The weight and force of the liquid metal falling all in one place, when poured in from the broad side of the mould, causes the metal to rise

at the sides and thicken almost at once, and when the contraction of the mixture is completed, there will be found a cavity existing in the middle and two ears projecting from the top end of the bar. When the pouring takes place from the narrow side, or edgewise, of the ingot mould, the metal will, of course, flow to the opposite side and commence to thicken, thus preventing the desired uniformity at the end of the bar from being obtained, one of the sides being longer than the other. The thickness of the cast-iron mould and its not being heated hot enough in proportion to the thickness, explains the thickening at once of the liquid metal when it reaches its sides. It is the function of the iron mould to hold the metal in the liquid condition uniformly as it rises upwards from the pouring. The remedy for the removal of these difficulties will now be apparent. Heat the ingot mould to a degree proportionate to the thickness of its walls, and pour in the liquid mixture of metals more slowly, particularly at the end of pouring; or, get your assistant to give the top end of the ingot mould one or two sharp raps with a hammer immediately the last portion of metal leaves the crucible, you will then have level-ended and more uniform castings, showing very little waste of material.

Remedy for Shoots and Runners in Casting Ingots of Gold and Silver.—These obstacles may be brought about in two ways; firstly, by pouring the metal in a too pasty condition—like the yolk of an egg—into an extra long ingot mould for the quantity or weight of metal being prepared. The pouring in this case will be too slow, the very opposite of that which causes the difficulties in the preceding paragraph, especially at the end of the process, as the metal will then set almost as soon as it leaves the lip of the crucible and enters the ingot mould, leaving long projecting shoots or runners to form on the end of the solidified metal, consistent with the condition of fluidity and manner of pouring. Another cause is the irregular and insufficient warming of the iron mould and the pouring in of properly melted metal much too quickly for the temperature of the mould, which, in consequence of the unequal degree of heat of the two substances and their coming in violent contact with each other, causes some of the liquid metal to be rejected, and shooting upwards, becomes chilled far too rapidly to fall again uniformly to its place in the mould, as it sets before that can be effected, the last traces

of the pouring being more prominently effected in this way. The remedy for obstacles of this kind, when they present themselves, is to remelt the metal under more favourable conditions, put some finely powdered charcoal in the crucible with the mixture of alloy, and when it begins to melt add some more charcoal, so as to always keep the fused metal well covered. Heat the mould uniformly and quite hot, and choose an iron mould having a holding capacity compatible with the weight of metal being melted; pour neither too slowly nor too rapidly, and you will be surprised at the results.

Remedy for Small Black Streaks in Rolled Silver.—This trouble is caused through bad melting. When the metal is rolled thin and used in the manufacture of cigar cases, card cases, match boxes, and other articles having to be finished plain, streaks sometimes present themselves in the last stages of finishing. These streaks appear of various lengths, very narrow, exhibiting a blackish shade alongside the silver finish, of a much deeper hue than the best black polish to be got on silverware. The streaks are derived from specks cast in the metal in the form of ingots for rolling, and although then very minute, become elongated into streaks as the ingots are rolled into sheets. The more the sheets are rolled in thinness, the longer the streaks become, and as the sheets are not very materially widened in the process of rolling, the streaks themselves do not much widen out, but are largely elongated, and therefore cause disfigurement of the work when the finishing stage is reached. These streaks are caused by using impregnated lump charcoal and the too free use of an iron or steel stirring-rod for mixing up the different ingredients of the crucible. The iron or steel stirring-rod gradually dissolves away with constant use, small portions being constantly detached, some of which enter the liquid metal, while other portions are retained in the lump charcoal (the latter being allowed to remain in the crucible for the whole of the heats performed in a day's work without once being turned out to cleanse the crucible in some casting foundries), the portions retained in the charcoal having a far more deleterious effect on the second heat being performed than on the first one, and each subsequent one throughout the day becomes worse than the preceding one in the quantity of iron or steel taken into the liquid silver. The oxidised and iron impregnated charcoal, through being allowed to remain in the crucible, is

constantly giving up portions of its impurities to each fresh melt, and no wonder there arises serious complaints from workers in the precious metals of the streaky and specky nature of the metal given to them for manual operation, when it is prepared under such conditions. The remedy is not far to seek in a matter of this kind, and I was not long in finding the cause in a case in which my advice was sought. The remedy lies in keeping your pot clean, using powdered charcoal, just sufficient to protect the surface of the metal, stirring with a *thoroughly dried* wooden stirrer, melting the silver at the lowest possible temperature consistent with good mixing, pouring at a medium rate, and the removal after every heat of any substance remaining in the crucible, you will then have, if the operation has been skilfully performed, wonderfully good metal, soft and ductile, and free from streaks, pin-hole, sand blisters. The latter generally come from gases which are absorbed while the metal is being melted, but are sometimes given out again while the casting is taking the solid form, but not always. The wooden stirring-rod eliminates gases in a wonderful manner: overheated metal, soaking in the fire after fusion has been effected, boiling the metal until it bubbles, a lack of charcoal sufficient to cover the metal, are all contributory causes to the setting up of blisters and blow-holes. Boiling metal in silver mixtures should never be allowed to take place, as it then absorbs gases with great rapidity. Overheated silver loses some of its properties and takes up gases in their place. The hotter the metal is made, the more gas it will absorb in the fire, and consequently the more blow-holes and blisters will ultimately be found in the metal when it comes to be worked.

Sudden Cooling of Gold and Silver Bars after Casting.—The success of this practice depends entirely upon the composition of the alloyed mixture of metals. Modern gold alloys, particularly those of 9 carat, will not in all cases stand such rough treatment as to allow of their being immediately plunged into cold water, or cold pickle, while still red hot from the melting, without injury. Some preparations are more liable than others to become brittle and to seam and crack, unless the temperature is very much lowered below that of the solidified casting-point, through the too sudden contracting of the molecules forming the chief constituents of alloy; and there can be no doubt that the large proportion of copper or of composition employed

in alloying is the cause of these difficulties arising, for when a larger percentage of silver (15 to 20 per cent. in the whole amount) is used in place of some of the copper or of the composition, similar obstacles are not presentable, so that it must be owing to the different physical properties imparted to certain preparations by the varying proportions of alloy, as to whether the resultant metal is capable of standing the immediate treatment of the cold-water plunge or not. The point is one that has often been discussed, and it is commonly believed by many persons that equally good metal results in the one case as in the other, but this is not exactly my experience, for I have found that when dipping ingots of gold containing larger proportions of copper, or of composition, with a corresponding reduction of the necessary proportion of silver, at a red heat, they are liable to seam and crack, and I have witnessed several bars of both alloyed gold and silver which have cracked right through from having been plunged while too hot into a cold liquid. Gold mixed with silver and copper in reasonable proportions, and when I mention reasonable proportions, I mean that the silver should not be less than 15 to 20 per cent. in the whole amount of the prepared alloy. Such alloys will stand the quenching immediately after removal from the ingot mould without injury. But the modern alloys will not stand such rough treatment, in consequence of being coarser in the grain, and the contraction of the molecules being rendered too precipitate causes ingots of mixed metals, particularly those which are liable to absorb sundry gases in the melting, to slit and crack, their escape being prevented by the abrupt closing of the skin of the metal by immediate quenching after melting. It is far better to give all bars of this kind a reasonable time to cool down somewhat before dipping into water or pickles of any kind, than to risk their physical properties being injured by expediting the work by sudden cooling, as you may undo all the work of the melter in one minute. Some alloys will barely stand touching while red hot, and are allowed to cool in the atmosphere, or their workable properties would become entirely destroyed. The question of dipping red-hot gold and silver ingot bars with safety depends entirely on the ingredients of alloy and of their relative proportions to each other, to the temperature employed in the melting, and to the non-absorption of sundry gases.

The alloying metals should be, as far as possible, free

from impurities; the silver for gold alloys should not be too sparingly used; the temperature of the furnace should not be too high, so as to cause overheating of the metal (which in its turn causes sundry gases to arise within the fluid metal); and by following these directions the ingot bars may be cooled immediately in water or pickle after they have set into the solid form, and very little difference is perceived in the working from those which have been allowed to cool down gradually. It is a rule with some to anneal the ingots after casting, to allow them to partially cool down, and then to pickle them. This is a very good plan, as the ingots of metal are rendered much softer, and are not then so likely to be over-rolled at the rolling mill before being there annealed for the first time.

Fire-Sparks in Pouring Gold and Silver Mixtures.—This is the flying-off of red sparks of fire the moment the molten metal touches the iron mould at the beginning of the casting operation. I have been consulted with regard to some information on this subject, and I have no hesitation in saying that the phenomenon of sparking in pouring the precious metals from the crucible into the iron moulds is contrary to any melting theory, or to the production of good metal. The practice of causing fire-sparks to be emitted during the pouring is entirely wrong, and may be ranked with ideas of the "remotest antiquity," for the most modern practice adopted by those who are now producing the best gold and silver bars is to melt them at the lowest possible temperature consistent with the requisite fluidity. The fire-sparking—to any person not having witnessed it—may be compared to the filing of a piece of steel in a gas flame, and most jewellers are familiar with the sparking action produced by it, without my entering into further detail on the subject, suffice it to say, the occurrence of fire-sparks in the pouring of the precious metals is the truest indication that the metal has been terribly overheated, and that the physical qualities, as a natural consequence, have considerably suffered by allowing such action to take place. The metal resulting from having been exposed to so high a degree of heat will be harsh and feebly tenacious, a truism which the workers soon find out when they come to work up the metal into different articles of jewellery. It also produces a sponginess in the metal inconsistent with carefully and moderately heated mixtures of gold and silver during their fusion.

