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PRACTICAL

DENTAL METALLURGY.

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PRACTICAL

DENTAL METALLURGY.

EXPLANATION OF TERMS USED.

ALL temperatures, unless otherwise specified, are given Centigrade. As many readers will probably have a limited chemical knowledge the following explanations may be useful.

ATOMIC WEIGHTS.

These are the proportions by weight in which one substance or element replaces another in a combination.

All the elements replace each other in combinations in precisely the same manner and in invariable proportions. Sometimes a substance will combine with another in two or more different proportions, these being always multiples of each other.

WATER OF CRYSTALLIZATION.

The weight of any salt or combination of a metal does not always give simply the proportions of the elements contained, as frequently there is also water in combination. This, as water of crystallization, is always the same for the same compound, and when once known can be allowed for.

SPECIFIC HEAT.

The heat which diffuses itself through substances accumulates in them in quantities which differ according to their peculiar nature, not depending on either weight or volume. Different bodies require different quantities of heat to raise their temperature equally, and disengage different quantities of heat in cooling through same number of degrees of temperature. The different capacity of bodies for heat is called specific heat when bodies are compared with regard to their weight. Equal weights of bodies heated to an equal temperature, but having different specific heats, raise the temperature of a given quantity of water through a different number of degrees. Thus, the specific heat of zinc being 0·0927 and lead 0·0293 accounts for the fact that zinc requires so much longer to melt than would be expected, judging from the comparatively small difference

in the melting points of the two metals. It also accounts for the fact that a much larger quantity of cold water is required to cool a zinc die than a lead reverse of the same weight, the total quantity of heat taken up and rendered latent or inappreciable to a thermometer being much greater than is the case with lead, this heat again making its appearance and proving its presence by the greater quantity of water heated by the zinc in cooling.

The specific heat of a metal may be an important consideration to the dentist in many cases: for instance, the high specific heat of palladium, combined with its low conducting power, prevents the sudden chill felt with a gold plate in the mouth on drinking a cold liquid, and also in a similar manner assists in preventing scalding with hot liquids. This is one of the reasons why palladium is unequalled by any metal for artificial dentures.

SYMBOLS.

These are the short forms by which the substances are denoted in chemical compounds, and are used for simplicity and convenience in all chemical works.

Name.	Symbol.	Atomic weight.	Melting point, centigrade.	Specific gravity.	Specific heat.	Boiling point.	Tenacity in lbs., sq. in.	Resistance to crushing in lbs., sq. in.
			Degs.			Degs.		
Hydrogen	H	1						
Oxygen	O	16						
				water = 1·0000				
Aluminium ...	Al.	27·5	700	2·6000				
Antimony	Sb.	122	425	6·7010	0·050		1066	
Bismuth	Bi.	210	265	9·8220	0·029		3250	
Zinc	Zn.	65	411	6·9154	0·092	1040	8000	
Cadmium	Cd.	111·6	320	8·6355	0·038	860		
Tin	Sn.	118	228	7·2900	0·051		5000	15000
Lead	Pb.	206·4	334	11·3839	0·030	1040	1824	7000
Pure Iron	Fe.	55·9	1600	7·8439	0·110		60000	38000
Nickel	Ni.	58·6	1600	8·6370	0·108			
Copper	Cu.	63	1173	8·7210	0·095		cast 19072	11700
Mercury	Hg.	200		13·559	0·032	350		
Silver............	Ag.	108	1023	10·4280	0·056		41000	
Gold	Au.	196·2	1102	19·5000	0·028		20400	
Palladium	Pd.	106·5		11·5000	0·059			
Platinum	Pt.	196·7	2534	21·5000	0·031			
Cast Brass......							17978	10300
Brass Wire ...							49000	
Cast Iron							19000	92000
Steel							120000	

NOTE.—The melting points of metals as given in figures are never perfectly reliable. The most modern authorities differ considerably, and the degrees as given must be only taken as an approximation.

COMPARISON BETWEEN THE CENTIGRADE AND FAHRENHEIT THERMOMETER SCALES.

Centigrade.	Fahrenheit.	Centigrade.	Fahrenheit.
Degrees.	Degrees.	Degrees.	Degrees.
260	500	130	266
255	491	125	257
250	482	120	248
245	473	115	239
240	464	110	230
235	455	105	221
230	446	100	212
225	437	95	203
220	428	90	194
215	419	85	185
210	410	80	176
205	401	75	167
200	392	70	158
195	383	65	149
190	374	60	140
185	365	55	131
180	356	50	122
175	347	45	113
170	338	40	104
165	329	35	95
163	325·4	30	86
160	320	25	77
157	314·6	20	68
155	311	15	59
150	302	10	50
145	293	5	41
140	284	0	32
135	275		

A ROUGH METHOD OF ESTIMATING HIGH TEMPERATURES.

Degrees Centigrade.	
411	Zinc melts.
525	Slight glow in the dark.
700	Dark red.
900	Cherry red.
1000	Bright cherry red.
1023	Fine silver melts.
1150	Orange.
1102	Fine gold melts—(1250° Bayley).
1173	Fine copper melts—(1050° „).
1300	White.
1350	Steel melts.
1500	Dazzling white.
1600	Wrought iron melts.
2534	Platinum melts.

BEHAVIOUR OF METALS WITH ACIDS.

Not attacked by dilute sulphuric acid at ordinary temperatures.

Gold, Platinum, Antimony, Lead (Copper very slightly), Mercury, Silver, Bismuth, Tin (Palladium slightly attacked).

Soluble in dilute sulphuric acid.

Iron, Zinc, Cadmium, Aluminium, Nickel (Tin with the assistance of heat).

Not attacked by dilute nitric acid.

Gold, Platinum, Aluminium, Palladium.

Soluble in dilute nitric acid.

Lead, Cadmium, Iron, Copper, Nickel, Mercury, Silver, Bismuth, Zinc. Antimony and Tin are oxydized but not dissolved.

Not attacked by hydrochloric acid.

Antimony, Gold (Copper if air is excluded), Mercury, Platinum.

Slightly attacked.

Lead, Palladium, Silver, Bismuth.

Soluble in hydrochloric acid.

Aluminium, Cadmium, Iron, Nickel, Zinc, Tin.

Soluble in solutions of soda and potash.

Aluminium, Zinc (Tin when heated).

Attacked by fused alkalis at high temperatures.

Platinum, Palladium.

BEHAVIOUR OF SOLUTIONS OF METALS WITH COMMON REAGENTS.

Metal.	Caustic potash.	Carbonate of potash.	Ammonia.	Carbonate of ammonia.	Sulphuretted hydrogen.
Zinc	W	W	W	W	No precipitate
Nickel.........	G	G		G x	,, if acid
Aluminium ...	W x	W	W	W	,,
Arsenic					Y
Antimony ...	W x	W	W	W	O
Tin	W x		W x	W	B r
Cadmium ...	W	W	W x	W	Y
Copper	Bl	G Bl	G Bl x	G Bl x	B B
Bismuth	W	W	W	W	B B
Lead	W x	W	W x	W	B
Silver	Br	W	Br x		B

Explanation :—x, Precipitate soluble in excess o reagent; W, white; G, green; Y, yellow; O, orange; Br, brown; Bl, blue; B B, brownish black; B, black.

BEHAVIOUR OF METALS BEFORE THE BLOWPIPE, ON CHARCOAL, WHEN HEATED BY THE REDUCING FLAME *(in the blue cone)*.

Leave an infusible white residue.

Aluminium, Zinc. If moistened by cobalt nitrate and again heated, Aluminium becomes blue, Zinc green.

Form an incrustation on the charcoal.

White, garlic odour, distant from flame—Arsenic.

White, nearer to flame—Antimony.

Yellow when hot, white when cold—Zinc.

Faint yellow when hot, white when cold, near to the flame—Tin.

Yellow—Lead.

Dark orange yellow when hot, lemon yellow when cold—Bismuth.

Brownish red or yellow—Cadmium.

Dark red, very slight—Silver.

BEHAVIOUR OF METALS IN AIR.

Metals.	At ordinary temperatures. Dry air.	At ordinary temperatures. Moist air.	At high temperatures.
Aluminium ...	No change	Slowly tarnishes	Burns, forming $Al^2 O^3$
Bismuth	No change	Slowly tarnishes	Burns to $Bi^2 O^3$
Cadmium	No change in air free from carbonic acid	No change in air free from carbonic acid	Burns to Cd O
Copper	No change	Tarnishes	Burns to Cu O
Gold	No change	No change	No change
Platinum	,,	,,	,,
Palladium	,,	,,	Oxydizes at low red. Oxide is reduced again at higher temperatures
Lead	Tarnishes	Tarnishes	Burns to Pb O
Mercury	No change	Slowly tarnishes	Burns to Hg O
Nickel	No change	No change	Forms Ni O
Silver	Blackened if sulphuretted hydrogen is present	Blackened if sulphuretted hydrogen is present	No change
Tin	No change	No change	Forms $Sn O^2$
Zinc	Tarnishes	Tarnishes	Burns to Zn O

ALLOYS.

GENERAL PROPERTIES.

Most metals combine in the proportions of their atomic weights, or in multiples of these, forming what may in many cases be considered feeble chemical combinations. The resulting alloy is frequently different in specific gravity to the calculated mean; the combination takes place in some cases with the evolution of intense heat (Platinum and Tin as an example), and, where two metals only are in combination, such as copper and mercury, or palladium and mercury, there is no doubt that these are best when the relation to the atomic weights is strictly observed. When, however, we get alloys with three or more metals, such as tin, silver, mercury, &c., all my experience goes to prove that the atomic proportions form mixtures which apparently are never at rest; there are constant internal changes and apparently sub-alloys forming, which make the result, so far as dentists are concerned, anything but desirable, as these changes frequently show themselves by continued changes in form, extending over months or years.

In compound alloys it is, therefore, necessary not to use any of the metals in their atomic proportions to each other and to make the alloy in such a manner that the separation of sub-alloys is, as far as possible, prevented.

Experience and the knowledge of the practical manipulation of certain alloys will do much to prevent these forming in the fused mixture, but no amount of skill will entirely prevent them. It is, therefore, necessary to test every ingot of every compound alloy for all properties required before permitting it to be used. An experience of many years, with every possible appliance for precision in working, only goes to prove that failures in producing a uniform alloy are frequent, and testing every ingot is an absolute and unavoidable necessity if uniform results are to be obtained.

In alloys where mercury is not a component part the differences between 2 ingots or between 2 parts of the same ingot are of small practical importance, although they still exist in almost every alloy made, notably so in the silver coinage. It is no unusual case for the two opposite edges of a shilling or florin to give different results on assaying, although the alloys are made with every possible care and precaution.

CONTRACTION OF CASTINGS IN COOLING—

i.e., the amount of difference between the size of the impression in sand and the casting produced.

Cast iron	·125
Copper	·193
Brass	·210
Lead	·319
Tin	·278

The superiority of iron castings for exact work in making dies is clearly demonstrated by the above, irrespective of the fact that one die will do all necessary in a far superior manner to a die made with any other metal. Iron runs perfectly in open sand in the usual manner of casting dentists' dies. A little sawdust or charcoal powder should be sprinkled over the surface of the metal in the crucible.

TENACITY OF METALS.

A wire of the same diameter will support the following comparative weights without breaking:—

Iron	549	lbs.
Copper...	302	,,
Platinum	274	,,
Silver	187	,,
Gold	150	,,
Zinc	109	,,
Tin	39	,,
Lead	27	,,

POWER OF CONDUCTING HEAT.

Gold 53, Platinum 8, Silver 100, Copper 74, Iron 12, Zinc 36, Tin 14, Lead 9, Brass 24, Bismuth 2.

DILATION BY HEAT.

				Expansion between the freezing and boiling point of water.
Platinum	expands	1 in	... ...	1097
Palladium	,,	,,	... ...	1000
Antimony	,,	,,	... ...	923
Iron (cast)	,,	,,	... ...	901
Gold	,,	,,	... ...	667
Copper	,,	,,	... ...	557
Brass	,,	,,	... ...	524
Silver	,,	,,	... ...	499
Tin	,,	,,	... ...	424
Lead	,,	,,	... ...	350
Zinc	,,	,,	... ...	336

The contraction in cooling from castings corresponds to the above; the contraction of zinc being the greatest, nearly 3 times that of cast iron.

APPARATUS.

The chemical portion of this book does not go into the matter of quantitative analysis. For this work more time and more apparatus are necessary than are available by a dentist in ordinary practice. For the detection of certain metals the processes are given when moderately simple; in other cases it will be better to put the matter in the hands of a qualified chemist.

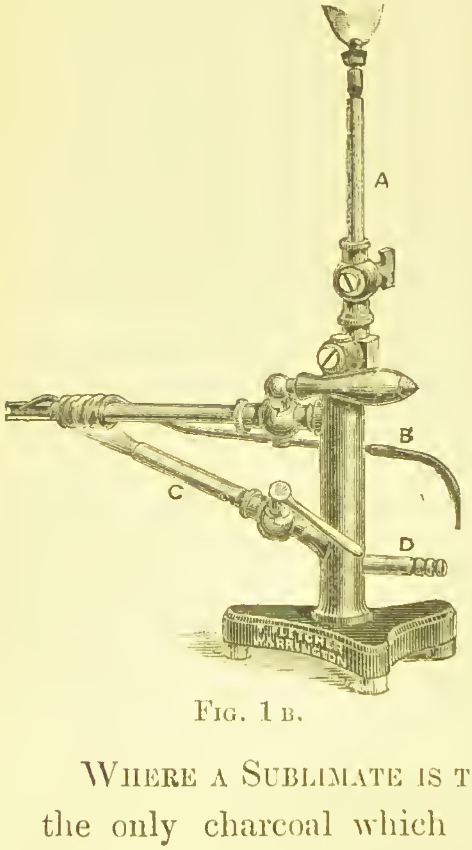


Fig. 1 B.

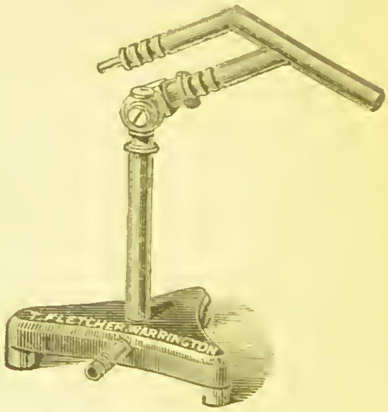


Fig. 8 D.

Where a Sublimate is to be obtained on Charcoal the only charcoal which does not give a coloured ash, and so interfere with the result, is that made

from pitch pine. This is not to be obtained commercially in England; in fact, the only place I know it is to be obtained is from the laboratory man at the Freiberg School of Mines. It is better to dispense with charcoal slabs and use aluminium plate instead, on which sublimates are more visible and more easily recognized. The work of Lieut.-Col. Ross gives full instructions for the use of this. Sublimates may also be obtained on a blackened slip of fireclay.