Remedy for Fire-Sparks.—Do not allow the metal to become overheated in the fire, and pour at the lowest possible temperature at which, as a fluid, it will leave the crucible. Keep some charcoal in the crucible from the start, and add more when wanted, so that the metal is always well covered, and the moment the proper heat is reached, immediately pour the mixture into the mould. Let this method be the melter's universal guide, always bearing in mind, the longer gold and silver mixtures remain in a melted condition exposed to a fierce heat, the more gases will be absorbed, and the more numerous the blisters will be, as well as the building up of sundry other difficulties, all antagonistic to their proper working capacities.

Note—*On Overheated Metal.*—I took all the waste metal, 20 oz. from large bar 400 oz., and remelted it under proper conditions, rolled the bar and submitted some strips of each to a severe testing by bending backwards and forwards with a pair of pliers until a fracture occurred, with the result that the overheated metal broke at the 7th bend, while my melt of the above scrap stood perfectly till the 11th bend.

Fire-Cracks in Rolling 18-Carat Gold.—The subject of fire-cracks in annealing 18-carat gold after the first rolling, has puzzled many craftsmen as to their cause. These fire-cracks are entirely different to air-cracks, blisters, edge-cracks, or other difficulties emanating after rolling. The theory of the trade was that the fire-cracks existed in the casting, and were brought out in the rolling, but this theory has now become exploded, for it has been found that neither the casting nor the rolling had anything to do with it from the point of view as the matter was then understood. It was entirely through wrong principles of treatment being adopted with regard to this particular standard, for exactly the same mode of treatment being followed with regard to the other standards produced no ill-effects. How was it, then, that 18 carat, more frequently than not, fire-cracked ? The fire-cracks usually presented themselves in a transverse form, that is, in a cross direction from edge to edge of the broad part of the bar, and not at the two outside edges. Sometimes longitudinal and diagonal cracks appeared among the transverse ones, but always on the flat surfaces. After a good deal of research and experiment, the cause of these fire-cracks was discovered by the writer and made known, and now very little is heard of their frequent occurrence. The fact is, 18-carat gold mixtures, differing from others,

will stand a good deal of crushing down at the rolling mill without any ill-effects resulting, while, on the other hand, it is to their distinct advantage that heavy rolling be adopted, for, without this, cracks will present themselves. When the rolling begins lightly, the particles of metal on both sides of the edges of the ingot become compressed to a certain depth, but the same extent of compression fails to reach the interior of the ingot, and, as a result, there will be two kinds of strain during annealing expansion, for when the metal is annealed there results a different strain on the outside to that of the inside, which latter has scarcely been compressed at all, and this unequal expansion causes the molecules of the interior to break through the outside skin, through their grain being larger and coarser, and by evolving a greater force of expansion (the fineness of the grain is given by heavy rolling in this quality of gold) the cracks then form. The modern method of avoiding fire-cracks in rolling 18 carat is to cast the bars as thick as possible, and in breaking down to give them as "heavy pinches" as can be done, so that the middle part of the bars will receive as much compression as the outsides, and the result of this is an equal strain is put upon the metal when the annealing operation takes place, and by these means fire-cracks are now entirely avoided. The heavy rolling imparts a much finer grain to the gold than can be given in the melting, and it all depends on the thickness of the bar and the degree of compression it receives in the rolling, whether it cracks or not. Roll 18-carat gold at two draughts to half its thickness, or to about twice its length, before annealing, and no more 18-carat cracky gold will be returned from the rolling mill for remelting by the manufacturing goldsmith before he can proceed with his work. After the first and second draughts have been given at the rolling mill, the rolling can then proceed in the usual manner without the danger of fire-cracks being produced, and as most goldsmiths and jewellers are familiar with fire-cracks in 18-carat gold, this thoroughly practical and sure method of avoiding them, no doubt, will be welcome information.

Cold Rolling.—Gold and silver alloyed mixtures are all rolled in the cold state at the rolling mills, and commonly roll very well as long as they are kept sufficiently soft by occasional annealing, which releases the strain put upon the particles of the metallic mass by the action or pressure of the rolls. Hot rolling of gold and silver alloys is impractic-

able and causes cracked edges, splitting down the middle, and otherwise inducing a high degree of brittleness. Alloys usually differ greatly in their respective proportion of ingredients, each manufacturer having a preference for his own special alloy, claiming for it some superiority of colour, or of its being possessed of higher physical properties which are more compatible with their particular branch of the gold-working trades than other alloys. For mixtures compounding the different standards of gold which have to be rolled and drawn into wire, the metal produced after alloying and melting must be malleable and tough. For casting purposes these requisites are not so absolutely necessary, wherein filing or turning has only to be complied with, and not rolling, for the manipulations of the work. The two former features, malleability and ductility, depend entirely upon the composition of the mixtures, and of the care bestowed in their preparation during the operation of melting. The facility with which an alloy of the precious metals can be rolled into thin sheets without exhibiting cracked edges, depends firstly upon its softness, and secondly upon the care with which it is treated by the operative at the rolls. A hard metal will not stand much reduction without soon becoming much harder; therefore the rolling of such alloys should not be continued as far as alloys of a much softer nature without an intermediate annealing; or, in other words, hard alloys require more frequent annealings than do very soft alloys, which are much more malleable. The soft alloys are melted at a low temperature and then gradually cooled, and this produces a much softer mixture than when the compounds are suddenly chilled. The same remarks entirely apply to annealed gold and silver ingots and their subsequent cooling during the process of rolling or "breaking" down at the rolling mills. In a properly prepared mixture the molecules of metal should be uniform in all parts, and these should be so crushed one into another during the rolling that the grain is not only made considerably finer, but that the exterior should consist of the same homogeneity to prevent fire-cracking when the metal comes to be annealed. Gold alloys are made harder or softer according to the respective percentages of silver, of copper, or of other metals used as adulterants, and the rolling should be temporised and extended in conformity with their degrees of hardness, or of softness, if the natural physical qualities resulting from the melting are to be

retained throughout the process. Too much rolling, without being several times annealed between the operation, will spoil the best melted ingots, for rolling strains the ultimate particles or molecules of the mass in proportion as the stress is continued, but the strain is released during the annealing, and the metal will then return to its normal condition again, and be fit for the next strain or pressure of the rolls, without incurring the slightest injury therefrom. Annealing at too high a temperature is also injurious, for at a red heat, copper, or other base metals, quickly becomes oxidised, and a scurf is produced on the surface, which results in a loss of the weight of metal sent for rolling, a loss which should never take place when the allied processes of rolling and annealing have been skilfully conducted under proper conditions.

ANNEALING.—This is a process whereby metals recover their softness after being rolled, stamped, drawn, or otherwise manipulated, which renders them hard and brittle. In annealing gold and silver alloys an even heat should be maintained in the muffle or oven, and the metal should receive the same temperature throughout, and not only on the surface. The degree of temperature in the muffle should only be such as to show a low red heat on a bar of gold or silver when placed in a dark place, as a test for ascertaining the degree of heat they may have received. Overheating in annealing is injurious. Gold and silver mixtures become harder after each passage through the rolls, and unless frequent annealings were indulged in during the process, would soon lose their malleability and ductility, and would split and crack in a manner such as would render them absolutely unworkable. Annealing at a low red heat in a muffle specially arranged for the purpose, and then cooling slowly, brings back their malleability and other physical properties to metals which have become hard and brittle by rolling, hammering, drawing, or other devices resorted to in working. When ingots are soft from recent annealing they will stand very considerable reduction in thickness on each subsequent pass through the rolls, particularly at the start, but the draught should be somewhat reduced, as they gradually become hard, to avoid cracking, and the displacement of the molecular arrangement of the atoms of the different mixtures, for when once these are displaced it is a difficult matter, even in the hands of the most experienced workmen, to restore the metal to good working condition

again without its being remelted. By annealing at the proper periods, the internal strains given to the mixtures by rolling are relieved, and the structure of the metal is again altered to its former condition; but the application of too high a heat in annealing—the same as in melting—likewise changes the character of an alloyed gold mixture, and the effect of overheating is so far noticeable as to be said that it is *burnt*, and this very much lowers its malleability, and still further its ductility and tenacity, by bringing about a certain form of brittleness, therefore the annealing, as well as the rolling, requires care and judgment in its performance to maintain the correct working properties of the metal; overheating causes the metal to lose toughness, and this is an essentially requisite qualification confined to the utility of some alloys, for it sometimes enables the artisan worker to produce a large number of articles of a given pattern, with less expenditure of time and labour than would be the case if the materials upon which he was engaged had been overheated in the annealing.

Overheating in annealing also causes a loss of metal, particularly in the lower qualities of gold alloys, owing to their being prepared too largely from the baser metals, copper, and composition, and to wrongly constructed muffles, in which the annealing takes place. Overheating in annealing in badly arranged muffles causes scurf to rise on the surface of the metal, through the base metals being too strongly acted upon by the hot air and flame of the muffle, without any protecting influence to safeguard their oxidisation, like the precious metals themselves bestow in the higher standards, for in all cases the base metals are first acted upon, but when the alloys are rich in the proportions of gold they contain, a certain protective influence is always given to the baser elements of alloy. The theory of the process of annealing is little understood, but it may be defined as the releasing of the strain in metals produced by mechanical treatment, such as rolling, hammering, or wire-drawing, whereby the series of atoms are hardened by compression, and that the application of heat to hardened metal produces a remarkable molecular change in its structure by softening its molecules so as to enable those processes to be again repeated without injury to the metal under treatment, the exact nature of the change depending on the composition of alloy, and on the previous treatment it had undergone in the mechanical processes, as to whether

it receives its full measure of success or otherwise. The operation of annealing with gas is more injurious to gold and silver alloys than with either coal or coke fires, and were it not for the extra cost of the material, the latter is to be preferred, as being the least injurious when good hard coke is used for heating the muffle. Gas annealing causes sulphur fumes to be emitted, a portion of which combines with the base metals used in alloying the different compound mixtures, copper uniting directly with sulphur when heated, forming the sulphide of the oxide of copper, and this causes brittleness and extra loss in the weight of metal from oxidisation when, after rolling, gas annealing is adopted in preference to the older and better methods. Silver will also unite with sulphur when annealed in its fumes; but more to follow.

ANNEALING CONTINUED.—As there are different degrees of hardness in the various preparations of goldsmiths, according to the component parts of the different metals used and to their mode of fusion, some of these may become so hardened in the rolling as to almost reach breaking strain, but the original softness may generally be restored, and in some cases improved upon, by heating the metal to a temperature best suited to the mixture under treatment and allowing it to cool slowly without plunging it into a cooling liquid of any kind. Bad and insufficient annealing, that is a term I will describe as half-annealing, by not continuing the heat long enough to penetrate beneath the surface, will destroy the malleability and other physical properties of most alloys, if again passed through the rolls in the partly softened condition, for if this was done, the molecules beneath the surface, being much harder than those on the surface, would cause the metal to crack and split badly during subsequent rolling. Very bad gold, caused by impurities in the alloying materials and overheating in the melting, should be annealed after every pinch of the rolls, which in most cases should be heavy, and this procedure will generally restore the much desired properties for working. Too high temperature in annealing also alters the structure of most alloys used in goldsmithing as to be especially injurious by assuming with some of them the form of a frizzled surface, and this entirely alters the character of the metal that the surface becomes perished or burnt, whereby its nature is destroyed, and this is the more observable in common gold alloys in which an extra quantity of silver is used to prepare

them to stand the nitric acid test, than in those containing nearly all copper as the alloying material.

Gold-silver alloys, if overheated in annealing, fuse much more easily than gold-copper alloys; they are, however, much harder and more elastic in some of the standards employed for goldsmiths' work, and require to be repeatedly annealed to retain, during rolling, their full physical properties. Care should be bestowed in the annealing of such mixtures so as not to frizzle the surface. The right temperature in annealing correctly relieves the internal strains put upon the metal in rolling, or other devices employed for its reduction, which renders it much easier to work. Overheating tends to lower the tenacity of an alloy, whilst if it is frizzled, it hardens the surface so much as to reduce its power of extension to much below the usual limit. The remedy for this would be to again slowly anneal, but not so hot as before, allow to cool slowly, roll lightly, again anneal, and slowly cool; proceed in this manner until the metal has regained its former elasticity, and this is indicated to the experienced workman by the peculiar nature of the rebound when the metal is slightly bent, which is entirely different to the snapping or breaking strain of brittle and overwrought metal. By following this device it is oftener possible than not to restore over-annealed metal to its proper condition again if the operations are skilfully carried out. The more a gold or silver alloy is worked without annealing, the harder it becomes, and the less easy the manipulations appear to the craftsman as he proceeds with his work, until at last the metal begins to crack or break; he then thinks it time to anneal his material when the damage is done. If more attention was paid to the points I have laid down, much less scrap metal would be returned to the melting-pot, and much wasted time and labour would have been saved. Gold-silver alloys, also gold-composition and gold-spelter alloys, require to be more frequently annealed during the rolling than do gold-copper alloys, for the reason that they become sooner hard under the pressure given, and the original softness of the former can only be retained by being more frequently annealed during all the manipulatory stages. Frequently in annealing 9-carat alloys a copper scale is formed on the surface, and this copper scale is increased in quantity the lower the grade of the standard when prepared with a preponderance of copper. Copper scale is the black oxide of copper, CuO, which forms on the surface of inferior

gold alloys when they are heated to a red-heat, and is caused by the oxygen of the hot air playing within the muffle uniting with the base metal to form oxide. The scale on low-quality alloys is dead black in colour, and when the metal is cooled off after annealing, if bent, it will be observed that a scurf-like substance is emitted from the surface in the form of dust or fine scales, and this reduces the weight of the ingot of gold every time the metal is annealed. Gas annealing, and also overheating, causes an increased proportion of this scale to arise, therefore both operations are rendered more wasteful than low heating in a suitably arranged muffle which does not admit of an excess of atmospheric air, for when a coppery gold alloy is heated with access of air, and the heating is prolonged, it will be found that the oxide which is formed on the surface is much thicker and easily peels off, but when the annealing is effected at a low red-heat, after a short heating it will be found that the metal is smooth, but uniformly black, and that no scale has been produced. These alloys turn black as soon as a low red-heat is reached, and they are then sufficiently annealed for every purpose of the goldsmith and jeweller. The smooth black coating, unlike the scaly surface, adheres tenaciously to the metal, and cannot be removed by subsequent rolling and bending, but rolls with the metal, and appears to protect the latter from subsequent oxidisation in all the stages of rolling, so that there is no loss of metal whatever when returned from the rolling mill—where this method is in operation—to the manufacturer. No pickling is required. We are sometimes told that a loss of 7 dwt. on 30 to 35 oz. is quite reasonable and cannot be avoided in rolling ingots of 9-carat gold. This in two cases has been brought to my knowledge. In another case a loss of 3 dwt. on 50 oz. seemed to satisfy the owner when mentioning the matter to me, but on my informing him that there need be no loss or at most of only a few grains, and that my rolling was done without loss, he was desirous of gaining some of the knowledge which my extended experience and researches had taught me in the matter of treating alloys of the precious metals, with the view of having the "quite reasonable loss" dispensed with in the future, which is caused in the way I have indicated. Gas annealing causes more scurf to arise on the surface of sundry alloys, and consequently more waste arises. Also, the metal annealed by this process is not so soft and its pliability not so great, owing to the combination of some

sulphur with the surface of the material subjected to the sulphurous flame of the gas, and it is a well-known fact that sulphur makes gold and silver alloys brittle. Such metal also requires more polishing in finishing wares executed from gas-annealed mixtures, because the metal is always rougher in all the processes of manufacture, notwithstanding the more frequent picklings which may have been indulged in throughout the different stages of working. Gas annealing causes the surfaces of low-grade gold alloys to become rich in oxide through their rapid oxidisation by the reactions of the sulphur fumes and the conversion of the baser elements of alloy into sulphides, and these penetrate below the surface and damage the underlying metal to such an extent that difficulty, in some instances, is found in working up the metal. It is not necessary to pickle the different alloys in rolling and wire-drawing when the annealing is conducted under proper conditions as regards the construction of the muffle, the fuel employed as the source of heat, and the correct temperature applied, so as to reduce the metal to its softest state again after it has become hard, thus an unusual amount of waste may be avoided, which is much too common, and then the metal will be found smoother and work more easily in all the different technical applications incidental to the manufacture of jewellery.

Melting and Rolling Sterling Silver.—It is generally expected that no trouble will be experienced in melting and rolling sterling silver, as also the lower-grade alloys. But the operators at the furnace very often find what is not expected does really happen, and the man who heats his metal too much above the melting-point soon finds out—although he is slow to admit it—that his metal is not as good as his contemporary's, who melts and pours at a temperature just above the melting-point necessary to fuse the ingredients forming the mixture, for the latter's work usually results in good sound ingots which roll and work well in all the manipulative processes incidental to the silversmith's craft. I have heard of some operatives in charge of the melting in silversmith's manufactories making it a constant practice to continue the heating for three minutes longer after the metal has become thoroughly fused. Now, this is not necessary, and in many cases it is positively injurious, and it is a well-known fact in the brass and German silver trades that those mixtures are not as good when overheated and poured at too high a temperature as