THE BEST BLOWPIPE is one of the two engraved on previous page. The jet must be of very fine bore and in good condition, so as to give a clearly defined and sharply pointed blue cone.

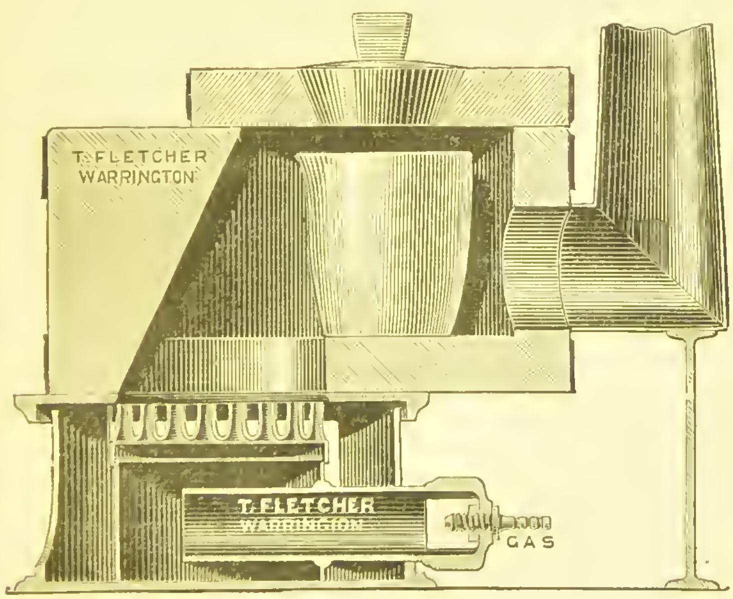


FIG. 63.

FOR ROASTING OR OXYDIZING, and also for melting metals in crucibles at temperatures not exceeding the fusing point of fine silver, the gas furnace, Fig. 63, is all that could be desired. Roasting and cupelling may also be done in the muffle furnace, Fig. 61, provided a slit is cut in the back of the muffle so as to allow a current of air to pass through.

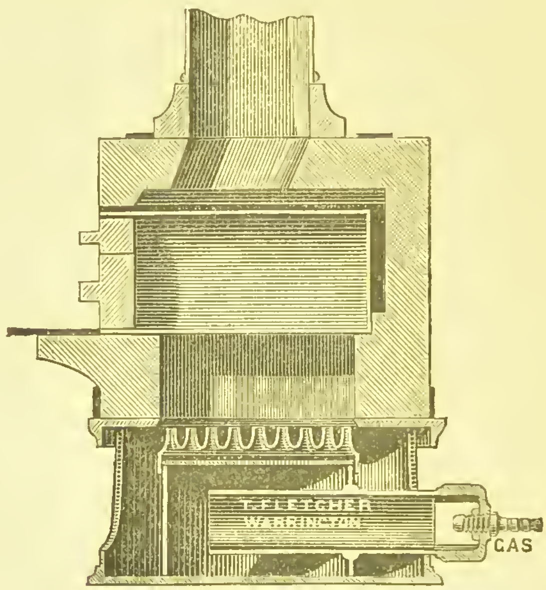


FIG. 61.

FOR THE FUSION OF ALL METALS IN CRUCIBLES, and more especially for those metals fusing at high temperatures, the injector furnace, Fig 41, is the simplest and most powerful. This requires a blast of air from a good foot blower.

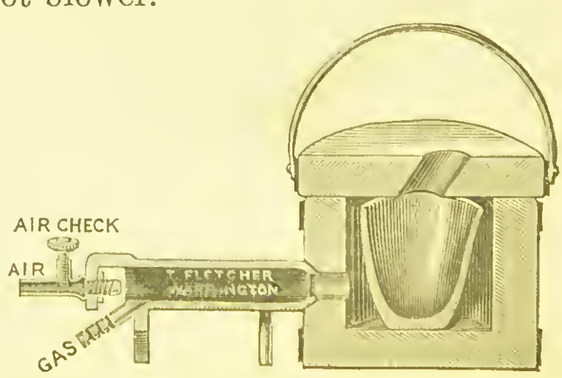
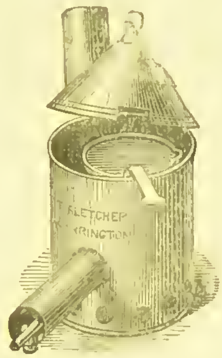


FIG. 41.

For Melting Metals at Temperatures below Redness the ladle furnace is the simplest and readiest apparatus.



Where Gas is not obtainable a lamp burning solid paraffin is the most satisfactory for blowpipe analysis.

For soldering, the cleanest method, in the absence of gas, is to use a spirit lamp with a wick about three-eighths of an inch wide, and one inch long. This when properly used, gives a powerful flame, well under control. The spirit holder should be at a few inches distance from the wick holder, and the connection made between the two with a tube.

SEFTSTROM'S CHARCOAL FURNACE.

A Charcoal or Coke Furnace in which refractory metals can be fused rapidly and almost as easily as in a gas furnace can be made as follows:—

Make a double sheet iron box, the inner box being about 12 inches square and open at the top, the outer one being about 3 inches larger each way and connected to the inner one by a flange round the top so as to be air tight. The outer box has an inlet for air from a blower: the inner one has six or eight half-inch holes punched through the sides about four inches from the bottom, and is lined with slabs of fireclay having holes corresponding to these. When in use, the top should be partially covered with a slab of fireclay. The blast enters the hole in the outer casing, and passes through the holes in the inner casing, to the fuel. The crucible must be supported on a block about 3 inches high. With this furnace, using charcoal as a fuel, and a good blower, cast iron or steel can be perfectly melted in about 10 minutes after the fire is lighted. This furnace, which is known as Seftstrom's, can be purchased from any dealer in chemical apparatus. A good draft furnace for general use can be made in an ordinary fireplace by removing the grate and build-

ing a square box of firebrick with an iron grate at the bottom: the box does not need to be over 9 inches square and the same height; the front above the furnace must be left open, and closed when the furnace is in use by a plate of iron with a handle for lifting away. It is better to fit a door also to the ashpit with a hole about 2 inches diameter having a tube fitted in and projecting 2 or 3 inches, to which a fan can be connected, or into the centre of which a jet of air from a footblower can be directed to urge the draft when required.

In building any furnace of firebrick or slabs, fireclay must be used as a cement instead of mortar, and the fireclay must be mixed, not with water, as is usual, but with a solution of silicate of soda, which can be readily and cheaply obtained in almost any part of the world. Joints made in this manner will bear firing immediately they are made, and will stand rough use with ladles, &c., under circumstances where a furnace built with fireclay cement alone would rapidly be broken up.

A furnace of this kind is readily adapted to muffles for continuous gum, crucibles, ladles, and all the work necessary in the laboratory, and when not required can be quickly extinguished by closing the hole in the ashpit door by a cap. If required for muffles a ledge should be left at the back about 5 inches above the top of the firebox, to carry the muffle, and the front will require to be built up, leaving a hole with door about 9 inches above the top of the muffle to enable fresh fuel to be added as required. If the shaft is 9 inches wide clear inside the muffle should not exceed 4½ inches, as room is required on each side to allow the fuel to fall down at the sides of the muffle. If no blower is used a chimney of at least 20ft. high should be allowed for continuous gum work, but a modification of Seftstrom's furnace can be built giving ample heat and requiring no chimney.

As a fuel Durham coke (not gas coke) will be found to fulfil every requirement, although charcoal, when not too costly, is to be preferred for quick work and high temperatures.

PETROLEUM VAPOUR BLAST.

A very small quantity of the vapour of the lighter petroleums mixed with the air which is blown into a blast furnace burning solid fuel reduces the consumption of fuel and lessens the trouble of falling fuel and disturbance of crucibles. It also increases the heat enormously, if not in too great quantity. The peculiar roar caused by this addition to the air is readily recognized, and disappears when the vapour is in excess. The simplest way to apply it is to

allow a slow drip of benzoline or gasoline into the fan chamber or into the air pipe from the blower; other things being equal, this simple addition doubles the power of any furnace. It is probable that a drip into the ashpit of a draft furnace might also have the same effect, but I have had no experience with this, having discarded solid fuel entirely for many years. In an ordinary laboratory where gas is not available the work is increased fully 50 per cent., and in some classes of work is more than doubled. It is, therefore, not advisable to use solid fuel where gas or gasoline is available.

FIREBRICKS.—Where not exposed to mechanical injury a mixture of one part by bulk of dry fireclay with 3 or 4 parts of sawdust, moistened, worked into form and burnt enables very much higher temperatures to be obtained in a furnace than can be obtained with ordinary firebricks. This mixture is used for the casings of the well known injector furnace, and is one of the most important points in its construction. The use of simple fireclay instead of this mixture would reduce the power of the injector furnace to about one half, and would render it totally useless for many most important operations. When temporary experiments are to be made quickly, casings of this mixture may be used with perfect success without burning in a kiln, and with careful handling they stand fairly well in daily use. Nickel melters almost invariably use the casings simply dried in a warm place without firing before they are used.

EXAMINATION OF METALS ON CHARCOAL WITH THE BLOWPIPE.

The blowpipe used must give a steady and clearly defined blue cone. Beyond the point of this cone and at as long a distance from it as the heat can be obtained, is the oxydizing flame, afterwards denoted by O.F. Inside the blue cone is the reducing flame, afterwards denoted by R. F. The sample to be submitted to this must be small enough to be entirely surrounded by flame and perfectly protected thereby from the action of the external air.

When charcoal is used, the ash formed by its combustion must not be mistaken for a sublimate or coating produced by the substance in the flame, and by a preliminary experiment the colour of the charcoal ash must be perfectly known so as to prevent risk of errors.

The appearance of some metals not of use to dentists is given to prevent possible mistakes. When metals are in an alloy the distinctive marks are usually fainter than when the pure metal is tested.

ARSENIC volatilizes without fusing, and coats the coal with arsenious acid in both flames; the white coat appears greyish when thin, and is at a distance from the assay. It can be driven off by simply warming with the flame, and if rapidly treated by the R. F. colours is a pale blue. It evolves when heated an odour of garlic.

ANTIMONY melts easily, coating the coal with oxide in both flames. The white coat, bluish in thin layers, is not so distant as with arsenic. It can be driven about by heating gently with the O. F. and disappears in the R. F., tinging it a pale green. When melted and heated to redness it remains melted and glowing for some time, evolving dense white fumes, which condense partly on the coal and finally surround the button with white pearly crystals.

LEAD coats the coal with oxide in both flames. When warm this is dark lemon yellow; when cold, sulphur yellow, and bluish white in thin layers. When the coal is heated to glowing the coat changes its place, and the flame is at the same time coloured blue.

BISMUTH gives a coat of oxide dark orange yellow when hot, lemon yellow when cold, and nearly white in very thin layers. It can be driven about on the glowing coal like lead, but does not colour the R. F. like lead.

CADMIUM melts easily and burns in the O. F. with a dark yellow flame and brown fumes, coating the coal with oxide rather near the assay. Nearest the assay the coat is thick, crystalline, and very dark, nearly black. Further off it is reddish brown, and in very thin layers orange yellow. It can easily be reduced and driven about with either flame, but gives no colour. Beyond the furthest limits of the coat the coal sometimes shows a variegated tarnish.

ZINC fuses easily and burns in the O. F. with a strongly luminous greenish white flame, and dense white fumes which coat the coal with oxide. The coat is rather near the assay, yellow whilst hot, white when cold. It becomes luminous under the O. F., but is not volatilized. It is very slowly volatilized by the R. F.

TIN in the O. F. is covered with oxide which can be blown away. In the R. F. the metal becomes clear and coats the coal with oxide, which is pale yellow whilst warm and luminous under the O. F. On cooling it becomes white. It is so close to the assay that it borders directly on it and cannot be volatilized. It is slowly reduced to metallic tin by the R. F.

SILVER fused for some time with a powerful oxydizing flame gives a slight reddish brown coat of oxide. If combined with a little lead a coat of yellow oxide of lead forms. With antimony present a white coat forms, which becomes red on continued blowing. If it contains both a crimson coat forms.

PLATINUM AND PALLADIUM give no reaction.

GOLD.

Specific Gravity, 19·5	*Symbol*, Au.
Specific Heat, 0·028	*Atomic Weight*, 196·2
Tenacity in lbs., sq. in., 20,400	*Melting point*, 1102° C.

Found native.

PURIFICATION FOR DENTAL PURPOSES.—Dissolve in nitro-muriatic acid, precipitate by sulphate of iron, and fuse the precipitate with borax and a small quantity of nitrate of potash.

Gold is also refined on a large scale by passing chlorine gas through it whilst in a state of fusion. It may also be purified by melting with lead and cupelling on bone earth in the same manner as silver; this, however, does not remove all the other metals present.

The clean surfaces of absolutely pure gold will weld without the aid of heat, and if the welding property is destroyed by accidental moisture or impurities, it can be restored partially without the aid of heat by washing the surface with chloroform.

CRYSTAL GOLD is prepared by slowly heating an amalgam of gold in a muffle until the whole of the mercury is driven off. If a very light spongy mass is required the first part of the mercury may be removed by pure nitric acid without the assistance of heat, which would fuse an amalgam having a large proportion of mercury. An amalgam of 6 mercury and 1 gold crystallizes in four-sided prisms; the whole of the mercury can be driven off from this by heat, leaving the gold in a light spongy mass.

Gold and Silver combine in all proportions, forming a soft ductile alloy of greenish colour when the silver is in large proportion.

Gold 22, silver 1, copper 1, forms a hard alloy, having a specific gravity of 17·344.

GOLD IN AMALGAMS renders them cleaner and pleasanter to use, but reduces the power of setting, thereby also probably reducing the shrinkage of amalgams which have this fault.

The English Sovereign weighs 123¼ grains, and contains 113 grains pure gold.

To reduce sovereigns from 22 carats to lower standards add for each coin—

For 16	carat	46	grains	alloy.
„ 18	„	27½	„	„
„ 20	„	12½	„	„

Hard Springy Gold, *16 carat:—*

Gold 36, Silver 6, copper 12.

6 1 2

36 6 ~~12~~

6 1 2

6 dart 1 dart 2 darts

GOLD SOLDERS—

For 22 carat — take 22 carat gold 24 parts, silver 2, copper 1.

For 18 carat — take 18 carat gold 24 parts, silver 2, copper 1.

For 16 carat — take 16 carat gold 24 parts, silver 8, copper 6.

Brass is generally used, *i.e.* the alloy of 7 copper, 3 zinc, in preference to copper for all gold solders. The presence of a trace of zinc causes the solder to flow much more freely. It may be taken as a general rule that the use of zinc in a gold solder is not acknowledged, and yet, curiously enough, the zinc is to be found in nearly if not all good solders. The following 3 formulas are taken from Oakley Coles "Manual of Dental Mechanics."

16 CARAT SOLDER for 18 or 20 carat plate:—Fine gold 6, copper 2, fine silver 1 (*the previous remarks as to brass will also apply to this*).