when the medium course is adopted, and this principle holds good in the silver industry. In the preparation of a sterling silver mixture the wisest course to pursue will be to put the copper first in the crucible, then place the crystals of silver on the top, adding afterwards a little charcoal powder, so that when the silver begins to melt—this will melt before the copper—it is protected from the air and subsequent oxidisation and loss of metal, more charcoal being added as occasion requires, but it is not advisable to add too much, just enough to keep the fluid from being exposed is all that is necessary. When the fusing metal reaches a certain stage it will assume the form of a stiff paste, with sundry portions of unmelted copper intermingled therein. If the operative now takes up his wooden stirring-rod and, gently at first, moves it round and round in the nearly molten mass, he will find it a little resisting if there are still unmelted lumps of copper existing, but these will rapidly disappear as the stirring is continued, by becoming dissolved into the silver, and the mixture will then assume a watery consistency, at which stage it should immediately be withdrawn from the furnace and poured at a moderate rate into the ingot mould. The wooden stirring-rod evolves great heat within the mixture and causes any portions of unmelted copper to melt more quickly by the reactions taking place in the mixture during its immersion, which are of a heat-raising nature, and thus a more intimate mixture of the ingredients is formed, and the time somewhat shortened for the charge to remain in the furnace. The operation of melting gold and silver alloys requires careful attention to all the details appertaining thereto, and if these be attended to, the process is very much simplified, and complete satisfaction will be invariably obtained in the physical properties of the resultant metal. No flux other than the slight charcoal covering is necessary to effect the fusion of new mixtures, providing the conditions to which I have alluded are thoroughly followed and carefully carried out from the beginning to the end of the process. But when a quantity of gas has become intermingled with the molten liquid from sundry unavoidable causes, a good pinch of dried common salt put into the melting charge, followed by a good stirring, will nearly always effect a cure. The injurious effects of sulphur fumes may be corrected by the addition of a small lump of cyanide of potassium just before the pouring is to take place. Films of oxidised metal formed on the surface of the melted

mixture may be remedied, and the metal released from its oxygen by the timely application of a little boric acid. A very small quantity of each of these substances is sufficient for effecting the respective purposes, viz., the removal of injurious elements from a melting charge.

ALLOYING 9-CARAT GOLD.—When this standard gold is to be used for hall-marking purposes it is best not to employ too much spelter, or, in fact, any other base metal containing an excess of spelter as one of the alloying ingredients, to tone down the red colour of the copper and to save a portion of the necessary silver from motives of economy, for this practice sometimes leads to the smashing of the work at the Assay Offices, as too much zinc affects the cupellation process adversely in assaying. Too much spelter is therefore not good policy in the preparation of alloys intended to be hall-marked, being a very volatile metal, and partly escaping in the form of vapour, is liable to cause an appreciable loss of the other constituents of assay, thus rendering the assays different in their results as regards the exactness of the standard. They become foul in consequence of the rapid oxidisation of the zinc, and the fluidity of the lead thus becomes diminished; and from these causes it is almost impossible to keep the assays clear; a very necessary requirement to enable the standard to be reported correctly.

The theory of the variation of the assays being that the zinc having so great an affinity for oxygen, it oxidises along with it some portions of the precious metals, and these having been extracted with the base metals by the bone-ash composing the cupel, the remaining bead of the precious metals invariably suffers in weight as a natural consequence, and falls short, more or less, of the requisite fineness to complete the standard.

ROLLING MILL ANNEALING MUFFLE.—This muffle differs considerably from the annealing muffles in use by goldsmiths and jewellers in their manufactories, which are well known to every worker, a detailed description of these, therefore, is unnecessary here, but the mill muffle, being differently constructed, calls for a few particulars regarding its arrangement. This muffle varies in dimensions in different rolling mills in accordance to the volume of work which has to pass through it. The usual dimensions, however, for ordinary work are about 12 to 15 ft. long, and about 5 or 6 ft. wide for the outside measurements. The inside of the muffle in which the work is placed for annealing is about

6 ft. long and 3 ft. wide, that is, it is capable of receiving an iron pan of about those dimensions, on which the work is placed to facilitate its admission and removal to and from the muffle. This is done by withdrawing the iron pan by means of a long pair of tongs, the work being taken off the pan, when sufficiently annealed, by the same pair of tongs, and placed on the bricked floor of the annealing shop to cool, and then another batch of work is placed on the pan, the pan is then pushed back into the muffle, and the door (which is of iron) closed. The iron pan is turned up a few inches on one side, usually the left, and against this turned-up edge the smaller pieces of gold and silver are placed as a safeguard from their slipping off the pan. The accompanying

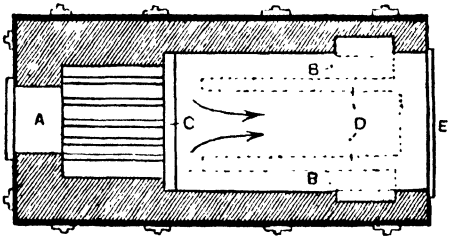

FIG. 21.—Section of an Annealing Muffle.

sketch fully illustrates the principle on which this muffle works.

The muffle is built of ordinary brickwork D, and is lined throughout with firebricks, the outside being covered over with iron plates about $\frac{3}{8}$ in. thick, and the whole bolted together with T-irons, the rods being secured by nuts, as shown. This application gives the muffle much longer service without repair. The height of the muffle-bed from the floor level is about 3 ft. at the muffle door end E, and slightly more elevated at the bridge end C. The inside of the muffle is about 2 ft. deep, a little more than 6 ft. long, and a trifle over 3 feet wide, so as to allow of the easy play of the aforesaid iron pan in its action in conveying the work to and from the muffle. The fire-bridge C, for a muffle of the above dimensions, would be about 1 ft. 4 in. of the height of the inside of the muffle. The fire is kindled on the grate at A, and the heat and flame passes over the fire-bridge C, along the top of the muffle, through the two openings marked B, at the sides near the front of the muffle, then

turns underneath the muffle, running its full length on both sides, again turns at the bridge end, and this time passes straight under the middle of the muffle, thus heating the muffle in every part. The waste heat ultimately passes down into the flue, and finally into the chimney-stack. An ordinary jeweller's muffle is usually built in one of the chimneys of the manufactory, and consists of an aperture 12 in. long, 10 in. deep, and 10 in. wide, lined with firebricks, a narrow opening for the flue being provided at the top just inside the door, not at the back, which cause the flames to be brought over the work. A draught-hole to admit the air, 10 in. square, is provided about 12 in. underneath the actual muffle, to which it is advisable to have a door for regulating the draught according to requirements.

Regarding the loss of gold in mill rolling, a manufacturer requests me to state if my previous remarks on the subject apply to the thin sizes which are in general use, or only to the thick sizes used for wire-drawing. My answer is to all sizes. I am informed that his loss only begins when it gets thinner in the rolling, and amounts to 1 dwt. on every 10 oz. Now this may be caused through the pickling of gold every time after it is annealed, and this detaches small portions of copper from the surface, and so reduces the weight. It is a common belief among some mill rollers that it is absolutely necessary to pickle thin gold and silver before it can be again passed through the rolls, the desired object being to remove fire marks and oxidisation, but a little thought given to the subject will at once knock both these projects on the head, for in nearly every case, when the precious metals reach a certain stage in the rolling, they are rolled up into coils and put into the muffle in that form, so that there is little actual surface for the flame of the muffle fire to get at, further than that of the outside. Very little oxidisation can therefore take place, and this is more of the nature of a glaze, and rolls with the metal without detriment to it, or to the rolls, as commonly supposed. I have had rolling done down to the thinnest possible sizes, and have thoroughly investigated the matter in every possible way, with the view of a correct solution of the difficulty, and I have arrived at the aforesaid conclusion. It is a universal practice for the roller to cut off the pointed ends of the strips of flat metal (or ribbons, as they are sometimes called) after reaching a certain thinness, to enable them to take the rolls evenly by presenting a broader end, and so avoid puckering,

and it is possible all these ends are not returned into the mill warehouse with uniform regularity when the loss is heavier through a little carelessness in some of the duties of the mill hands. There is no need for pickling in rolling down to any stage, providing the alloy is right, and the right heat is given in annealing. The precious metals only require heating to a low red-heat for the annealing to be most effectively performed, but the conditions of the flame and the sources of heat have a lot to do with rolling-mill losses, and unless these are carefully attended to I fear rolling-mill losses will still continue to be recorded as heretofore, for it is not always safe even to take the opinions of most practical workmen without any scientific training, a careful technical study being essential to the solution of the manifold obstacles invariably met with in precious-metal working.

CHAPTER XXV

TABLE TO CONVERT PENNYWEIGHTS AND GRAINS INTO DECIMALS OF AN OUNCE, WITH TABLE OF 8½-CARAT GOLD ALLOYS

HAVING now pointed out most of the difficulties arising in the melting of gold and silver alloys of the better standards, not omitting the causes which lead up to them, and also having provided the workers with simple remedies for safeguarding and correcting those defects in a plain manner which cannot fail to be helpful to the successful practice

Grains.	Decimals.
½	·001
1	·002
2	·004
3	·006
4	·008
5	·010
6	·012
7	·015
8	·017
9	·019
10	·021
11	·023
12	·025
13	·027
14	·029
15	·031
16	·033
17	·035
18	·037
19	·040
20	·042
21	·044
22	·046
23	·048
24	·050

Pennyweights.	Decimals.
1	·050
2	·100
3	·150
4	·200
5	·250
6	·300
7	·350
8	·400
9	·450
10	·500
11	·550
12	·600
13	·650
14	·700
15	·750
16	·800
17	·850
18	·900
19	·950
20	1·000

Example.

Express ·354 oz. in dwt. and gr.

		Dwt.	Gr.
·300 oz.	=	6	0
·050 ,,	=	1	0
·004 ,,	=	0	2
·354 oz.	=	7	2

of the art of gold and silver working, I shall now continue the subject with a description of the distinctive qualities of the lower standards, giving their component parts and the uses for which they may be variously employed. These consist of no particular standard, and are manufactured to suit the various markets of the world. Their fineness can only be ascertained by an assay. I commence the new departure by recording on p. 313 a table of decimals, showing how to convert pennyweights and grains into their respective decimals of an ounce, as these weights are now compulsory in the jewellery trade.