15 CARAT SOLDER.—Gold coin 144, silver 30, copper 20, brass 10.

(It is not stated if silver coin is to be used or fine silver.)

18 CARAT SOLDER.—Gold coin 30, silver 4, copper 1, brass 1.

Some dentists who make their own solder simply add 1 part of zinc to 12 parts of the gold for which the solder is required.

It may be taken as a rule that ordinary fine silver and fine gold should never be used for alloying. They are frequently sufficiently impure to be utterly unfit for any of the requirements of the dentist, containing metals in small quantities *(such as lead)* which spoil the alloy and make it brittle. It is much safer always to take coins, as the fact that the coin has been rolled from the ingot and stood the blow of the dies, is always a proof that the metal can be trusted not to produce a brittle ingot. Many samples of gold almost chemically pure are quite unworkable. Before the process of refining by chlorine gas was discovered this fact caused very serious difficulties and losses at the English mint.

FALSE COINAGE.—In melting sovereigns care is requisite in examining each coin. A very large number of splendid imitations are made of platinum heavily gilt. I have had large quantities of these, purchased along with platinum scrap, and so long as the gilding is perfect they can only be detected with the greatest difficulty.

An alloy of 16 platinum, 7 copper, 1 zinc also makes imitations of gold coinage so perfect as to be beyond ordinary detection. The falsification of gold coinage is not confined to English coins, but is, if anything, more frequent with French, Spanish, and American coinage.

A PASTY ALLOY OF GOLD AND MERCURY is used for heavy gilding, the mercury being driven off by heat.

ASSAY OF GOLD.

The exact assay of gold is beyond the province of the dentist, but a very close approximation may be got by taking any known and convenient quantity, say, for the convenience of calculation, 10 or 25 grains, melting with it 4 or 5 times its weight of silver, rolling into an extremely thin sheet, curling this up into an open spiral (technically called a cornet), and boiling in a glass vessel with strong pure nitric acid for 15 or 20 minutes. The acid must then be carefully washed away, fresh acid added, and the boiling again carried on for the same time. The result when washed and dried consists of the fine gold contained in the sample along with any platinum if present. It can be melted up again with borax, and the silver can be precipitated from the acid by salt as chloride and reduced to metallic state (see silver) if desirable. Zinc is sometimes used in the place of silver for this process.

It must be borne in mind that this process will not succeed unless a large proportion of silver—at least 4 times the weight of the gold—is used, as when the surface silver is dissolved out the gold must be sufficiently open and porous to allow the acid free access to the centre; otherwise some silver is left undissolved, and the result is not correct.

When platinum is present in objectionable quantities it can be separated by rolling the sample of gold (without melting with silver) very thin, dissolving it in about 4 times its weight of nitro-muriatic acid, (which should be mixed when wanted in the proportions of 1 Nitric acid to 2½ Hydrochloric acid,) and the solution is assisted by a little heat. The silver present falls as insoluble chloride, which must be separated by decanting and washing, adding the washings to the gold solution. Evaporate this to nearly dryness, add a little hydrochloric acid, and again evaporate so as to get rid of the nitric acid.

Dilute largely with water and add slowly a solution of proto-sulphate of iron until a precipitate ceases to form. Wash this precipitate with sulphuric acid to remove all traces of iron, then wash repeatedly with hot water, dry and melt with borax in a crucible.

The platinum may now be separated from the solution, if necessary, by adding a solution of muriate of ammonia. These processes, although sufficiently correct for any purpose required by a dentist, are not absolutely correct, greater care is required in many points for an exact assay.

A ROUGH AND PERFECTLY SATISFACTORY WAY OF REDUCING DIRTY FILINGS AND WASTE to good working gold is to boil it in a cast iron enamelled cup with about 3 times its weight of strong nitric acid, to near dry-

ness, adding a little more acid—say about one-third the quantity first used, and boiling down again. The residue must now be washed with hot water, and what remains after washing melted with borax in a crucible. This gives a gold about equal in quality to the bulk from which the filings were made, and is both simple and certain in the results.

COLOURING GOLD.

A thick pasty solution of a mixture of nitrate of potash, sulphate of iron and common salt is used for extracting the alloy from the face of gold. It is generally used boiling hot, in a crucible, and the finished work dipped into it. When sufficiently coloured the adhering mixture is washed off with boiling water. This process requires some little practice to prevent streaks and irregular colouring, and a good quality of solder must be used, or it is liable to be blackened and the joints made weak.

SILVER.

Specific Gravity, 10·5	*Symbol*, Ag.
Specific Heat, 0·056	*Atomic Weight*, 108
Tenacity in lbs., sq. in., 41,000	*Fuses at* 1023° C.

PREPARATION.—Silver ores are first combined with lead by fusion, and the alloy allowed to solidify slowly. Lead nearly free from silver crystallizes out first and is removed by ladles: the remainder is heated on a bed of bone earth in a reverberatory furnace. The lead becomes oxydized, and the fused oxide of lead is absorbed by the bone earth until, as the last trace of lead disappears, the silver suddenly brightens on the surface. This process yields what is known as fine silver, or cupel silver. It almost invariably contains both gold and palladium, the latter in sufficient quantity to totally condemn it for amalgams, in which the merest trace of palladium is a serious fault. When the ores contain sulphide or other silver salts, another and longer process of purification is necessary, which need not be referred to here.

PURIFICATION FOR AMALGAMS.—Dissolve in pure nitric acid and precipitate with common salt. The precipitated chloride of silver is thoroughly

washed several times with hot water, dried, and mixed in the proportions of 3 chloride of silver to 1 of finely powdered resin. Heat slowly at first until flames cease to be given off, and then raise the heat to the melting point of silver, adding a little borax.

If the chloride is fused in the ordinary way with carbonate of soda the loss of silver is considerable, even when the operation is performed on small quantities at once in a skittle pot, not only from the spitting, but from the absorption of the fused chloride by the crucible.

FUSED SILVER, unless covered by charcoal or a flux, absorbs oxygen, which is again given off in cooling, causing spitting and excrescences on the surface of the mass.

SILVER AND TIN.—An alloy of 5 tin, 4 silver, is still largely used for amalgams : it has less permanence in the mouth than many other alloys, notably less than silver as an amalgam, but the addition of tin reduces the discoloration of the plug.

SILVER AND MERCURY.—All alloys of silver and mercury expand more or less in hardening. When precipitated silver is used the combination takes place with such rapidity that the mass is hard in a few seconds; the evolution of heat is also considerable. The rapidity of combination is reduced by the use of a mixture of precipitated silver and filings, if the precipitate is in excess and the mass is inserted before the hardening commences, there is a risk of bursting the tooth by the gradual expansion of the mass. The expansion is readily seen by packing the amalgam in a glass tube and finishing the surface level with the glass. In a few days it will be seen to have lifted above the surface of the tube. If a great excess of mercury is used the mass only partially hardens and the results are uncertain.

SILVER AND COPPER.—These alloy in all proportions, but the ingots are invariably irregular in composition in different parts.

TAVEAU'S AMALGAM.—This compound, which was introduced first by M. Taveau, of Paris, in 1826, consists of coin silver filings mixed with excess of mercury which was afterwards squeezed out. It has, when properly worked, a slight expansion during and after setting, and preserves the teeth well. Its intense blackness is the greatest objection to its use.

A small proportion of copper with silver in an amalgam quickens the setting, makes it cleaner to mix in the hand, but increases the discoloration.

The salts of silver are poisonous.

PLATINUM.

Specific Gravity, 21·5 *Symbol*, Pt.
Specific Heat, 0·031 *Atomic Weight*, 196·7
Melting point, 2534° C.

The correct name for this metal is Platina (Spanish, small silver). The name has become corrupted by modern chemists, and the absurdity of a common Spanish word with a Latin termination is apparently likely to be perpetuated.

Found native, combined with palladium and other metals.

The platinum, separated from the other metals with which it is found, by dissolving in nitro-muriatic acid and precipitation, is fused in two saucer-shaped blocks of lime placed over each other, either by a large oxyhydrogen blowpipe passing through a hole in the upper block, or more recently by a blowpipe burning hydrogen gas supplied with air under very heavy pressure. It cannot be fused in an ordinary crucible, as no refractory clay known will stand the required heat without fusion, but scraps may be welded together at a bright red heat if clean.

PLATINUM AND CARBON.—These combine at temperatures over redness forming a brittle carbide of platinum.

It is therefore essential that platinum alloys shall, if required to be perfectly malleable, be melted in fireclay crucibles, which it is also advisable to line with magnesia or lime.

Working Platinum Scrap.—Where it is necessary to work up scrap into a mass it may be fused with either arsenic or antimony. When either of these alloys is heated in the air it gives up the other metal, leaving platinum almost pure and in a fit state for working. The fusion with arsenic is a common commercial process, carried out on considerable quantities at once in the injector furnace, the alloy being cast and afterwards heated to expel the arsenic. As the vapours are excessively poisonous, great care and perfect ventilation are absolutely necessary for safety.

Platinum and Cadmium, made by fusing excess of cadmium with platinum and driving off the excess of cadmium by heat, contains 46·02 platinum (1 equiv.) and 59·98 cadmium (2 equiv.). White, fine grained, and very infusible—no commercial use at present.

Platinum and Tin.—3 platinum, 16 tin, make a brittle alloy which crystallizes and remains unchanged in moist air. 12 tin, 1 platinum, slightly malleable.

Platinum and Steel.—A small proportion of platinum improves the qualities of steel in all points except liability to rust, which is increased.

PLATINUM AND NICKEL.—Equal parts make a fine malleable alloy of a pale yellow colour melting at a bright red. Not yet sufficiently examined.

PLATINUM AND COPPER.—The soft platinum used for chemical purposes is frequently alloyed with a small quantity of copper to give it hardness for dental purposes. This alloy, commonly used in England by dentists, is neither used nor saleable at the dental depôts in America, where the purer soft platinum alone is used. The peculiar harshness and rigidity of the copper alloy is objectionable, as the malleability of the platinum is greatly injured, although the rigidity enables the plates to be made much thinner for the same stiffness.

PLATINUM, COPPER, AND ZINC.—7 platinum, 16 copper, fused together under borax and then 1 part zinc added, is stated by Gmelin to yield a gold-coloured highly extensible alloy which does not oxydate by roasting, and is not attacked by boiling sulphuric acid.

PLATINUM AND MERCURY.—Spongy platinum combines with mercury when worked together in a warm mortar. This amalgam has not yet been sufficiently examined for dental purposes. It may be made as a paste and used for covering silver, &c., with platinum by driving off the mercury by heat and hammering the porous surface of platinum left.

Platinum and Silver.—This alloy, known as dental alloy, is exceedingly difficult to make uniform. A layer richer in platinum collects at the bottom of the crucible and becomes mixed in streaks in the ingot when poured. These streaks can always be seen when the alloy is blackened by immersion in hydrochloric acid.

The best way to make this alloy is to melt with excess of platinum in a fireclay crucible in the injector furnace at a heat just below the softening point of the crucible ; stir repeatedly with a claypipe stem, and pour quickly into an oiled ingot mould. If streaky it should be remelted, placing the button left in the crucible on the top of the metal which has been previously poured.

Hot sulphuric acid will remove the silver from the surface of the alloy, leaving a nearly pure face of platinum.

Platinum and Gold.—Platinum is frequently added to gold for dental purposes to produce a hard alloy. The hardness and elasticity of the alloy known as lemel, produced by melting dentists' waste, is principally caused by the platinum present. The use of platinum in gold for plates, so frequently recommended in America, is a mistake. It has not the permanence and resistance to acids shown by the ordinary alloy commonly used in England.

PLATINUM GIVES TO AMALGAMS the property of rapid hardening. The value of this property, discovered by myself some years ago, has been recognized by almost every maker of amalgams in the world. It communicates to an amalgam also the power of retaining its form after hardening; provided it is in sufficient quantity, but in this case it also causes a dirtiness in mixing in the hand which can only be remedied by adding a large proportion of fine gold. It is now a common custom of some makers to replace platinum by copper, copper having the same power to cause quick setting without, however, being able to prevent the objectionable change in form after hardening. The difference between the two can be usually recognized with ease by packing the amalgam in a glass cup of about $\frac{3}{8}$ in diameter and covering it with a coloured fluid and sealing over with wax. The changes in form will be readily seen from day to day—often lasting for months. For comparative testing the packing of these plugs must be done with great care, and the mercury must be in so small a quantity as not to work up to the surface, or the amalgam becomes irregular in composition in different parts and of no value as a test.

The peculiar dirtiness and adhesiveness in the hand caused by alloys containing platinum is simply the result of the perfect fit produced by the amalgam. To fill the general requirements of dentists at present this dirtiness, really a valuable quality, is not admissible, and it must be corrected by the addition of other metals.

Of the modern alloys for amalgams, all which I have examined, without exception, contain either platinum or copper, sometimes both. Those quick-setting alloys which are acknowleged not to contain platinum contain copper in its place, which, as before stated, does not communicate the permanence of form only to be obtained, so far as is known at present, by platinum.

PLATINUM AND IRIDIUM.—A small percentage iridium greatly increases the hardness of platinum and improves its qualities for all purposes except where softness is necessary.

PLATINUM FOIL coated with cohesive gold has been and is used for filling. The peculiar harshness of the metal render it difficult to insert a plug, except in the simplest cavities, so as to be water tight. When this can be done it makes exceedingly good work without the objectionable colour of gold, the plugs being almost white when finished.

PALLADIUM.

Atomic Weight, 106·5 *Symbol*, Pd.
Specific Gravity, 11·5 *Melting point*, about 1600 C.
Specific Heat, about 0·059

Found native in a pure state, and also reduced from ores containing it by processes too complicated and troublesome to be of interest to dentists. By igniting the cyanide or the ammonio-protochloride the metal is obtained as a light spongy mass, too dense, however, to use with mercury as an amalgam.

PRECIPITATED PALLADIUM may be prepared from a solution of any of its salts, or the metal may be dissolved in nitro-muriatic acid, the excess of acid being driven off by evaporating nearly to dryness and the resulting salt dissolved in water. From this solution the metal may be precipitated in a form suitable for dentists' use by metallic iron or zinc, the precipitate washed with weak nitric acid and dried.

It may be prepared to combine with mercury so as to set quickly or slowly by varying the strength of the solution, but it must be borne in mind that unless precipitated palladium sets very rapidly when mixed with mercury, it is totally useless for dental purposes: the plugs fail, unless fully hard, in so short a time that the amalgam is difficult to insert whilst it remains plastic. Plugs of palladium amalgam generally contain about 70 to 80 per cent. of mercury.

Palladium combines with antimony, bismuth, zinc, tin, iron and lead, forming very brittle alloys.

PALLADIUM AND NICKEL.—Malleable alloys taking a brilliant polish. Not sufficiently examined.