In adding decimal quantities together, it is absolutely necessary to keep the decimal points in a straight line one under the other, as shown, or mistakes will occur.

Table of 8½-Carat Gold Alloys

No.	Gold.	Silver.	Copper.	Compo.	Spelter.	Total.	Remarks.
1	·354	·075	·571	...	...	1·000	Red Gold.
2	·354	·575	·071	...	...	1·000	Green Gold.
3	·354	·100	·271	·275	...	1·000	Yellow Gold.
4	·354	·088	·400	·158	...	1·000	Deep Yellow Gold.
5	·354	·646	...	...	...	1·000	White Gold.
6	·354	·571	...	...	·075	1·000	Bluish-White Gold.
7	·354	·083	·563	...	...	1·000	Spinning Gold.
8	·354	·171	·425	·050	...	1·000	Bright Gold.
9	·354	·212	·434	...	...	1·000	Bright Locket Gold.
10	·354	·300	·309	·037	...	1·000	Enamelling Gold.
11	·354	·275	·334	·037	...	1·000	Enamelling Gold.
12	·354	·200	·421	...	·025	1·000	Bright Gold.
13	·354	·104	·542	...	...	1·000	Brooch Stamping Gold.
14	·354	·125	·446	·075	...	1·000	Ring Gold.
15	·354	·083	·500	·063	...	1·000	Stamping Gold.
16	·354	·133	·438	·075	...	1·000	Bracelet Gold.
17	·354	·062	·546	·038	...	1·000	Tube Gold.
18	·354	·087	·492	·067	...	1·000	Spring Tube Gold.
19	·354	·400	·246	...	...	1·000	Pale Polishing Gold.
20	·354	·125	·421	·100	...	1·000	Rich Brown Gold.
21	·354	·100	·460	·086	...	1·000	Curb Gold.
22	·354	·150	·471	...	·025	1·000	Bright Gold.
23	·354	·137	·484	...	·025	1·000	Deep Yellow Gold.
24	·354	·131	·265	·250	...	1·000	Palish Yellow Gold.
25	·354	·050	·596	...	...	1·000	Red Chasing Gold.
26	·354	·250	·390	...	·006	1·000	Bright Bright Gold.
27	·354	·450	·196	...	...	1·000	Setting Gold.
28	·354	·425	·221	...	...	1·000	Setting Gold.
29	·354	·300	·304	·042	...	1·000	Transparent Enamelling Gold.
30	·354	·067	·579	...	...	1·000	Red Enamelling Gold.

All the compos are No. 4 in the table of compo metals for alloying gold.

In the foregoing 8½-carat gold table will be found alloys suitable for every class of work in every branch of the precious-metal trades, and with one or two exceptions they can easily be worked by the ordinary workman, no particular skill being required above that necessary to the most commonplace alloy. The exceptions are Nos. 3 and 24, and when using these alloys, care must be taken in annealing not to heat them too hot, and also not to shake them while at a dull red heat, or they will be liable to crack and break asunder. This is the only special care that is required; if the gold ingots have been well prepared in all other respects, their capacity for working is all that could be desired.

The compo used in the preparation of the aforesaid alloys was what is known as citron composition, and is No. 4 in my table of composition metals for alloying gold, consisting of two-thirds copper and one-third spelter.

The 8½-carat alloys I have described are melted together in the same way as before explained in dealing with the 9-carat alloys, but require to be more carefully melted on account of the greater proportion of copper used, which is the more likely to become oxidised, and this oxidisation is the very worst obstacle you will have to contend with in rendering these alloys free from workable defects. However, I have already provided the operatives with the best safeguards, in the exhaustive descriptive matter relating to the 9-carat alloys, which, if followed in its entirety, will be found the least troublesome in the end, in effecting good work.

CHAPTER XXVI

THE next quality of alloys to be considered is the $8\frac{1}{4}$-carat gold :—

Table of $8\frac{1}{4}$-Carat Gold Alloys

No.	Gold.	Silver.	Copper.	Compo.	Spelter.	Total.	Remarks.
1	·344	·081	·575	...	...	1·000	Red Gold.
2	·344	·500	...	·156	...	1·000	Green Gold.
3	·344	·550	·106	...	...	1·000	Green Gold.
4	·344	·287	·369	...	...	1·000	Enamelling Gold.
5	·344	·206	·425	...	·025	1·000	Bright Gold.
6	·344	·300	·300	·056	...	1·000	Transparent Enamelling Gold.
7	·344	·100	·556	...	...	1·000	Spinning Gold.
8	·344	·237	·369	·050	...	1·000	Bright Bright Gold.
9	·344	·125	·531	...	...	1·000	Brooch Alloy.
10	·344	·133	·452	·071	...	1·000	Bracelet Alloy.
11	·344	·087	·500	·069	...	1·000	Stamping Alloy.
12	·344	·100	·556	...	...	1·000	Curb Gold.
13	·344	·125	·381	·150	...	1·000	Yellow Gold.
14	·344	·050	·525	·081	...	1·000	Soft Tube Gold.
15	·344	·175	·481	...	...	1·000	Hard Spring Gold.
16	·344	·150	·469	...	·037	1·000	Belcher Chain Alloy.
17	·344	·300	·306	...	·050	1·000	Pale Polishing Alloy.
18	·344	·500	·106	...	·050	1·000	Green Gold.
19	·344	·094	·487	...	·075	1·000	Lustrous Bright Gold.
20	·344	·125	·131	·400	...	1·000	Rich Yellow Gold.
21	·344	·206	·438	...	·012	1·000	Rich Bright Gold.
22	·344	·083	·490	...	·083	1·000	Bright Yellow Gold.
23	·344	·075	·581	...	...	1·000	Red Chasing Gold.
24	·344	·087	·569	...	...	1·000	Red Enamelling Gold.

No. 2 in the table of compo metals for alloying gold. All the other compos are No. 4 in the table of compo metals for alloying gold.

In melting these alloys, charcoal should be put into the crucible with the mixed metals, and more added when the melting of them begins to take place, and if care is observed to keep the different mixtures at all times covered with charcoal, and, therefore, completely protected from the gases of the fire, the workable qualities of the resulting ingots of gold, or of silver, will be much better than they would be were any of the compound mixtures left more or less exposed

to air currents, etc., while in the melted condition. Many ingots of the precious metals have been spoiled by not complying with this rule, and the point expressed should always be strictly observed as one of the fundamental principles of melting. Lack of sufficient charcoal on these low-quality alloys is one of the causes of blow-holes, which come from gases absorbed while the metal is being melted, and are given out again (though not always) when the ingots are cooling, after being cast. Overheating the mixtures, as also continuing them in the fire after fusion has been effected, are contributory causes.

Some practitioners make it a rule to boil their metal before pouring. This is a bad practice in melting the precious metals, no matter what grade of standard they may consist of, for the hotter the metal is got the more gases will be absorbed, and, consequently, the more blow-holes will ultimately be found in the metal when it comes to be worked up. Boiling metals after being melted causes them to suck in gases with greater rapidity than is the case when their fusion has been effected at a much lower temperature. Let it therefore always be borne in mind that the hotter a mixture is made during fusion the more susceptible it is to gaseous matter, and that the lower-grade alloys are more adversely affected, in consequence of the large proportion of copper they contain, than are those of a higher grade of standard containing less copper in their composition.

The alloy No. 20 in the above series is a handsome gold colour, and requires to be treated with care while it is hot, otherwise it will fly and crack in a manner peculiar to all gold mixtures containing an excess of spelter, the distinguishing features of which, and the mode of working, I have already explained. The next alloy is the 8 carat.

CHAPTER XXVII

Table of 8-Carat Gold Alloys

No.	Gold.	Silver.	Copper.	Compo.	Spelter.	Total.	Remarks.
1	·333	·117	·500	·050	...	1·000	Red Gold, Gilding.
2	·333	·117	·550	...	...	1·000	Another Red Gold.
3	333	·560	·107	...	...	1·000	Green Gold.
4	·333	·125	·267	·275	...	1·000	Yellow Gold.
5	·333	·200	·217	·250	...	1·000	Pale Yellow Gold.
6	·333	·200	·383	...	·084	1·000	Another Pale Gold.
7	·333	·100	·467	...	·100	1·000	Bright Gold.
8	·333	·133	·284	·250	...	1·000	Brooch Stamping Gold.
9	·333	·150	·467	...	·050	1·000	Locket Gold.
10	·333	·133	·534	...	...	1·000	Soft Stamping Gold.
11	·333	·442	·225	...	...	1·000	Acid Resisting Gold.
12	·333	·400	·125	·142	...	1·000	Stands Nitric Acid.
13	·333	·225	·242	·200	...	1·000	14-Carat Colour.
14	·333	·134	·458	...	·075	1·000	Rich Bright Gold.
15	·333	·134	·450	...	·083	1·000	Another Bright Gold.
16	·333	·217	·450	...	...	1·000	Hard Gold.
17	·333	·125	·292	·250	...	1·000	Bracelet Gold.
18	·333	·300	·330	...	·037	1·000	Pale Polishing Gold.
19	·333	·167	·450	·050	...	1·000	Deep Yellow Gold.
20	·333	·137	·230	·300	...	1·000	Bright Yellow Gold.
21	333	·417	·250	...	...	1·000	Acid Resisting Gold.
22	·333	·667	...	...	...	1·000	White Gold.
23	·333	·075	·550	·072	...	1·000	Soft Tube Gold.
24	·333	·350	·267	·050	...	1·000	Enamelling Gold.