PALLADIUM AND SILVER.—An alloy very poor in palladium has been recently introduced under the name of "Palladium." This alloy is practically worthless, a large percentage of palladium is necessary to protect silver from the action of sulphuretted hydrogen, and the present excessive cost practically prohibits its use for this purpose. Pure palladium, if obtainable at a reasonable price, is the best metal known for plates for artificial teeth, owing to its high specific heat, its extreme lightness and hardness, requiring no alloy, and also to its absolute freedom from tarnish.

As an alloy, the presence of palladium in small quantities is frequently objectionable. It is, so far as is known at present, absolutely inadmissable, even in so small proportion as 1 in 2000 in silver for making amalgams. It is almost invariably present in every sample of silver, and may be separated by dissolving in nitric acid and precipitating the silver as chloride, the palladium and gold present in the silver being left in solution.

TIN.

Atomic Weight, 118	*Symbol*, Sn.
Melting point, 228°C.	*Specific Gravity*, 7·3
Specific Heat, 0·051	*Crystalline.*
	Malleable.

Resistance to crushing in lbs., sq. in., 15,000
Tenacity ,, ,, 5,000

PREPARATION.—The ore is roasted, to drive off sulphur and arsenic and convert the other metals into light oxides readily separated from the heavier tin stone by washing, and is then fused in contact with charcoal.

The purest tin in commerce is grain tin, easily recognized by its form, which is a mass of imperfectly formed crystals.

It almost invariably contains arsenic, and also frequently copper; for amalgams and special purposes it must be purified by oxydizing finely divided tin with excess of nitric acid, washing the resulting binoxide with hydrochloric acid and water, and reducing with charcoal in a crucible at a bright yellow heat approaching white.

ALLOYS OF TIN.

Tin 12, antimony 1, is the alloy called pewter. The addition of bismuth to tin lowers its fusing point considerably.

Tin 12, copper 2, antimony 3, forms a good alloy for casting dies, superior to zinc.

Tin 5, silver 4, Townshend's amalgam, is the common alloy in general use. This amalgam does not retain its shape after hardening: the plugs almost invariably lift at the edges after being in the mouth some time.

Tin 10, silver 8, gold 1, is an alloy also generally sold for amalgams. It is rather pleasanter to use than the preceding, but is not to be depended on for good work. Different makers vary the proportions slightly, but practically all are alike.

Tin 10, silver 8, gold 1, copper 1, has been largely used for some years both as the so-called gold amalgams and also the platinum amalgams. Copper in small quantity, from 5 to 7 per cent., has to a certain extent the property of replacing platinum in an amalgam giving the alloy the peculiar quick setting caused by platinum, and also preventing the dirtiness in the hand which is caused by platinum, and which with the latter metal requires to be corrected by the addition of gold in larger proportion.

Copper can only be considered an inferior substitute for platinum, as it imparts only to a very slight extent the permanence of form given by platinum. In the absence of platinum a very small proportion of copper distinctly improves any amalgam without affecting its colour to any appreciable extent.

Alloys containing Tin and Silver are always exceedingly difficult to make uniform, more especially if, as is almost invariably the case, the silver contains a trace of palladium, and they are never reliable for dental purposes without thorough and systematic testing for all required properties. The absence of palladium simplifies the matter to a great extent, but does not do away entirely with the difficulty.

FUSIBLE PLUGS.

Tin 5,	lead 3,	bismuth 7,	mercury 3,	fuses at	50° C.
„ 5	„ 3	„ 3		„ „	94° C.
„ 1	„ 2	„ 4		„ „	95° C.
„ 4	„ 4	„ 1		fuses at 320° F.	160° C.
„ 6	„ 1			„ 383° F.	190° C.

Modelling Trays.—When these are required of special shapes and the metal cannot be bought in the sheet, they may be made of tin cast and rolled to the right thickness; common tinman's solder or an alloy of tin 2, and lead 1, can be used for soldering the joints. Trays made of pure tin do not discolour and are far preferable to the ordinary pewter or Britannia metal trays.

Britannia Metal.—Tin 42, antimony 3, copper 1, brass 1.

Salts of tin, as a rule, are poisonous if soluble.

IRON.

Specific Gravity,	7·84	*Melting point* (pure)	1,600° C.
Specific Heat,	0·011	*Atomic Weight*,	55·9
		Malleable.	

Resistance to crushing in lbs., sq. in., 38,000
Tenacity „ „ 60,000

Not prepared on a laboratory scale.

Pure bar iron becomes soft at a red heat, and may be welded at a white heat.

If it contains sulphur it is brittle when hot: if phosphorus it is brittle when cold.

The successive shades of yellow, red, blue, and grey with which iron or steel becomes covered, are caused by very thin films of Ferrosoferric oxide—($Fe O Fe O^3$,) which transmit light more or less, producing the tints of Newton's coloured rings.

A Coherent Covering of the magnetic oxide, which preserves iron or steel from rust under ordinary conditions, may be formed by exposing the iron at a high temperature in closed chambers to the action of steam (Barff's process). Iron or steel may also be protected from rust by complete immersion in a weak solution of soda or any alkali.

Pure Iron.—Malleable or wrought iron.—This is largely used for workshop purposes, and its good qualities increase in proportion to its freedom from carbon, sulphur and phosphorus, which are, however, almost always present in varying proportions.

Steel.—Thin bars of pure iron are enclosed in pots filled with charcoal powder and kept at a red heat for 5 to 8 days. The carbon gradually penetrates the iron, forming steel. If the process is continued too long an excess of carbon is taken up and the bars fuse together, forming cast iron.

Indian Steel or Wootz contains a very small proportion of aluminium, and may be imitated by fusing steel with aluminium. It is distinguished by its extraordinary hardness.

Steel fuses at about 2530°C. At 215°C. it turns straw yellow, at 282°C. it becomes purple. By repeated exposure to a red heat in contact with air, steel is converted into iron, the carbon being burnt away: it is, therefore, advisable in making fine steel tools to heat them to the lowest temperature at which they can be worked, and to do this as seldom as possible. Steel may be readily melted in small quantities in the injector furnace, but it is difficult to make sound castings; they are almost invariably porous and full of bubbles; steel is usually cast under a very heavy head of metal or under hydraulic pressure.

BERLIN IRON CASTINGS.

CAST IRON contains more carbon than steel. It is more fusible than steel, and is extremely easy to melt in the injector furnace. The production of fine castings in iron is a very simple matter, and many of the castings now made in zinc would be better made in iron. The impressions which can be reproduced in cast iron are wonderfully delicate, and markings of almost microscopic fineness are reproduced with ease. There have been occasionally some very delicate castings exhibitied as curiosities, and which are made in Berlin. These are produced by grinding and sifting, or levigating fine casting sand until an impalpable powder is obtained which is mixed with paraffin oil or water and painted on the pattern. This is then backed up with common casting sand, which absorbs the excess of moisture

and adheres firmly to the fine coating, thus producing an exceedingly fine surface to the mould. By this means castings of intricate patterns, weighing only a few grains, are produced. I have had many castings of iron produced in this manner weighing from 2 to 5 grains, the surfaces of which were covered with delicate tracery. Ordinary cast iron when so thin as this is very liable to fracture, and is converted by the following process into malleable iron.

MALLEABLE IRON.—The carbon may be removed from cast iron, making it identical with wrought iron in chemical and mechanical properties, by enclosing the castings in close vessels, the space between the castings and the vessel being filled with chalk, ashes, or oxide of iron, so as to exclude air as much as possible: and heating to redness for several days, the time required depending on the thickness of the casting from which the carbon has to be removed.

SULPHIDE OF IRON (Spence's metal),—see Antimony.

ALLOYS.

IRON AND ZINC form a brittle alloy. It is this alloy which causes the so-called galvanized iron to be brittle and worthless when the zinc bath in which the iron is immersed is at too high a temperature.

Iron and Tin form a slightly malleable alloy which does not cause the same deterioration of the iron when tinned as when coated with zinc.

Cast iron 79, tin 19·5, lead 1·5, a good casting metal, giving sharp impressions.

TEMPERING STEEL.

	Fahrenheit.	Centigrade.
Light straw colour	430°	221°
Dark straw	470°	243°

The above for wood, ivory, and vulcanite tools.

Brown yellow	500°	260°

For gravers and tools for metal cutting.

Bright blue	550°	288°

For springs and saws.

Forging Fine Steel Instruments.—These must never be heated in an ordinary blowpipe flame, as it ruins the quality of the steel. Direct the jet downwards on a block of charcoal and heat the steel with the rebound of the flame from the charcoal, which gives a saturated bath of carbonic acid. In the absence of charcoal heat in the white part of the flame of a common lighting burner:—do not heat too quickly, and work at the lowest temperature possible, hammering until nearly cold. Harden by sticking the point into a tallow candle.

A thin coating of soap prevents scaling in hardening to a great extent, but not entirely. Polished instruments may be hardened and tempered without losing their polish by wrapping tightly with thin soft platinum foil. Chronometer springs are coiled on an iron or steel mandril, covered with platinum foil and hardened in the same manner without losing their polish.

NICKEL.

Atomic Weight, 58·6 *Symbol*, Ni.
Specific Heat, 0·103 *Specific Gravity*, 8·63
Melts at a blinding white heat, 1600 C.

PREPARATION.—Nickel oxide is mixed with about 5 per cent. of finely divided carbon, and exposed to a clear white heat in perfectly close vessels. It may be reduced in the injector furnace in a covered crucible in about 25 minutes, the heat required being just below the oftening point of the most refractory clay crucibles. If the nickel oxide is pure and in excess, the nickel obtained is malleable. If the carbon is in excess, the nickel is hard and brittle, the two forms corresponding to wrought or malleable, and cast iron. If nickel is fused with a small quantity of either manganese or aluminium it becomes very malleable and ductile, working with ease like soft wrought iron. In this form it might, and probably will, eventually, supersede wrought iron for all instruments where freedom from liability to rust is of importance. The cost has recently been greatly reduced, and is not now an insuperable objection to its free use.

Nickel is frequently reduced from its ores in combination with copper, forming an alloy which is used for making an alloy called Nickel silver, Spanish silver, German silver, and other ridiculous names, but which is in reality a nickel brass, *i.e.*, brass rendered white by the addition of a small proportion of nickel.

Nickel is largely used for electro-plating, and its valuable properties for this purpose are well known. Nickel plating cannot be economically done on a small scale, and it is now so cheaply done, depositing by dynamo-electric machines from the double chloride of nickel and ammonia, using a dissolving plate of cast or rolled nickel, that the process needs no further description. It has been proved that nickel plating does not entirely prevent the rusting of iron and steel. Where the total prevention of rust is necessary it is now usual to cover the steel or iron first with a deposit of bronze, and then covering this with nickel. The protection by this method is perfect.

The salts of nickel are poisonous and generally of very intense colour, so that its use as an alloy for fillings, although otherwise favourable, is out of the question.

ALLOYS.

Nickel and Iron unite in all proportions, forming an alloy similar in properties to iron and less liable to rust in proportion to the quantity of nickel contained in the alloy. The carbide, *i.e.*, nickel and steel, is, on the contrary, more liable to rust than steel alone.

German Silver, or Nickel silver, is an alloy of nickel, copper, and zinc, the best alloy in use being about 6 nickel, 20 copper, 8 zinc.

MAGNESIUM.

This is at present used only by dentists in the form of ribbon or wire to burn for the production of a white light of great power for matching artificial teeth and operations in the mouth in the absence of daylight.

The salts of magnesium are not poisonous.

MERCURY.

Atomic Weight, 200 *Symbol*, Hg.
Specific Heat, 0·032 *Specific Gravity*, 13·56
Boils at 350° C.

PREPARATION.—By distilling mercurial ores in contact with lime or oxide of iron to remove the sulphur.

PREPARATION IN PURE STATE.—1. By distilling corrosive sublimate mixed with iron filings. 2. By distilling red oxide of mercury and afterwards agitating with dilute nitric acid. 3. By boiling a solution of corrosive sublimate in a clean iron vessel. 4. By covering mercury with very weak nitric acid and heating for three or four hours: the latter process fills every requirement for dental purposes.

ALLOYS.

MERCURY AND SODIUM.—These combine in all proportions, forming a pasty or fluid alloy, which has the property of amalgamating many metals which do not readily combine with mercury alone; for instance, cast iron, if rubbed with this alloy, is

perfectly amalgamated, and admits of being soft soldered with a blowpipe or copper bit, making a firm joint which cannot be obtained by any other process of soldering.

To make this amalgam, place in a dry test tube a globule of mercury about twice the size of a pea, cut off a piece of sodium about half the size, carefully free it from naphtha with blotting paper, then cut it into a number of very small bits, and having heated the mercury slightly, add the bits of sodium one by one. The metals will combine with a slight explosion, forming a pasty amalgam, which must be kept in a closely stoppered bottle.

MERCURY AND POTASSIUM.—Similar to the above.

MERCURY AND BISMUTH.—Similar in many properties to the amalgam of copper and mercury known as Sullivan's amalgam (see Copper), but not practically applied for fillings at present.

MERCURY AND ZINC.—Similar to above, but brittle.

AMALGAMS FOR FILLING TEETH.—See Copper, Tin, Silver, Palladium and Platinum.

MERCURY AND NICKEL.—Not permanent, the nickel oxydizes out on exposure to air, leaving fluid mercury.

Mercury in Alloys and Amalgams.—It is the common custom for alloys, made with the greatest precision and care, to be mixed with varying proportions of mercury according to the ideas of the user. It is well known, and also appreciable to all who give the matter a thought, that a variation in one constituent of an alloy alters the whole character of the compound, that a variation in mercury is no more to be permitted than a variation in any other metal where uniform results are expected. It is therefore an absolute necessity that the proportions of alloy and mercury shall be weighed. Until this is done uniform results are not to be expected.

The salts of mercury are poisonous.

ALUMINIUM.

Atomic Weight, 27·5 *Symbol*, Al.
Fusing point, 700° C. *Specific Gravity*, 2·6

Prepared by reducing the oxide (alumina) by potassium or sodium with the assistance of heat.

Alloys with iron, but the alloy is little known. Fused with copper, it forms what is known as aluminium bronze or aluminium gold.

Aluminium at one time was expected to prove a valuable material for artificial dentures. Why a metal so readily soluble in alkalis and in hydrochloric acid should ever have been used in the mouth with any hope of permanence it is difficult to understand; the slightest chemical knowledge would have prevented a blunder which could hardly be anything but an expense to the dentist and an annoyance to the wearer.

The salts of aluminium are not poisonous.

ANTIMONY.

Atomic Weight, 122 *Symbol*, Sb.
Specific Gravity, 6·7 *Melting point*, 512° C.
Tenacity in lbs., sq. in., 1066 *Specific Heat*, 0·050

Stated by Holtzapffel to expand in cooling.

PREPARATION.—Heat 8 parts by weight of sulphide of antimony—mixed with 6 parts of cream of tartar, in a crucible to near redness, and add sufficient nitrate of potash (2 to 3 parts) until the mass is perfectly fused: Or, a mixture of 177 parts of sulphide of antimony with 82 parts iron filings heated to bright redness in a closely covered crucible and allowed to cool without disturbance.

The iron takes up the whole of the sulphur at a low red heat, but the mixture requires a bright heat to fuse the sulphide of iron and metallic antimony to enable them to separate into layers in the crucible.

Pure antimony fuses before the blowpipe on charcoal, forming a shining bead which burns completely away with evolution of inodorous vapours, and becomes covered, on cooling, with white needles of antimonic oxide. Impure antimony exhales a garlic odour when fused, becomes covered with slag, has a dull surface, and ceases to burn when the blowpipe flame is withdrawn; the oxide given off is also yellow.

A solution of antimony in nitro-muriatic acid gives a yellowish red precipitate with hydrosulphate of ammonia: the precipitate is perfectly soluble in excess of the precipitant. A black precipitate denotes the presence of impurities—probably lead, iron, or copper.

SPENCE'S METAL.

Antimony Sulphide.—This, like most of the metallic sulphides, may be dissolved with the aid of heat in excess of sulphur, forming a compound known as Spence's metal, which can be used for casting purposes. These compounds are, however, too brittle for the usual requirements of dentists, although they possibly might be useful for forming dies in some cases where plaster of Paris is too soft.

Alloys of Antimony, with Bismuth, Zinc, Tin, Lead, Copper Nickel, Silver, Mercury, Gold, Platinum and Palladium, are all white and brittle when the antimony is in excess.

Antimony 4, tin 5, and silver 4, has been used as an alloy for amalgams; but it has no properties essentially different from other common amalgams in which antimony is absent.

Casting Metal for Dies.—Copper 2, antimony 3, tin 12: the antimony must be added after the other metals are perfectly fused and mixed. This makes a much harder die than zinc, and is in many respects superior.

The salts of antimony are poisonous.

COPPER.

Atomic Weight, 63 *Specific Gravity*, 8·72
Specific Heat, 0·095 *Melts at* 1173° C.
Symbol, Cu.

Found native or reduced from the oxide by fusion with charcoal.

Welds at a red heat.

If exposed to air during fusion it absorbs oxygen which is given off in cooling, causing the mass to be porous. If melted under charcoal or common salt this does not take place, and a solid casting may be obtained.

Copper Sulphide.—See Antimony.

ALLOYS.

Sullivan's Amalgam.—Precipitate from a weak solution of sulphate of copper by rods of pure zinc. Wash the precipitated copper with strong sulphuric acid (the addition of a small quantity of nitrate of mercury assists greatly), and add mercury in the proportion of 3 copper to 6 or 7 mercury. This alloy has the property of softening with heat and again hardening

after a few hours. It is an absolutely permanent filling, as the copper salts penetrate and perfectly preserve the tooth. If after a time the filling is removed the decay is still permanently arrested, owing to the protecting action of the copper salts absorbed. The intense blue black colour of the teeth in which this alloy is used is the only objection to its use, as the loss in weight by solution in the mouth is so small as not to be injurious, although the alloy is intensely poisonous if dissolved.

1 copper, 2 bismuth, expands strongly on cooling.

7	copper,	3	zinc,	Ordinary brass.
26	„	34	„	Hardest alloy.
91	„	9	„	Most malleable alloy.
33	„	67	„	Most tenacious alloy.
31½	„	68½	„	A white alloy.

6 brass, 5 silver, 2 zinc, common silver solder;
13 copper, 12 pure silver, fine silver solder.

19	copper,	1	tin,	malleable bronze, fuses	1,300° C.
9	„	1	„	gun metal, fuses	1,160° C.
4	„	1	„	bell metal „	1,050° C.
2	„	1	„	1-10 arsenic, speculum metal.	
10	„	4 nickel, white as silver.			
2	„	1 zinc, nickel silver (so called).			

Copper 10, arsenic 1, is so similar in appearance to silver as to have been substituted for it.

Copper 3, lead 1 to 1½, pot or cock metal, used for very common brasswork.

Copper 6, zinc 4, Muntz metal, will roll and work at a red heat.

Copper 1, zinc 1, spelter solder for brazing.

Ordinary brass is sensibly hardened by a very slight addition of tin.

The salts of copper are poisonous.

LEAD.

Specific Gravity, 11·39	*Symbol*, Pb.
Melting point, 334° C.	*Atomic Weight*, 206·4
Specific Heat, 0·030	*Boils at* 1040° C.

Resistance to crushing in lbs., sq. in., 7000
Tenacity „ „ 1824

PREPARATION.—Native Carbonate, or Litharge, is fused in contact with charcoal. If the ore contains sulphur it requires to be roasted previous to its fusion.

Native lead almost always contains gold and silver, and a large portion of the silver of commerce is obtained from this source.

LEAD SULPHIDE, Spence's metal.—See Antimony.

ALLOYS.

LEAD TIN.—Unite in all proportions, forming soft solder. The alloy is harder, more tenacious, and more fusible than either tin or lead alone.

5 lead, 8 bismuth, 3 tin, form an alloy which fuses below the boiling point of water.

The salts of lead are poisonous.

Metallic lead in sheet has frequently been used for fillings; in fact, the French word for filling, *plombage*, which means leading, comes from the general use of lead for this purpose. I have seen plugs of lead foil which have remained perfect in the mouth for a great number of years.

BISMUTH.

Atomic Weight, 210
Specific Heat, 0·029
Symbol, Bi.

Specific Gravity, 9·654
Melting point, 260° C.
Crystalline.
Not malleable.

PREPARATION.—Found native, requires a gentle heat to fuse it from the matrix.

PURIFICATION.—Dissolve in nitric acid, pour the clear solution off, and precipitate by the addition of water. The pure mono-nitrate of bismuth which is precipitated is mixed with charcoal and fused in a crucible to reduce it to the metallic form. The mass when cold and broken is composed of brilliant reddish white crystals, which show little or no tendency to tarnish when exposed to air for a long period.

Bismuth when fused expands in solidifying, and communicates this property to alloys containing it. It also considerably lowers the fusing point of any metal or alloy.

ALLOYS.—The addition of bismuth to amalgams makes them excessively sticky and adhesive, necessitating, at the same time, an increase in the proportion of mercury required.

Amalgams containing a trace of bismuth will build and adhere to a flat dry surface, and may be used as a metallic cement for joints in apparatus which require to be perfectly air tight and to stand heavy pressures. A good alloy for this purpose is 1 bismuth, 15 tin, 15 silver, fused and filed up, and then mixed in the proportion of 1 alloy to 4 of mercury. This alloy is so excessively sticky as to be useless for fillings.

An alloy of 3 parts each bismuth, fine gold, and platinum with 15 of fine silver, and 10 of tin, is very similar to precipitated palladium, and has been used as a substitute for this costly metal. One curious point about this alloy is that if it contains the merest trace of palladium it is almost worthless; and, as ordinary fine silver is rarely if ever free from palladium, this alloy can only be made from silver reduced direct from the chloride. 8 bismuth, 5 lead, 4 tin, type metal forms the fusible alloy used on the Continent for producing the beautiful casts of the French medals by the clichée process.

1 bismuth, 2 tin: the best alloy for turning in the lathe. Used for producing patterns of rose engine and geometric turning for printing from.

The salts of bismuth are not poisonous.

ZINC.

Atomic Weight, 65 *Specific Gravity, cast* 6·9, *rolled* 7·2

Specific Heat, 0·092

Melting point, 411° C. *Malleable and ductile, more especially when warm.*

Symbol, Zn. *Boils at* 1040° C.

Tenacity in lbs., sq. in., 8000

Preparation.—Zinc oxide, or the roasted native carbonate or silicate, is mixed with one-eighth its weight of charcoal powder, and heated to whiteness in retorts of earthenware or iron. The zinc is reduced and volatilized, and condenses in the colder parts of the apparatus.

Purification.—After repeated use as dies, zinc becomes thick and useless. It can be perfectly purified for use by the following processes. The first is recommended as the best and simplest.

1.—Heat the zinc to dull redness in a ladle and pour on it a small quantity of strong hydrochloric acid, stirring sharply with a stick; the evolved gases ignite on the surface, and a thick dross separates and floats on the metal. About one tablespoonful at

once, repeated two or three times at intervals of a few seconds, will perfectly clear 10 or 12 lbs. of zinc. This process does not remove iron.

2.—Sulphur, mixed with grease, is sharply stirred about at the bottom of melted zinc in order to convert the foreign metals into sulphides.

Neither of the above processes will remove lead, which can be got rid of by allowing it to settle and cutting it out. The lead can readily be formed by a chisel owing to its softness.

SULPHIDE OF ZINC.—See Antimony.

OXIDE OF ZINC.—This is largely used in filling materials. The oxide for this purpose is prepared in several different ways.

1.—The heavier part of the sublimed oxide formed by the combustion of metallic zinc is collected from the flues and separated by passing through a winnowing apparatus or other means.

2.—Pure zinc oxide is compressed into porcelain crucibles and heated to intense whiteness for a time, depending on the size of the crucible. The semivitreous mass obtained is broken up by stamps and separated by sifting through silk sieves.

3.—The oxide is rammed into strong steel chambers and exposed to a hydraulic pressure of not less than 90 to 100 tons on the square inch. The hard, marble-like block obtained is cut out with chisels, broken up by stamps, and sifted as before described.

4.—Pure metallic zinc is dissolved in pure nitric acid, the solution evaporated in porcelain vessels until it solidifies in cooling, and then is heated to redness in porcelain crucibles. If the heat is gradually applied the oxide may be produced by this process in fairly large crystals which are almost as hard as corundum.

The oxide prepared by 1 and 4 is sufficiently hard to cut glass, and the difference between the oxides prepared by the above processes can be readily distinguished by the microscope.

Zinc oxide in an extremely dense form is also produced by the reduction of heavy zinc compounds, such as the silicate, or zinc spar (carbonate) with or without the assistance of other substances, and with the assistance of heat. It is probable, however, that these processes are superseded for the simple and more satisfactory ones given previously. Although not a zinc compound, it may be as well to mention here that a mixture of sulphate of lime and oxide of iron, corresponding to what is now known as Roman Cement, has been used for fillings, but the colour is objectionable, and the reports as to its permanence are not satisfactory.

ALLOYS.

ZINC ANTIMONY.—Hard brittle steel coloured alloy. Properties little known.

ZINC BISMUTH.—Do not combine readily, and separate on fusion.

ZINC LEAD.—Same as zinc bismuth. A mixture of these metals, which can hardly be considered a true alloy, is used for composition gas piping.

ZINC TIN.—This alloy in almost any proportion is superior to zinc alone for dies. The impression from the sand is much finer, the shrinkage in cooling is greatly reduced and is more equal. 2 zinc, 1 tin, will probably be found the best proportion.

Owing to the low temperature at which this alloy melts care must be taken to have the dies perfectly cold before pouring on the lead for the counter die, and the lead must be barely hot enough to pour and not sufficiently hot to char a slip of paper.

CADMIUM.

Atomic Weight, 111·6	*Symbol*, Cd.
Melting point, 320° C.	*Specific Gravity*, 8·6
Specific Heat, 0·038	*Crystalline.*
	Malleable.

PREPARED from the sulphide by dissolving in strong hydrochloric acid and the excess of acid expelled by evaporation. The cadmium is then precipitated by carbonate of ammonia added in slight excess, to re-dissolve any copper or zinc which may be present. The precipitate is washed, heated to redness, mixed with thoroughly ignited lampblack and heated to redness in glass or earthen retorts: the metal then distils over. In colour and lustre it has a strong resemblance to tin, but is harder and more tenacious. It is very ductile, malleable, and nearly as volatile as mercury, condensing like it into globules which have a metallic lustre; its vapour has no smell. When heated in the open air it becomes slowly converted into oxide. The sulphide of cadmium, which frequently forms on plugs containing this metal, is yellowish orange in colour and is insoluble in alkalis.

THE USE OF CADMIUM has been so repeatedly condemned for all dental purposes that a notice here

would be unnecessary but for the fact that it has again been recently introduced in amalgams, to which it imparts the property of malleability.

MALLEABLE AMALGAMS, which owe their peculiar properties to the presence of cadmium only, cannot be too strongly condemned, and those who make and offer them for sale damage the reputation of the unfortunate dentists who are persuaded by their plausible statements to use compounds which, if the makers know anything, they must know are utterly worthless.

Cadmium may be detected in an alloy by its forming brownish yellow or red film on charcoal if heated by the blowpipe.

THE ALLOYS have no practical value to dentists. Cadmium was first introduced as a filling material by Dr. Evans, of Paris, in 1848, the alloy he used being tin, with a small proportion of cadmium.

or pink) to each ounce of powder will give a medium shade for fillings, or a gum colour. The 2 oz. powder bottles will be supplied either colour, ready for use at same price.

EXTRA PLASTIC AMALGAM.—Free from discoloration, and an absolutely permanent filling in all cases. 21s. per oz. ; 5 oz. packets, 95s.

ARTIFICIAL DENTINE.—Nerve capping, Oxy-sulphate of zinc. 4s. per packet.

WHITE ENAMEL.—Oxychloride of Zinc. 6s. per packet. Powder only 4s. Liquid in drop bottles, 2s. Liquid in corked bottles, 1s. Powder in bulk, 40s. per lb. troy.

COPAL ETHER VARNISH.—A water-tight varnish which will adhere to a damp surface. 1s. per bottle ; 6s. per half-pint.

CARBOLIZED RESIN.—For nerve treatment. 1s. per bottle ; 6s. per half-pint.

AMALGAM BALANCE, to obtain the exact proportion of mercury and filings without weights, 2s. 6d. each.

MIXING TUBE, for amalgams, 3d. each.

FLETCHER'S NEW MERCURY BOTTLE, containing sufficient pure mercury for 3 to 4 ozs. of filings, 1s. ; or with Johnson, Matthey, & Co.'s mercury (ELECTRICALLY PURIFIED), 2s.

CYLINDER MOULD, for working amalgams into cylinders ready for use, 8d.

BONE SPATULAS, for mixing White Fillings, 4d. each.

STEEL SPATULAS, nickel plated, 3s. each.

The following method of mixing amalgams is so simple, and so faultless in every point, that every dentist is most urgently desired to use it exclusively:—

To use this method weigh with the new differential balance, the proportions re-

Price 2s. 6d.

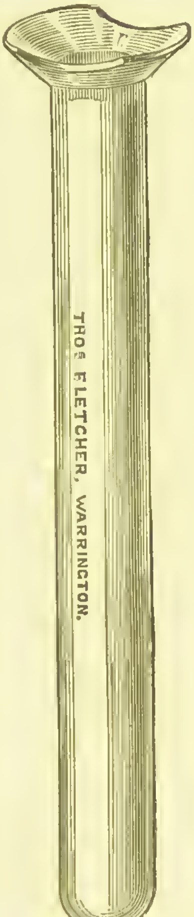
quired by putting mercury in the cup E.P. for the Extra Plastic Amalgam, or in the cup P.L. for the Platinum Amalgam, then pouring filings into the cup F. until the mercury is balanced.