All the compos are No. 4 in the table of compo metals for alloying gold.

These alloys are used in the manufacture of jewellery of the commoner kind, and are sold under the name of "bright gold," a description representing no particular standard, as they are below the lowest alloy marked by the assay authorities. The various mixtures are melted, as before described, the gold, silver, copper, and compo (when that metal is used) being put into the crucible in the reverse order as they appear above, and a spoonful of charcoal powder placed on the top; and this protects the metals from injurious effects as they sink down in the crucible under the heat of the furnace fire. The spelter, when that is preferred, is added to the fused mixture at the last moment,

and the mass should then be quickly stirred and withdrawn from the fire without delay to prevent volatilisation of the spelter and the production of faulty gold. When any of these alloys are well melted, a teaspoonful of sal-ammoniac powder strewed over the surface will greatly add to their toughness and benefit in working, by causing any deleterious substances in the metals used for alloying to be converted into chlorides, and these are either rendered volatile or are retained in the charcoal to the advantage of the mixed alloy of gold resulting from the process. These alloys can be wrought and worked like the other alloys which have preceded them, and are, most of them, soft and ductile.

CHAPTER XXVIII

THE next alloys to be described in continuation of this subject are the $7\frac{1}{2}$ carat; they consist as follow :—

Table of $7\frac{1}{2}$-Carat Gold Alloys

No.	Gold.	Silver.	Copper.	Compo.	Spelter.	Total.	Remarks.
1	·312	·150	·538	...	...	1·000	Red Gold for Gilding.
2	·312	·100	·588	...	...	1·000	Red Gold for Chasing.
3	·312	·575	·113	...	...	1·000	Green Gold.
4	·312	·113	·300	·275	...	1·000	Yellow Gold.
5	·312	·688	...	...	...	1·000	White Gold.
6	·312	·613	...	...	·075	1·000	Bluish White Gold.
7	·312	·400	·250	·038	...	1·000	Enamelling Gold.
8	·312	·200	·425	·063	...	1·000	Bright Locket Gold.
9	·312	·183	·442	·063	...	1·000	Another Locket Gold.
10	·312	·175	·363	·150	...	1·000	Fine Bright Gold.
11	·312	·175	·363	·100	·050	1·000	Very Fine Bright Gold.
12	·312	·163	·525	...	...	1·000	Curb Gold.
13	·312	·163	·450	·075	...	1·000	Another Curb Gold.
14	·312	·163	·508	...	·017	1·000	Tough Gold for Wire.
15	·312	·200	·457	...	·031	1·000	Bright Bright Gold.
16	·312	·250	·425	...	·013	1·000	Stands Nitric Acid.
17	·312	·250	·400	·038	...	1·000	Stands Nitric Acid.
18	·312	·169	·469	·050	...	1·000	Ring Gold.
19	·312	·400	·288	...	...	1·000	Pale Polishing Gold.
20	·312	·313	·375	...	...	1·000	Rich, Lasting Bright Gold.
21	·312	·200	·475	...	·013	1·000	Bracelet Gold.
22	·312	·350	·338	...	...	1·000	Transparent Enamelling Gold.
23	·312	·300	·388	...	...	1·000	Another Darker Gold.
24	·312	·275	·413	...	...	1·000	Pin Stem Gold.
25	·312	·238	·375	·075	...	1·000	Polishing Gold.

All the compos are No. 4 in the table of compo metals for alloying gold.

When using spelter as a separate metal in compounding these alloys, it must not be added to the contents of the crucible until the other metals are in a complete state of fusion, and then it must be introduced as rapidly as possible, having previously heated it nearly to the melting-point by holding it with the tongs over the mouth of the crucible, or by any other convenient means to prevent burning

and loss of spelter by volatilisation, and also to avoid the chilling of the already-fused metals in the pot. By adopting the precautionary measure of heating the spelter, a too-rapid cooling of the other metals need not be feared, and they will remain thinly fluid after the introduction of the spelter; the wastage will be less, and the resulting gold alloy will be more uniform as regards fracture, hardness, and colour than it would be were not the preparatory heating of the spelter put into practice. Overheating the spelter, or leaving it in the fire too long, causes defective gold, by increasing the hardness of the mixture and giving other properties to the alloy entirely different from those desired. Hence it is of the utmost importance not to force the heating of the melted alloy further than is absolutely necessary after the spelter has been added to it.

These alloys are known by jewellers and goldsmiths under the name of "*bright gold*." They are much more fusible than ordinary 9-carat gold, and are used to serve the purpose of the better mixture. The public demand requires just now a cheap article, and it has it by buying a mixture consisting of a value only according to the proportion of gold it contains, and as the articles bear no official stamp of genuineness it is difficult for the purchaser to ascertain the exact standard, only by an assay. Such compound mixtures are generally harder, more high-sounding when struck, and have a greater springiness than alloys containing less silver in their composition. The lower mixtures are generally possessed of a more or less greenish-white tinge, according to the proportion of silver they contain, and by these means their quality may sometimes be adjudged, though not always, the richer gold alloys being occasionally alloyed with more than the accustomed proportion of silver, when required for special purposes; and these will then show a much lighter colour when the articles are finished to a bright finish, that is, not electro-gilt, but buffed and rouged as the final process to the work. There are still lower alloys than those above-named used in the goldsmith's art and in the manufacture of jewellery, some of which I will proceed to describe.

CHAPTER XXIX

THE next alloys are the 7 carat, or ordinary common bright gold ; these are given in the following table :—

Table of 7-Carat Gold Alloys

No.	Gold.	Silver.	Copper.	Compo.	Spelter.	Total.	Remarks.
1[1]	·292	·292	·416	...	...	1·000	Locket Gold.
2	·292	·333	·375	...	...	1·000	Acid-Resisting Gold.
3	·292	·225	·483	...	...	1·000	Sovereign Purse Gold.
4	·292	·250	·420	·038	...	1·000	Deep Bright Gold.
5	·292	·300	·408	...	...	1·000	Bright Gold.
6	·292	·250	·458	...	...	1·000	Dark Bright Gold.
7	·292	·275	·433	...	...	1·000	Yellowish Tinge.
8	·292	·325	·383	...	...	1·000	Stands Nitric Acid.
9	·292	·300	...	·408	...	1·000	Lustrous Bright Gold.
10	·292	·300	·308	·100	...	1·000	Another Bright Gold.
11	·292	·300	·375	...	·033	1·000	Fine Bright Gold.
12	·292	·337	·334	·037	...	1·000	Enamelling Gold.
13	·292	·283	·425	...	...	1·000	Curb Gold.
14	·292	·275	·433	...	...	1·000	Another Curb Gold.
15	·292	·708	...	...	...	1·000	White Gold.
16	·292	·600	·108	...	...	1·000	Green Gold.
17	·292	·362	·346	...	...	1·000	Hard-Spring Gold.
18	·292	·400	·296	...	...	1·000	Common Pen Gold.
19	·292	·287	·384	...	...	1·000	Bright Bright Gold.

[1] No. 1 compo in the table of compo metals for alloying gold. All the other compos are No. 4 in the table of compo metals for alloying gold.

All these alloys, in the working, will require to be more frequently annealed, both in the " breaking down " at the rolling mill and also in the different stages of manipulation to which they are subjected in the manufacturers' workshops, or they will become too hard and crack out on the edges, for an extra degree of hardness is imparted to the gold alloyed in this manner, which adapts the articles made from such metal to stand hard wear ; they are therefore largely used for cheap jewellery in Birmingham in the manufacture of such articles as lockets, pendants, sovereign purses, studs, bracelets, pins, brooches, sleeve-links, cheap rings, and numerous other articles of an inexpensive nature,

when quantity rather than quality is desired, such mixtures of gold being always used as a substitute for a better alloy. The increased proportion of silver used in these alloys is to enable the articles manufactured from them to stand the aqua-fortis test, for without the extra silver to protect the copper, the metal would boil up green on applying the acid to the surface, and cause the wares to exhibit all the appearance of having been made from base metal. Such mixtures require extra care in annealing and in soldering, on account of their easy fusibility, or they will become frizzled and partly perished by the heat, they having a much lower melting-point than 9-carat alloys proper; and judgment must be used by workmen as to the proper periods for annealing their work, as this must always be done at the proper time, or the gold mixture will become too hard for successful working, and they will find, as the reducing process proceeds, if the annealing is neglected the gold will become brittle, and ultimately crack and break to pieces; then probably the alloy, and if not that, the melter, will be blamed for a perplexity entirely of their own bringing about, which they have caused through errors in the manipulatory processes.