F.—E.P. give 3 filings to 1 mercury (extra Plastic).

F.—P.L. give 4 filings to 1 mercury (Platinum).

Put the finger over the mercury, pour the filings into the mixing tube, then the mercury, and shake briskly for a few seconds, covering the open end of the tube with the finger.

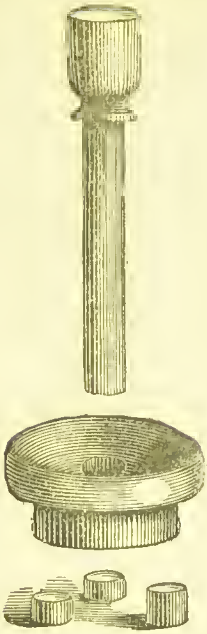
The resulting mass is in the best possible form for working into discs, with the cylinder mould.



Mixing Tube, full size, Price 3d.

FLETCHER'S NEW MERCURY BOTTLE, containing sufficient pure mercury for 3 to 4 oz. of filings, 1s.; or with Johnson, Matthey, & Co.'s mercury (ELECTRICALLY PURIFIED), 2s.

Mercury Bottle, full size.



Cylinder Mould,
Price 8d.

Balance mixing tube, and ebony cylinder mould complete, free by post 3s. 6d.

Any alloy is greatly improved in its working by this method of mixing, and perfectly uniform results are obtained with the greatest ease. Less mercury is required to obtain firm cylinders, and all is taken up with uniformity throughout the fillings, which is *not the case with any other process of mixing known at present.*

With ordinary scales the weighing of proportions is a nuisance, but the little balance does all required in the simplest way without the use of weights and with practically no trouble.

WHEN WORKED IN THE ABOVE MANNER THE IMPROVED EXTRA PLASTIC AMALGAM WILL BE FOUND, BOTH IN COLOUR, PERMANENCE, AND EVERY PROPERTY, THE NEAREST TO PERFECTION OF ANY KNOWN FILLING, GIVING RESULTS WITH EASE WHICH EQUAL THOSE OBTAINED WITH THE PLATINUM AMALGAM BY THE MOST SKILLED OPERATIONS ONLY. It must not be understood that slovenly, careless work will give the best results; on the contrary, this material responds and repays the utmost skill of the best operators, requiring only much less time to produce the same results.

This process of mixing is now invariably used in my daily ingot testing, in which plugs of about half-inch cube are made with my amalgams, absolutely and permanently tight to the extreme edge against the most penetrating dyes, and I will undertake to make in the mouth the largest plugs equally perfect in cavities either WET OR DRY.

NOTE.—*EXTRA PLASTIC AMALGAM.—If the above process is not used, this must be mixed in a small mortar. It cannot be mixed in the hand, as it adheres most tenaciously to any dry surface.*

NOTE. The paste [illegible] ... is of no importance. If it becomes [illegible] it should be returned direct to me for exchange. (No charge.)

FLETCHER'S

PATENT PORCELAIN CEMENT.

INSTRUCTIONS.

The Cement [illegible] packet. Eight grains of colour [illegible] of pink [illegible] of powder will give a medium shade for filling [illegible] point [illegible].

Mix a small quantity of the "Porcelain," which is in the form of a thick fluid or jelly, with as much powder as can be incorporated, working thoroughly and quickly with a [illegible] spatula. It is much firmer than an oxychloride, and packs well even when apparently set. Finish with a burnisher, slightly oiled to prevent sticking, and varnish carefully. Protection from water is not essential, but the best results can only be obtained when water is excluded by careful varnishing.

If the Cement is properly mixed with sufficient powder, it becomes hard in about two minutes, and will ring if struck with a steel instrument ten minutes after mixing. If mixed to set slower than this, the results in the mouth are not so good.

Repairing Rubber.—Cut dovetails, and pack in one piece without a joint, using the pink colour. An oily burnisher gives a hard polished face, and the case may be worn in ten minutes if the Cement is protected with varnish.

For Grey or Brown.—Colour as required; secure dry [illegible] in the usual manner; burnish and varnish. When left rough and unvarnished the Cement has a dull appearance, which disappears in the mouth.

Packets, 5s.; Powder alone (any colour) in 2oz. bottle, [illegible]; Porcelain Paste (*Patent*), and jar, 2s.; Colour, brown or pink, 6d. per tube; Copal Ether Varnish, 1s. per bottle.

FLETCHER'S

PATENT-PORZELLAN-CEMENT.

Der Cement wird, wenn es nicht anders auf den Paqueten [illegible], ungefärbt versendet. Für Füllungen [illegible] auch für [illegible] Zahnfleisch geben acht Gran Farbe eine Matt-Schattirung. Auf Wunsch wird [illegible] schon mit Farbe vermengt [illegible] Gebrauch fertig: Pulver in 2 Unzen-Flaschen zu demselben Preise geliefert.

GEBRAUCHS-ANWEISUNG.—Man mische eine kleine Quantität des "Porzellan," der die Consistenz einer dicken, gallertartigen [illegible] besitzt, mit so viel Pulver, als sich damit verbinden lässt, und arbeite es mit einem steifen Spatel durch. Dieser Cement ist bedeutend [illegible] als ein Oxychlorid und bindet sehr gleichförmig wenn er [illegible]. Man finire mit einem Polirer, der schwach geölt ist, um dem Ankleben zu begegnen und bestreiche sorgfältig mit Firniss. Schutz vor Nässe ist zwar nicht wesentlich; die besten Resultate jedoch können nur erzielt werden, wenn die Feuchtigkeit abgehalten und sorgsam gearbeitet wird.

ZEIT DES ERHÄRTENS.—Wenn der Cement mit Sorgfalt gemischt [illegible], erhärtet er in ein bis zwei Minuten. Es kann zwar das Erhärten verzögert werden, wenn man weniger Pulver verwendet, [illegible] empfiehlt sich letzteres nicht, indem der beste Erfolg sich [illegible] ergiebt, wenn der Cement mit soviel Pulver gemischt wird, als zum schnellen Erhärten nothwendig ist.

CAUTCHOUC ZU REPARIREN.—Man schneide Schwalbenschwanz und stopfe genau in der selben Weise wie mit Cautchouc, in dem man [illegible] Farbe verwendet. Ein geölter Polirer giebt eine harte, glänzende Oberfläche und die Form kann in zehn Minuten entfernt werden, nachdem der Cement durch Firniss geschützt ist.

VERWENDUNG FÜR ZAHNFLEISCH ODER BLOCKZÄHNE.—Man [illegible] nach Bedürfniss, befestige durch Oesen an den [illegible] Platte und firnisse. Lässt man den Cement [illegible], so erhält er ein stumpfes Ansehen und sticht im Munde ab.

Preis pro Paquet 6 sh.; Pulver allein jede Farbe [illegible] Flaschen von [illegible] Unzen Inhalt 10 sh.; Porzellan Paste (patent) pro Krug 2 sh.; [illegible] Firniss 1 sh. per Flasche.

PLOMBAGE-PORCELAINE BRÉVETÉ DE FLETCHER.

Le plombage se livre à l'état incolore, à moins de mention contraire indiquée sur l'enveloppe. Il suffit d'ajouter 8 grains (0 gramme 50) de substance colorante (brune ou rose) par once (30 grammes) de poudre pour obtenir une teinte moyenne convenable à la plupart des obturations [illegible]. On livre au même prix les flacons de poudre [illegible] mélangée de l'un ou l'autre des principes colorants, c'est-à-dire prête à servir.

MODE D'EMPLOI.—Mêler une petite quantité de la "porcelaine," qui se présente sous l'aspect d'un liquide épais gélatiniforme, avec la proportion de poudre capable de s'y incorporer, en ayant le soin de malaxer le tout, d'une manière complète et rapide, à l'aide d'une spatule [illegible]. Le composé est beaucoup plus ferme que les [illegible] et il se laisse comprimer et tasser convenablement, même lorsqu'il parait s'être solidifié. On terminera l'obturation avec un [illegible] légèrement huilé pour l'empêcher d'adhérer à la surface du plombage, qu'il faudra ensuite vernir avec soin. Il n'est pas indispensable de protéger le ciment contre le contact des liquides buccaux [illegible], les meilleurs résultats ne s'obtiennent qu'à la condition [illegible] exclure l'humidité par un bon vernissage.

TEMPS NÉCESSAIRE À LA SOLIDIFICATION.—Manipulé convenablement, le ciment doit prendre au bout d'environ deux minutes. On [illegible] retarder la solidification en employant une moindre quantité de poudre; mais il ne faut agir ainsi qu'en cas d'absolue nécessité, [illegible] les meilleurs résultats exigent une prise rapide du ciment.

RÉPARATION DES PIÈCES DE CAOUTCHOUC.—Découper des queues [illegible], dans lesquelles on foulera le composé de couleur rose, comme [illegible] de caoutchouc. L'action d'un brunissoir huilé donne une [illegible] et polie, et la pièce peut être remise dans la bouche au bout de deux minutes, si l'on a le soin de protéger le ciment avec une couche de vernis.

[illegible] ARTIFICIELLE.—Employer la pâte de couleur rose, [illegible] adhérence à la plaque selon les procédés ordinaires; polir [illegible]. Le ciment qu'on laisse rugueux et non vernis a une appar[illegible] disparaît dans la bouche.

FLETCHER'S PLASTIC FILLINGS.

PLATINUM AMALGAM. [illegible]

packets, 90s. Fine or medium [illegible]

PORCELAIN CEMENT. [illegible]

per packet. Separately, powder, 4[illegible] [illegible]

1lb. troy, 50s.

EXTRA PLASTIC AMALGAM. Free from [illegible]

lutely permanent filling in all cases. 21s. per oz. [illegible] 5 oz. packets [illegible]

ARTIFICIAL DENTINE. Nerve capping. Oxysulphate of Zinc [illegible]

per packet.

WHITE ENAMEL. Oxychloride of Zinc. [illegible] per packet [illegible]

only, 4s.; Liquid in drop bottles, 2s.; Liquid in corked bottles [illegible] Powder in bulk, 40s. per lb. troy.

COPAL ETHER VARNISH, 1s. per bottle; 6s. per half pint.

CARBOLIZED RESIN, 1s. per bottle; [illegible] per half pint.

AMALGAM BALANCE, to obtain the exact proportion of [illegible] filings without weights. 2s. 6d. each.

MIXING TUBE, for amalgam, 3d. each.

FLETCHER'S NEW MERCURY BOTTLE, containing [illegible] pure mercury for 3 to 4 ozs. of fillings. 1s.; [illegible] with Johnson Matthey and Co.'s mercury (ELECTRICALLY PURIFIED), 2s.

CYLINDER MOULD, for working amalgams into cylinders ready for use. 8d.

BONE SPATULAS, for mixing White Fillings, 4[illegible]

Steel spatulas, nickel plated, 3s. each.

THOMAS FLETCHER,

4, MUSEUM STREET,

WARRINGTON.

PLEASE READ THE INSTRUCTIONS

PRICE 3D.

THE USE OF

GASEOUS FUEL,

WITH SPECIAL REFERENCE

TO ITS APPLICATION TO

LABORATORY FURNACES.

BY

THOMAS FLETCHER, F.C.S.

Reprinted from the Journal of the Society of Arts, April 30th, 1880.

PRINTED AT THE GUARDIAN OFFICE, WARRINGTON.

THE SILVER MEDAL OF THE SOCIETY OF ARTS WAS AWARDED TO MR. FLETCHER FOR THE FOLLOWING PAPER.

Reprinted from the JOURNAL SOCIETY OF ARTS, *April 30th, 1880.*

Society of Arts, London.

NINETEENTH ORDINARY MEETING, Wednesday, April 28th, 1880.

Lord ALFRED S. CHURCHILL, Chairman of the Council, in the Chair. The Paper read was

The use of Gaseous Fuel, with special reference to its application to Laboratory Furnaces.

BY THOMAS FLETCHER, F.C.S.

The first point to be considered is the special nature of the fuel. It must be understood that my remarks apply, in many points, equally to the ordinary gas, as made from coal, for lighting purposes, and also to air charged with the vapour of the lighter petroleums and other hydro-carbons. When gas is made from coal, a part only of the coal is volatilised and converted into gas. To get an idea of the actual fuel value of ordinary gas, I will take the results as obtained at the Manchester gasworks, where a mixture of 75 per cent. of cannel and 25 per cent. of coal is used.

Fuel value of Gas.

From one ton of this mixture the residue is about 13 cwt. of coke, 13 gallons of tar, and 25 gallons ammonia liquor. The gas produced measures 10,000 cubic feet, which, if reduced to the solid form again, would weigh about 350 lbs. If we calculate this at, say, 1s. 2d. per cwt., which is a liberal allowance for its fuel value, we get the working value of gas as a fuel at about 4½d. per 1,000 cubic feet. The actual cost of the gas as delivered into tho mains, including the labour, fuel, and materials used, is about 1s. 1d. or 1s. 2d. per 1,000 feet. When these figures are compared with the cost of gas to the consumer, the difference is startling, and the fact is brought pretty forcibly to our minds that we have an excessively costly fuel to deal with.

In actual use, and when burnt with proper attention to details, it is not even so costly a fuel as coal for work which requires heat on a comparatively small scale and at intervals; in fact, for most of the work to be done in small laboratories, and also for cooking purposes, it has proved itself to be a cheaper fuel than coal or coke, owing not only to the fact that every cubic foot of gas burnt may be made to render its full duty, but also when the necessary work is done, the expense is instantly stopped.

Fuel value of Petroleum.

Gasolino, benzoline, and petroleum, which are hydro-carbons, are all practically the same as coal-gas in composition, varying only from each other in the temperature at which they begin to give off inflammable vapour. If we take them weight for weight with gas, a simple calculation shows them to be worth, as fuel, about 10½d. per gallon, coal gas being 3s. 6d. per 1,000 cubic feet, one gallon being about equal in fuel value to 250 feet of gas.

It must be clearly understood, in referring to the comparativo cost of the liquid hydro-carbons, that the value, as compared with coal-gas, is only true when they are burnt as gas or vapour.

Spray Furnaces.

When used as spray with steam, or a cold-air blast, the cost is very greatly increased, owing to the large quantity which is mechanically carried into what is practically a bath of carbonic acid gas, in or at the back of the fire, and which partially or entirely prevents its combustion. The duty obtained in spray furnaces is exceedingly low, and they are—so far as my experience enables me to judge—most costly and wasteful of fuel, unless a hot blast is used, so as to entirely vapourise the liquid before it begins to burn.

The figures I give are necessarily vague. Gas varies in quality, not only in every town, but also to a limited extent in the same town from day to day, and any exact figures for one place would not be correct for another. I simply give a rough idea of the fuel we have to do with as regards its practical value. When we consider the cost of gaseous fuel, it becomes of serious importance that the method of burning, so as to obtain a high duty, requires careful study.