I have already stated that there is a difficulty in soldering these common gold alloys not experienced with the ordinary 9-carat alloys, on account of their easy fusion (they fuse at a very low heat), and easy-running silver solder must be used in soldering the parts together to prevent warping, and also the sweating or scorching of the metal. There are no "hall-marks" for these alloys; nothing below 9-carat is "hall-marked," so that the purchaser may be buying anything between 6 carat and 9 carat, unless he deals with a respectable firm of known reputation for the quality of its wares. A fine, bright appearance of a lasting nature can be imparted to most of the alloys in the tables annexed when "bright finished," that is, rouged and buffed, and not electro-gilt, with the gilding left on as the final finishing operation to the work. There is no special difficulty in melting these low alloys that calls for more than general comment. The large proportion of silver used in their composition protects the copper, in a measure, from oxidisation, and if the mixtures are not overheated in the melting, and also in the annealing (all that is required in carrying out this operation is a low, red heat), they will stand all ordinary methods of treatment to which jewellers' golds are subjected, without injury to any subsequent manipulation to which

they may be required to be put. The precautions referred to, when heating the higher alloys, in a previous part of this subject, apply equally to these alloys of a lower grade of quality; but I would here further urge the advisability not to let any dross, should it form on the surface of the fused metal in the crucible, run with the metal when pouring into the ingot mould; any little carelessness in this respect will often cause defective ingots of gold. The dross and charcoal may readily be kept back from passing into the mould with the gold, by filing a hollow in the lip of the crucible and holding above it, with the left hand, a thin piece of flat wood, letting the gold run through the hollow beneath in a clear and uninterrupted stream into the mould.

CHAPTER XXX

THERE are intermediate alloys largely used between the respective standards I have given, but as these will be tabulated in a separate chapter, I will now proceed to the next, as the term goes, lower alloys; they are the $6\frac{1}{2}$-carat alloys.

Table of $6\frac{1}{2}$-Carat Gold Alloys

No.	Gold.	Silver.	Copper.	Compo.	Spelter.	Total.	Remarks.
1	·271	·150	·579	...	...	1·000	Red for Chasing.
2[1]	·271	·175	·554	...	...	1·000	Red for Gilding.
3	·271	·200	·329	·200	...	1·000	Yellow Gold.
4	·271	·250	·454	...	·025	1·000	Rich Yellow Gold.
5	·271	·350	·379	...	...	1·000	Acid-Resisting Gold.
6	·271	·325	·379	...	·025	1·000	Acid-Resisting Gold.
7	·271	·337	·392	...	...	1·000	Locket Gold.
8	·271	·300	·429	...	...	1·000	Stamping Gold.
9	·271	·679	...	...	...	1·000	White Gold.
10	·271	·575	·104	...	·050	1·000	Green Gold.
11	·271	·654	...	...	·075	1·000	Bluish White Gold.
12	·271	·325	·404	...	...	1·000	Enamelling Gold.
13	·271	·400	·329	...	...	1·000	Pale Polishing Gold.
14	·271	·350	·229	·150	...	1·000	Bright Lustrous Gold.
15	·271	·271	·458	...	...	1·000	Deep Bright Gold.
16	·271	·300	·429	...	...	1·000	Good General Alloy.
17	·271	·275	·454	...	...	1·000	Another.
18	271	·300	...	·429	...	1·000	Fine Bright Gold.
19	·271	·220	·472	·037	...	1·000	Alloy for Jobbing.

[1] No. 2 compo in the table of compo metals for alloying gold. All the other compos are No. 4 in the table of compo metals for alloying gold.

With regard to the alloys Nos. 1 and 2, for gilding, by gilding is meant the electro-depositing of pure gold on the surface of the finished articles to hide the coppery appearance they would otherwise present with so great a preponderance of copper alloy; and the amount of the pure gold deposited is so small, as a rule, as not to make any difference to the cost of the alloys. In fact, if it did make much difference by an extra deposit of gold being given to the articles, that is amply covered by the saving in the amount of the

silver used in the preparation of the alloys, less silver being employed than in the ordinary mixtures. The working facilities are also greater when less silver is used than when the opposite is the case, for silver has a great tendency to harden these lower-grade alloys, and also to make them fuse at a much lower heat, which, of course, increases the difficulty of soldering, especially with delicate and intricate work. The chief object in using so large a proportion of silver in the preparation of these alloys, over and above that employed in the higher-grade ones, is because it is a trade necessity of considerable value in distinguishing the metal from base imitations of gold-coloured metals, from its providing a resistance to the nitric acid test of the jeweller, for without a certain extra proportion of silver being incorporated in these low-grade mixtures, the resulting metal, on the application of a tiny spot of this acid, would become corroded, and a green froth appear almost immediately on the place where the spot of acid had been put, and that would give an indication as if the article was composed of base metal, and not gold at all. The silver, on being used in larger proportions in compounding low-grade gold mixtures, obviates this difficulty, and assists the gold in resisting the nitric acid test. It should be noted that the free use of silver considerably modifies the colour of both gold and copper, giving them a greenish-white tinge; but it imparts a closer grain to the metal thus compounded, which has its advantages, for it gives increased firmness, hardness, and solidity to gold mixtures, and that is no doubt one of the reasons why it is employed at various degrees of fineness for different kinds of jewellery work, and which has brought such mixtures within the range of practical utility. Gold alloys have a further downward tendency in fineness for various purposes in goldsmithing, and the table on next page shows the composition of various kinds of 6-carat gold alloys, which have been proved to be of practical service.

CHAPTER XXXI

Table of 6-Carat Gold Alloys

No.	Gold.	Silver.	Copper.	Compo.	Spelter.	Total.	Remarks.
1	·250	·300	·450	...	...	1·000	Elastic Gold.
2	·250	·400	·350	...	...	1·000	Acid-Resisting Gold.
3	·250	·350	·400	...	...	1·000	Locket Gold.
4	·250	·250	·400	·100	...	1·000	Polishing Gold.
5	·250	·425	·325	...	...	1·000	Pale Polishing Gold.
6	·250	·325	·400	...	·025	1·000	Bright Gold.
7	·250	·750	...	...	...	1·000	White Gold.
8	·250	·600	·100	·050	...	1·000	Green Gold.
9	·250	·275	·475	...	...	1·000	Enamelling Gold.
10	·250	·700	...	·050	...	1·000	Black Gold Alloy.
11	·250	·500	·200	...	·050	1·000	Dark Green Gold.
12	·250	·342	·408	...	...	1·000	Jobbing Gold Alloy.
13	·250	·150	·600	...	...	1·000	Red Chasing Gold.
14	·250	·200	·550	...	...	1·000	Red for Gilding.

All the compos are No. 4 in the table of compo metals for alloying gold.

Most of these alloys have been compounded by the author to suit the different purposes of his numerous clients in the jewellery and precious-metal trades, and can therefore be thoroughly relied upon as being practically ductile and malleable when correctly melted, and proper attention given to the annealing of the metal at regular intervals. Many of these alloys, on account of their cheapness, possess properties which make them extremely useful, in that they provide the great masses of the people with a gold article as a substitute in place of a better standard of gold of a much more expensive nature, and which the vast majority would be unable to possess themselves of. They also find employment for a larger number of operative workmen in the precious-metal trades of this and other countries of the world than would be the case were the manufacture made illegal. In many factories it is now the custom to electro-gild the finished gold articles made from these alloys, by giving them a colour approaching that of chemically pure gold. What is called the "dry gilding," or "bright gilding,"

is much in vogue. This finish represents a peculiar brightness as if brought about by the vigorous use of the rouge buff, but instead of showing the natural colour of the gold alloy on the surface, as that process would do, a thin, but very tenacious film of pure gold is shown instead, and this film is so bright that it represents in appearance the most highly polished, or even burnished, fine gold surface; a richness is thus imparted to the finished articles which makes it impossible to distinguish them at sight from those manufactured from a superior alloy, and this richness continues in wear for some considerable time—in fact, not until the film or layer of pure gold is entirely worn away can the inferior under surface be seen. A variety of useful purposes can be served by skilful manipulation with these low-grade alloys, and as a result of the different finishes which can be imparted to the articles, a steady demand has sprung into existence for the various finishes.

No useful practical purpose will be served by giving tables of lower gold alloys than 6 carat, as they are but very seldom employed in the jewellery and goldsmithing handicrafts. As a guide, however, to determine what proportion of gold to use in various intermediary alloys, when they are required to represent a certain value, I will supply the necessary information. For instance, a customer may desire to purchase wares in which the metal of which they consist is absolutely worth a certain fixed sum per ounce, and to provide for such contingencies I annex a table of sundry alloys of gold of varying values, with a separate column of their real standard caratage.

CHAPTER XXXII

THE carat system is not usually adopted in preparing bright gold and other fancy alloys below a certain standard.