So much has already been done that gas, even at its present high price, may be fairly considered a cheap fuel both for workshop and domestic use.

Before saying anything as to the flame to be used in furnace burners, I will explain the material used to retain the heat, and without which I believe it would be impossible to obtain many of the results which I will at the conclusion show you. It certainly would be impossible to obtain them without a very greatly increased consumption of gas. The material, of which all the furnace casings you see here to-night are made, is produced by a process patented by myself some years ago. It is a mixture of one part of refractory fire-clay or ganister, and from three to six parts of sawdust, the proportions being taken dry, by bulk. These are mixed, preferably with rice-flour paste, but water may be used for the heavier varieties, until slightly cohesive, rammed into moulds, and fired in an open kiln, with free access of air, so as to burn the sawdust out. The result is, a cellular clay, similar in texture to bread, and which retains the heat so perfectly that I can, in this casing, which is only one inch thick, melt a crucible full of cast iron, and then take the whole in my bare hands and carry it about. It will probably be better at once to explain the mode of making air-gas from benzoline or petroleum spirit, as my future remarks, except, perhaps, for blow-pipe use, will include both air gas made from spirit petroleum, and also coal gas. I find, with my more recent pattern of burners for both draft and blast furnaces, that coal gas and air gas may be used interchangeably, and for many of the more delicate purposes I prefer the air gas, as being free from sulphur. The generator which I now show you contains a layer of spirit petroleum at the bottom. In this the ends of cotton screens stretched on wire are immersed, the spirit is absorbed and carried by capillary action up the cotton, exposing a large surface of spirit to the air which is blown through. To perfectly saturate the air with the vapour, this box is divided lengthways in such a manner that the air passes backwards and forwards four times the length of the box, and in traversing this distance has to pass through thirty-two cotton screens, each about five inches square. A similar arrangement is used by the Sun and Alpha air gas apparatus, these having also a mechanical blowing arrangement. They are, however, excessively costly for furnace work, having complicated and bulky parts, totally unnecessary except for lighting purposes.

Process of making castings.

Air Gas making.

Description of generator.

Before going further, I must set right one great misconception with regard to the heat obtained from a gas flame. Many people imagine that a Bunsen, or blue smokeless flame, gives a larger quantity of heat than an illuminating flame. This is not the case; if the gas is equally well burnt, the total amount of heat from each

Heat from different flames.

is precisely the same, but the heat differs in one most important point in character.

Radiated heat.

The radiated heat, *i.e.*, that which travels in straight lines in all directions from the flame, and which makes the pleasant feeling of a bright fire, is far greater in quantity from an illuminating flame than from a blue one. If we want to cook a joint of meat by gas, and get the same satisfactory result as when roasted before an open fire, we use the direct radiated heat from illuminating flames placed over the meat, and inside the oven. If, without altering anything else, we convert the illuminating flame into a blue one by mixing air with the gas before burning, our cooking is practically at an end; the radiated heat disappears almost entirely, and, to get any result, we must now put the meat over the flame, and bake instead of roasting it. As you see, the hand may be held almost in contact with a non-illuminating flame, obtained by burning a mixture of gas and air. When I stop the air supply, the radiated heat becomes so intense as to be unbearable.

Its use in cooking.

Temperature of illuminating flame.

The actual temperature of an illuminating flame is very high, much higher than that of a blue flame; in fact, in a good illuminating flame, at the point where the white part commences, near the centre, it is sometimes possible to fuse an exceedingly fine platinum wire. It is this very high temperature which, to a great extent, causes the radiated heat observed; and, for the same reason, it is useless to expect a satisfactory gas fire made by heating blocks of asbestos with a gas flame, until a very much higher temperature flame is used than is the case at present.

Solid and hollow flames.

When we have a crucible or solid body to heat, radiated heat is not wanted, and the most economical plan, so far as is known at present, is to use a blue smokeless flame, and to place the body to be heated in actual contact with it. By this means, the heat is rapidly taken up from the flame without the deposition of soot, and without loss of heat by radiation into the surrounding air. We must now consider the fact that all flames under ordinary conditions are hollow and cold inside. I have here a pile of gunpowder, which I will place in the centre of this large and powerful flame, You see that not only will the gunpowder remain unchanged, but the centre of the flame is actually cold. To show this more clearly, I will use a burner with a flame which can be made either solid or hollow. I will first place the gunpowder in the hollow flome and then convert it into a solid one, and thereby ignite the gunpowder.

With care, it is possible to put the hand in the centre of this flame, provided the wrist is protected by wet cloths from the outer film of flame, but it is difficult to prevent scalding by the steam which is formed by the outer film of flame and the wet cloth. The actual temperature in the centre of this flame I have tested by introducing a delicate thermometer, and find it is usually about 110deg. Fahrenheit. I will also prove that it is hollow, by conducting the unconsumed gas and air from the centre of the flame by a tube, and igniting it, making, as you see, a second and separate flame, this second flame disappearing when the flame is made solid.

First solid flame.

I believe that the honour of being the first to obtain a solid flame is due to Mr. Wallace, of Manchester, whose plan I shall explain presently. He was, in fact, the pioneer of a new revelation with regard to gaseous fuel, and, I am sorry to say, his discovery nas not yet obtained the attention it merits from all makers of gas apparatus for heating purposes.

There is one condition, with regard to gaseous fuel, which requires close attention. The vessels to be heated are, as a rule, short and small; the gas must, therefore, be perfectly burnt not later than the instant the flame touches its work, and, therefore, for most purposes, a hollow and long flame is comparatively worthless.

To render the combustion more rapid, and to thereby shorten the flame, Gore, of Birmingham, first hit on the expedient of subdividing it into layers, producing a number of narrow flames with air spaces between. By this means he produced a short compound flame, which, with a little assistance from a chimney draught, would fuse cast iron in a crucible. Gore's furnace.

Following in his steps, Griffin, of London, produced a multitubular burner, virtually the same in effect as Gore's, in fact, a form of burner almost identical with Griffin's is shown on the specification of Gore's patent. Griffin's furnace.

These earlier burners had all one serious fault. If the chimney draught happened to be too great for the quantity of gas available, or if the gas supply was irregular, an excess of air was pulled in and mixed with the gas rendering the mixture explosive, and causing the burner to, what is commonly called, "light back." To prevent this, Mr. Stanistreet, of Liverpool, placed, as an experiment, a sheet of wire gauze on the top of the tubes, and communicated the result to me. With this arrangement, the gauze was destroyed every time the furnace was used, and to obviate this I placed the gauze under the tubes, thus making the first high temperature draught furnace burner which would bear sudden changes of the gas supply without an explosion. This burner has now been superseded by another form, which I have recently invented, and which, in principle and arrangement, is totally different. To explain the principle of the new burner, I must go back a little.

Wallace's burner is an upright tube, open at the bottom, with a small gas-jet underneath, pointing directly upwards; the top of the tube is covered with a perforated copper cap. The rush of the gas from the jet carries upwards with it a large quantity of air which, with a gas jet of one exact size, produces an explosive mixture. The perforated cap prevents the flame rushing down the tube, and we have, what we never had before, a solid flame, requiring no external air supply, produced by the quiet burning of an explosive mixture of gas and air. This being the case we obtain a short flame of very high temperature, which requires no excess of air to ensure perfect combustion, and we therefore work so as to get the highest possible duty from our fuel. Wallace's burner.

Following in the steps of Wallace, I found great inconvenience from the height and size necessary to produce large and powerful flames, but after a long series of experiments, hit on the plan of placing Wallace's injecting jet at one end of an open horizontal tube, leaving the other end open, and enclosed in a tight box, the upper side of which is covered with gauze. With this burner I obtain, as you see, a flame solid to the centre, in a convenient and simple form. I find from experience that there is no practical limit to the size of burners made on this principle. I have made them 18 inches in diameter on the surface of the gauze, capable of burning in one solid flame a gas supply of 200 cubic feet per hour; I have also made them 4 feet in length for coffee roasters, As this burner requires only an outlet for burnt air, it will work perfectly in very confined spaces, where an ordinary hollow flame burner cannot be kept lighted. I have here a solid flame burner, eight inches in diameter, which, with a well constructed boiler, will make steam sufficient for a one horse-power engine.

When I use this burner for draught furnaces, I make it with a cast iron grid, to prevent liability of the gauze to get red hot, and to prevent also the peculiar roaring noise caused by a solid flame produced with the assistance of a chimney, and which I shall again refer to; and you here see a few examples of its application for crucible, muffle, and porcelain painters' furnaces. One great difficulty with gas crucible furnaces has been a means of safely supporting a crucible, so as to hold it securely without interfering with the full impact of the flame.

Crucible supports.

Gore, in the first gas furnace made, supported his crucible by projecting ribs inside a taper cylinder. This caused liability to stick fast, and also necessitated the use of crucibles of one exact shape and size. Griffin made an advance on this, by carrying the crucible on a tripod grate of fire-clay. This although used at present, is liable to damage, and is not altogether satisfactory. Another plan introduced is to fix an upright plug of fire-clay in the centre of the burner; this is, in my experience, worse than Gore's original plan, as the stand is unsteady, and is also liable to stick and to come away with the crucible.

For draught furnaces, I have at least solved this difficulty completely, by placing the crucible on the solid bottom of the furnace, by the side of the burner, and drawing the flame sideways across the crucible, the chimney being placed at the opposite side of the burner. This not only completely solves the difficulty, but places the chimney in the best possibly position, and exposes the crucible more perfectly to the impact of the flame. I have received to-day a model of a further improvement on this, in which the flame is made to traverse completely round the crucible, that still further utilising the heat of the flame.

In the blast furnaces, the difficulty of supports is also overcome by placing the crucible on the bottom of the furnace, and inserting the burner at the side. The casings by which the heat is retained are of porous or cellular clay, the process of making which I have already described. All the casings which you see here to-night are made of this material, which I consider one of the most important points, where economy of fuel, speed of working, and great heat are required. Without this cellular clay, the results I obtain could not be approached, except by an enormous increase in the heating powers of the burners used.

Power of draft furnaces.

I do not think it probable, or possible, that really high temperatures will ever be attained in small draught gas furnaces, for several reasons. First, the very large burner surface necessary to make a perfect mixture of gas and air, with sufficient rapidity to burn a large quantity of gas instantly, and perfectly, makes the burner liable to damage. It will be found that, with a draught gas furnace, burning in an economical manner, the flame is in absolute contact with the burner surface, a state of things which, curiously enough, does not exist with a blast furnace, where the flame is always at a greater or less distance from the face of the burner. For this reason, I should never recommend the use of draught furnaces with long chimneys for very high temperatures, although for such work as the fusion of brass, silver, and gold, the usual routine work of laboratories, and the firing of glass, china, &c., they are perfectly adapted, and, if well constructed, will give a very high duty for the gas consumed.

Another objection to draught furnaces, is the difficulty of keeping all the lids and parts fitting so perfectly air-tight as to keep cold air out of the chimney, and thereby interfering with its satisfactory working. Where the pull of the chimney is great from its height, there is a great liability to this leakage of cold air into it, and there is also a great waste of heat in keeping the chimney at a sufficiently high temperature to enable it to work efficiently. Draught furnaces have their place and fill it, but for many purposes there is nothing to approach a blast furnace, used with either coal gas or gasoline vapour. The furnace I now show you, and which I will, at the conclusion, light and keep going for ten minutes, is perhaps the most perfect example of the great results to be obtained with gaseous fuel. The casing which holds the crucible is a simple thick pot of my porous clay, with a hole in the side, and a lid with a hole in the centre for the escape of the products of combustion.

Blast furnaces.

The burner, I consider, is as perfect for its work as the casing. It is a true solid flame, formed by injecting, with this little foot blower, a fine stream of air at a high pressure, into a tube, into which gas or gasoline vapour enters at the side. By using the air at a high pressure, the larger quantity of air required for combustion is pulled in mechanically at the openings in the tube, thus dispensing with the large and costly blowing apparatus, which would otherwise be necessary. The end of the tube against the hole in the casing may be open, but is then liable to make a rattling unpleasant noise; to prevent this, I cover it with a cap of gauze, which, when the furnace is at a blinding white heat, is perfectly cold, partly owing to the fact, as I previously explained, that a gas flame produced by a blast is never in absolute contact with the burner which produces it, and partly to the constant blast of cold air and gas passing through. The burner fits tight against the casing. A perfectly explosive mixture is made rapidly in very small quantities, and burnt in a close non-conducting chamber so perfectly and so instantaneously that not a trace of flame is visible in the furnace as may be seen by those interested, who will come and examine the furnace whilst working. In this furnace I can, as you will see, starting all cold, get a crucible well over a cast iron melting heat in five minutes, and to a blinding white, approaching a blue, heat in ten minutes.

Power of blast furnaces.

The gas consumed in this furnace, as I shall work it at the conclusion is about 40 cubic feet per hour. It therefore requires less than 4 cubic feet of gas to raise a crucible, sufficiently large to hold 2lbs. of cast iron, to over the fusing point of cast iron, and it takes about 7 cubic feet of gas to melt this weight of iron so that it can be poured. Let it be remembered, that this quantity of gas costs a little over one farthing, and is equivalent to about 4 ounces of coal. Let it also be remembered that this minute quantity of fuel not only melts the iron, but heats up a cold furnace and crucible. It is very easy to work the furnace with a very small gas supply, but in this case the heat is obtained much more slowly, and the total quantity of gas used to obtain the same result is greater.

Greater power and greater rapidity of working than shown by this furnace is not desirable, although it could be easily obtained by increasing the air and gas supply. No crucibles known will stand a greater power than this furnace gives with ease, whilst for simplicity of construction, and ability to bear hard work, anything better could hardly be desired. With this furnace, I think the art of heating crucibles by gas may be considered to be complete.

Consider, for one moment, the actual results obtained in this furnace with four ounces of fuel, and compare the number of pounds of coal or coke necessary to produce the same result, then the economy of gas fuel, under proper conditions, becomes self-evident. Bear in mind also that it is applicable to either coal gas or air gas from benzoline, the latter fuel enabling the furnace to be used for the fusion of pure nickel and delicate coloured enamels and glass, which the sulphur always present in coal gas would otherwise prevent the furnace being applied to. When we consider the important part which nickel is likely to play in the future for many purposes, more especially in its pure and malleable form, this power of melting this refractory metal in a simple furnace is a matter of no little importance.

Blowpipes.

I have time only to say a few words about blow-pipes. The flame of a blow-pipe is, to a certain extent, hollow; but not so much so as is the case with the ordinary flame, made without an air blast. The reason of the very high temperature obtained with a blew-pipe flame, is that the heat is driven to one point and accumulated there. I have here an example of an arrangement, devised by myself some years ago, for heating both the blast of air and the gas, producing a flame having a temperature far above that required to melt platinum.

A blow-pipe flame, however large, has little power compared with the burner of the blast furnace which I have just described, when we have large bodies of material to heat. The combustion is neither so rapid nor so perfect; in fact, the blow-pipe flame is hollow and long, with only one hot point. The furnace burner flame is solid, short, and of equal temperature throughout.