Table of Sundry Bright Gold Alloys

Carats.	Gold.	Silver.	Copper.	Compo.	Spelter.	Total.
8¾	·365	·100	·490	·045	...	1·000
8½	·354	·154	·450	·042	...	1·000
8⅜	·350	·200	·425	...	·025	1·000
8¼	·344	·216	·440	...	...	1·000
8 1/10	·337	·208	·455	...	...	1·000
8	·333	·133	·284	·250	...	1·000
7⅞	·325	·187	·438	·050	...	1·000
7 1/10	·320	·175	·505	...	...	1·000
7⅝	·316	·184	·500	...	...	1·000
7 1/20	·306	·300	·394	...	...	1·000
7¼	·300	·200	·450	·050	...	1·000
7	·292	·300	·371	...	·037	1·000
6 1/10	·287	·325	·388	...	...	1·000
6¾	·281	·237	·457	...	·025	1·000
6⅝	·275	·300	·375	·050	...	1·000
6½	·271	·325	·354	·150	...	1·000
6 3/10	·262	·350	·388	...	...	1·000
6 1/20	·256	·362	·382	...	...	1·000
6	·250	·375	·375	...	...	1·000
5 17/20	·244	·375	·381	...	...	1·000
5 7/10	·237	·350	·413	...	...	1·000
5⅝	·234	·362	·404	...	...	1·000
5½	·229	·362	·397	...	·012	1·000
5⅜	·225	375	·400	...	...	1·000
5 1/10	·221	·400	·379	...	...	1·000
5¼	·216	·375	·409	...	...	1·000
5	·208	·400	·342	·050	...	1·000
5	·208	·383	·384	...	·025	1·000

All the compos are No. 4 in the table of compo metals for alloying gold.

The proportions of silver and copper alloys may be easily varied from those in the table to suit any kind of work, as regards the colour tinge and other physical properties, by any one conversant with the mixing of metals, always bearing in mind the more silver there is in the alloy, the paler and harder the metal will be, and the more copper there

is, the darker and softer will be the result of the particular mode of mixing. The object in using so large a proportion of silver in these low-grade alloys, over those of a superior kind, has already been dwelt upon and need not be repeated.

The alloys should not be overheated in the melting, or in the annealing; in the latter a low red heat is quite sufficient, while in the former there is nothing so injurious to the metal as overheating, or burning it in the fire, as it is called, by allowing it to remain a long time in the furnace after it has become melted. This is called "soaking the mixture with heat," and is a very bad practice, and causes gas absorption, with the result that the metal is frequently inductile, spilly, and full of blow-holes; and it is a difficult matter indeed to persuade some operators who continually practise this system that it is entirely wrong. I have repeatedly seen metal allowed to remain in the fire simmering, as it were, for a considerable time after it was ready to pour, and I have often been asked to melt other persons' castings in order to see if I could restore the proper working features to the metal again, and numerous clients who have benefited at my hands can testify to the excellent results achieved in that respect. Leaving molten metal in the fire does not improve it; on the contrary, it certainly deteriorates it, and the very best metal can only be obtained by removing it from the fire as soon as it is melted sufficiently to mix uniformly and hot enough to pour into the ingot mould. These hints are repeated in reply to numerous inquiries on the subject of melting gold and silver alloys, as great diversity of opinion still exists in the jewellery trade regarding the degree of heat to which the metal should be raised before it is cast.

Various tinted gold alloys are used in high-class jewellery to give an artistic appearance to the work, and the richness of the colour produced will depend on the proportion and distinguishing characteristics of the substances used in the mixture of alloy. In some kinds of fancy work platinum is used for grey or white flowers, in others fine silver is used for the same purpose; fine gold is used for yellow flowers, while cadmium imparts a green colour to the gold, and iron or steel a grey colour. Copper gives a red tinge, and silver various tints from green to white, according to the greater or smaller contents employed. The following table gives the composition of the alloys most frequently used, with their special colours.

CHAPTER XXXIII

Table of Different Colours of Gold for Floral Work

Colour.	Gold.	Silver.	Copper.	Spelter.	Iron.	Cadmium.	Platinum.
Yellow . .	1·000	...	...	...	...	...	...
White . .	...	1·000	...	...	...	...	...
Grey . .	...	...	...	...	...	...	1·000
Pale Yellow .	·917	...	...	·083	...	...	...
Pale Yellow .	·917	...	...	...	·083	...	...
Yellow Grey .	·900	...	...	...	...	...	·100
Brown . .	·833	...	·167	...	...	...	...
Puce . .	·833	·167	...	...	...	...	...
Grey . .	·833	...	...	...	·167	...	...
Grey . .	·800	...	...	...	...	...	·200
Blue. . .	·750	...	...	...	·250	...	...
Green . .	·750	·250	...	...	...	...	...
Dead Leaf Green	·700	·300	...	...	...	...	...
Water Green .	·600	·400	...	...	...	...	...
Red . . .	·750	...	·250	...	...	...	...
White . .	·333	·667	...	...	...	...	...
Black . .	·250	·750	...	...	...	...	...
Puce . .	·800	·200	...	...	...	...	...
Brown . .	·800	...	·200	...	...	...	...
White . .	·500	·500	...	...	...	...	...
Greenish Yellow	·917	·083	...	...	...	...	...
Yellow . .	·583	·250	·167	...	...	...	...
Dark Yellow .	·583	·125	·292	...	...	...	...
Green . .	·750	·167	...	...	...	·083	...
Dark Green .	·750	·118	·090	...	...	·042	...
Pale Green .	·750	·125	...	...	...	·125	...
Red . . .	·583	·042	·375	...	...	...	...
Light Grey .	·750	...	...	...	...	·250	...

There are other alloys which evolve special tints of shading, but sufficient has been given to show the direction in which the alloying should extend to produce the desired colour in any required standard; if not, the necessary information will be found in the preceding tables of gold

mixtures amply sufficient for all the ordinary purposes of gold workers and jewellers. If good rich tints of the different shade of colour are desired of a lasting nature, the fine gold must not be overpowered too much or the effect will be deteriorated. The black gold is effected by dipping the finished work in an oxidising solution.

Table of Greyish-White Alloys prepared by the Author as Substitutes for Platinum and Palladium in Gem-Setting and in Floral Work, and at a less Cost than either of the more Expensive Metals

No.	Platinum.	Palladium.	Gold.	Silver.	Nickel.	Total.
1	·375	...	·125	·500	...	1·000
2	·333	...	·100	·567	...	1·000
3	·292	...	·108	·600	...	1·000
4	·250	...	·125	·625	...	1·000
5	·200	...	·175	·625	...	1·000
6	·333	...	...	·667	...	1·000
7	...	·750	...	·250	...	1·000
8	...	·700	...	·300	...	1·000
9	...	·500	...	·500	...	1·000
10	...	...	...	·333	·667	1·000
11	...	...	...	·250	·750	1·000
12	·250	...	·150	·600	...	1·000
13	...	·250	...	·750	...	1·000
14	...	·333	...	·667	...	1·000
15	...	·250	·125	·625	...	1·000
16	·125	...	·125	·250	·500	1·000

Palladium closely resembles platinum in its properties. It is intermediate between platinum and silver in colour. Palladium is slowly dissolved by nitric acid, but is not tarnished in the air and by sulphuretted hydrogen like silver. Palladium is a little heavier than silver, bulk for bulk, and when heated to redness, palladium tarnishes with the formation of a bluish film on the surface; but this is best removed by dipping the work into a hot solution of cyanide of potassium. Palladium is used in the gem-setter's art, and the alloy No. 8, containing 30 per cent. of silver, is capable of receiving a brilliant polish, superior to platinum.

Table showing the Weight of any Article in Sterling Silver, and the Approximate Weight of any exactly similar Article in 22-Carat, 18-Carat, 15-Carat, and 9-Carat Gold, and also in Platinum

(*Tested by drawing 4 ft. of solid wire to exactly the same size of each metal.*)

Sterling. Silver.	9-Carat Gold.	15-Carat Gold.	18-Carat Gold.	22-Carat Gold.	Platinum.
0·720	0·825	1·050	1·100	1·172	1·275
0·800	0·880	1·120	1·173	1·250	1·360
0·850	0·935	1·190	1·246	1·328	1·445
0·900	0·990	1·260	1·320	1·406	1·530
0·950	1·045	1·330	1·393	1·484	1·615
1·000	1·100	1·400	1·466	1·562	1·700
1·050	1·155	1·470	1·539	1·640	1·785
1·100	1·210	1·540	1·612	1·718	1·870
1·150	1·265	1·610	1·685	1·796	1·955
1·200	1·320	1·680	1·758	1·874	2·040
1·250	1·375	1·750	1·832	1·952	2·125
1·300	1·430	1·820	1·905	2·030	2·210
1·350	1·485	1·890	1·978	2·108	2·295
1·400	1·540	1·960	2·052	2·186	2·380
1·450	1·595	2·030	2·125	2·264	2·465
1·500	1·650	2·100	2·199	2·342	2·550
1·550	1·705	2·170	2·272	2·420	2·635
1·600	1·760	2·240	2·345	2·498	2·720
1·650	1·815	2·310	2·418	2·576	2·805
1·700	1·870	2·380	2·492	2·654	2·890
1·750	1·925	2·450	2·565	2·732	2·975
1·800	1·980	2·520	2·638	2·810	3·060
1·850	2·035	2·590	2·712	2·888	3·145
1·900	2·090	2·660	2·785	2·966	3·230
1·950	2·145	2·730	2·858	3·044	3·315
2·000	2·200	2·800	2·932	3·122	3·400

The standard of English platinum is fixed at ·950 per 1,000 in fineness, but this, it appears, contains other metals of the platinum group, and is not, therefore, pure platinum; but it is described as genuine platinum by jewellers, some of whom have expressed their opinion on being shown a piece of *pure* platinum that it was not platinum at all. And now, in conclusion, I express the hope, if I am spared, that I may issue a companion volume on solders, their preparation, treatment, and application.

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