Difference between coal and air gas.

I will now explain some of the differences between coal gas and gasoline or benzoline vapour, in practical use. Coal gas is never free from sulphur; and it is, therefore, difficult to use for the heating of metals and other substances, which are liable to damage by sulphur compounds. It is also not satisfactory for the fusion of enamels except in perfectly tight chambers, from which the products of combustion can be completely excluded.

The vapours of the lighter petroleums, on the contrary, are free from sulphur, and I have repeatedly fused the most delicate enamel colours in the open flame without the slightest injury.

Another curious difference in the two fuels is, that when gasoline or benzoline vapour is used with a blow-pipe, the flame is exceedingly liable to blow out. I can use no other satisfactory simile, except that the gasoline flame appears to be "brittle," and not to hang tenaciously to the blow-pipe as a gas flame does. When anything is in the gasoline flame, which is at a sufficiently high temperature to keep up the combustion, this is no disadvantage. In the furnace, air gas from benzoline burns with perfect steadiness, precisely like coal gas, but when we attempt to use it for blow-pipe work, the flame is continually leaving the point of the jet and blowing out. In this respect the field for experiment is yet open.

I believe I obtained from my friend Mr. Bower, only last night, an idea which may serve to solve this difficulty, but which I have not been able yet to test. I found that with benzoline gas his blow-pipe was much more satisfactory than my own, the only difference between the two blow-pipes being that his had an exceedingly thick air jet; mine had a very thin one. The jet of thick glass or metal does not appear to lift the flame away to the same extent, and some experiments will be made in this direction as soon as I return.

It must be remembered that coal gas is lighter than air; gasoline gas is, however, much heavier; and therefore the atmospheric, or Bunsen burners, made for coal gas, which are open at the bottom, will not work satisfactorily with gasoline gas, as the latter falls, and escapes from the lower openings. From gasoline gas, the only heating burners which can be used are those arranged in a similar manner to the solid flame burners, with a horizontal jet and air tube. On account of the weight of gasoline gas, if the generator is placed at the top of a building, the weight of the gas is sufficient to supply an argand burner in the lower part of the building, although the pressure obtained is not sufficient to work any of the common lighting burners which do not require a chimney.

I have two exceedingly curious flames to show you; one is a solid flame, produced on a surface of gauze by a chimney draught, the chimney being free to vibrate. The explosions, by the management of the chimney, can be varied in their rapidity, producing different tones. I do not recommend this in its present form as a musical instrument. I simply show it you as a curiosity. The other is a flame which requires close examination to see its beauty; and I will show it at the conclusion, whilst the furnace is working. It is produced under peculiar conditions. When the vapour of gasoline is burnt on a gauze surface, with just sufficient air to make a blue flame, the surface of the gauze is covered with innumerable round blue beads of flame, rushing about in all directions. I can offer no explanation of this, and I cannot produce the same effect with a coal gas flame under any conditions. Singing flame.

In conclusion there are many purposes to which gas fuel can be applied, far more perfectly than it is at present. In fact, we may say that its use, except in blast furnaces and blow-pipes, is yet in its infancy, and the work done by Gore, Wallace, and others, may be considered only as a small sign of what is yet to come. I believe the time is, perhaps, not far distant, when gas will be used exclusively for cooking purposes, and that its rapid adoption all over the world depends only on the makers of the apparatus. If the makers of gas-heating arrangements have to pay for all the gas wasted in their apparatus, I think many improvements would very quickly be made. My own experience is that the whole of the cooking for a family of eleven can be done perfectly, entirely without Cooking by gas.

the assistance of a fire, at a cost of about twopence per day for gas. When we compare this with the cost entailed by some apparatus now sold, the necessity for improvement is self-evident. Where liquids have to be boiled or vessels heated, the work must be done by one solid flame, not by a number, or one hollow flame; the ovens and pans must be as shallow and broad as possible, and must also be no thicker than is absolutely necessary. I have seen gas-cooking apparatus in which some two or three cwt. of iron has to be heated before any satisfactory work can be done. My own ovens and pans are as thin as they can possibly be made, and I find, by experience, that our largest oven is fully hot in two minutes. In a properly arranged water-heater, it requires about one and a half cubic feet of gas to boil one gallon of water; this is the result I get in actual work, under the best conditions. I may safely take it as an average, with the burners generally used for cooking, that from five to twelve cubic feet of gas is burnt to do the same work, owing partly to the improper construction of the burners, and partly to the faults, shape, and unnecessary weight of the vessels used.

Amongst the still more recent improvements in gas-heating apparatus which have not yet been made public, I may mention two. The first, which I now show you, is a simple and cheap arrangement for melting and pouring into ingots of different shapes, a few ounces of gold or silver, without the use of a furnace. My first arrangement of this kind was essentially different. on this, as you see, both blow-pipe, crucible, and ingot mould, are mounted on one rocking stand, the two sides of the ingot mould slide over each other to enable ingots of different shapes and weights to be cast, and the rocking stand, clamp, and blow-pipe, are all obtained in a single casting, reducing the cost of the whole to a few shillings. It is well known that the toughness and working properties of gold are greatly improved by this method of melting with a flat crucible and a blow-pipe, and the results compare very favourably with those obtained in the best furnaces. As regards time, a 3 oz. ingot can be melted and poured in two minutes with ease.

Another and more generally important apparatus is what may fairly be considered a new discovery, so far as gas is concerned. It is only too well known that good steel is ruined if heated with a gas blow-pipe flame, and that steel band saws brazed with a gas blow-pipe are brittle and worthless. It is also impossible to weld with the heat obtained from a blow-pipe. I find, by using the small hearth which I have here, filled with coke, broken small and by directing a blow-pipe through the open tuyere, I can get a welding heat in about two or three minutes, and I obtain heat which is for all practical purposes as good as a charcoal forge. For the repair of small tools, and for such delicate forgings as are necessary for sewing machines &c., this new adaptation of gas appears likely to become exceedingly valuable. It is, in fact, a small self-lighting forge, perfectly clean and simple in use and adapted for the most delicate work; its value those only who have delicate steel forgings to make can appreciate.

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MEDALS, &c., AWARDED TO THOMAS FLETCHER.

1871.—FIRST CLASS BRONZE MEDAL—Royal Cornwall Polytechnic Society.

1872.—SILVER MEDAL—Royal Cornwall Polytechnic Society.

1873.—INTERNATIONAL EXHIBITION PRIZE MEDAL.

1876.—EXHIBITION SCIENTIFIC APPARATUS — South Kensington.

1877.—CERTIFICATE OF MERIT — Mining Institute of Cornwall.

1880.—SILVER MEDAL—Society of Arts, London.

GLASGOW PHILOSOPHICAL SOCIETY.

(*Exhibition of Gas and Electrical Apparatus.*)

RESULTS OF THE TESTS MADE IN COOKING AND FURNACE WORK, AT MR. FLETCHER'S LECTURE ON OCTOBER 22nd, 1880.

Fletcher's Patent Gas Cooking Oven, 55s. size. Gas consumption in roasting meat, as tested by experimental meter during the lecture, 8 feet per hour. Gas consumption whilst cooking fish, joint, and fruit pie all at once, 14 feet per hour. Gas consumed in 1¼ hours, roasting 6 lbs. beef, baking one apple pie and grilling two herrings, 16 cubic feet; cost about one halfpenny. The time allowed for the lecture was not sufficient to finish roasting the joint: about 15 to 20 minutes more would be required, with an additional gas consumption of about 2 feet; but it was stopped at the conclusion to enable the joint and pie to be cut open and handed round to prove the absence of the slightest trace of taint from the strong smelling fish which had been cooked underneath at the same time.

In the best apparatus, *to which a silver medal was awarded* by the Manchester Corporation at the trial of cooking apparatus on September 22nd, 1880, the consumption of gas was 45 cubic feet in roasting 10 lbs. of *meat only*, being more than double the quantity of gas necessary in a perfect apparatus.

The herrings were grilled under the pie and joint, all at the same time, without a trace of taint or flavour from one to the other. The herrings were perfectly grilled, the pie was perfectly cooked, with a crisp brown crust; the meat was brown, juicy, and perfect in flavour, but, owing to the time, rather underdone. Ordinary gas was used.

FURNACE EXPERIMENTS with Fletcher's Injector Furnace, with self-acting gas-making apparatus, making its own gas from gasoline. Starting all cold, 1 lb. cast iron was fused and poured in 7 minutes; 1 lb. pure nickel was fused and poured in 11 minutes afterwards. The latter was left in the furnace a short time after the nickel was melted, and the refractory crucible was fused; but the nickel was poured out of the furnace without injury to any part, and without loss or injury to the metal.

FLETCHER'S
PERFECTED
SOLID FLAME GAS BURNER.

PATENT No. 3203, AUGUST, 1880.

FOR COOKING & GENERAL HEATING PURPOSES.

THE ONLY PERFECT BURNER FOR BOILING & DIRTY WORK.

It cannot be spoilt by any accident, and gives a perfectly solid flame, free from smell. In case of an accident choking the holes in the perforated copper dome, it can be lifted off (when the burner is warm) and cleaned; the whole burner is designed to stand the roughest and heaviest work without injury.

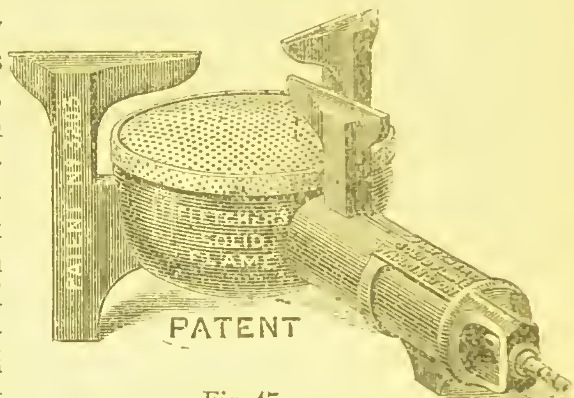

Fig. 47.
Engraved One-Third full size.

IT WILL WITH EQUAL EASE BOIL AN EGG, COOK A CHOP, BAKE A ROUND OF BEEF IN A SHEET IRON OVEN, OR MELT HALF A HUNDREDWEIGHT (OR MORE) OF LEAD IN AN IRON POT.

It will boil 2 quarts of water in 6 minutes in a flat Copper Kettle.

Fig. 47. PRICE, 6s. 6d. *Nickel Plated 2s. Extra.*

Smaller Size, Slightly under Half the Power, Fig. 48.

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Price 4s., or Nickel Plated, 5s. 6d

This is the best size for general domestic use.

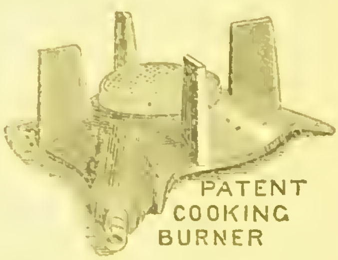


Fig. 48.

The Indiarubber Tubing must be a good size and smooth inside, made without wire. Special Tubing for this Burner, 6d. per foot. The supply tap and pipe must be good and clear when great power is required.

FLETCHER'S SOLID FLAME BURNER.

ORIGINAL PATTERNS WITH GAUZE.

These well-known Burners, of which many THOUSANDS are in use, are the first high power heating Burners ever constructed. They have the same power as the patent Burner, Fig. 47, but do not carry large vessels so steadily, and if used for dirty work the gauze is liable to require replacing, as it cannot always be cleaned.

PRICE—

BRONZED,

4s.;

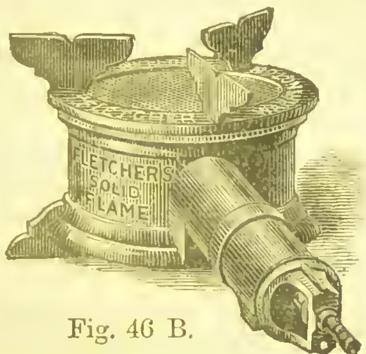


Fig. 46 B.

Engraving One-Fourth full size.

PRICE—

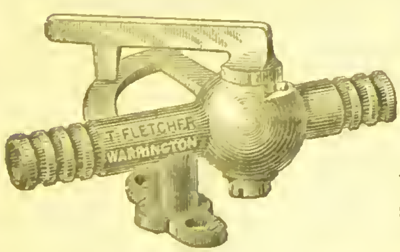
NICKEL

PLATED,

5 s.

GAS SUPPLY TAPS

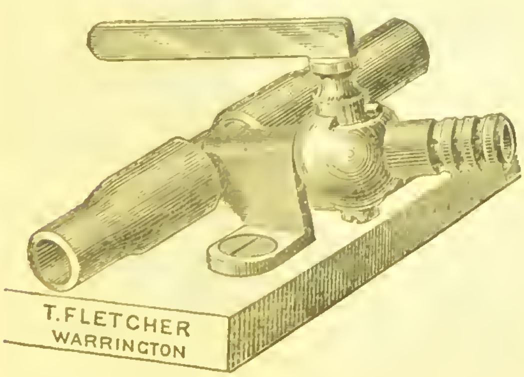
FOR CONNECTING WITH INDIARUBBER TUBING



Can be attached to a gas pipe by any person without soldering or trouble.

Price with $\frac{3}{8}$in. clear bore		..	2s.
do.	$\frac{1}{2}$in. do.	..	3s.

These can be supplied in sets of any number connected to one supply and fixed on a mahogany board, so that several taps can be used from one supply pipe without the assistance of a gasfitter. Price for each tap, double the above rates.



ANOTHER PATTERN for obtaining a supply out of a Gas Pipe without interfering with other lights. To fix this, cut about 3 inches out of the lead pipe with a sharp knife, and connect the cross tube with short bits of indiarubber tube, so as to make up the pipe as before, but with the tap leading out of it.

Price for $\frac{3}{8}$ size .. 2s.

Can be supplied in sets on a board as above, any number at 4s. each tap.

JEWELLERS' SOLDERING COALS.—Made of

compressed willow charcoal (same as the moulded carbon blocks). Size 2 X 2 X 6 inches, with flat sides. Price 1s. One of these will last out 50 blocks of charcoal. Size 1½ X 1½ X 5. Price 6d.

FINE WILLOW CHARCOAL, in sticks, free from flaws, (selected sticks only) 1s. per lb.

MOULDED CARBON BLOCKS for supporting small

work under the blowpipe. Cleanly, perfect non-conductors, and everlasting Price 1s. 6d. each. (For use with small blowpipes only).

These are circular, hollow on each face, and 4 inches diameter.

GREY INDIA RUBBER TUBING, smooth inside,

(without wire). Thick rubber 5-16ths bore, 4½d. per foot ; ⅜, 6d. ; ½in., 9d

---

IMPROVED FORM OF FLETCHER'S ORIGINAL HOT BLAST BLOWPIPE, Fig. 1*b*, 12s. 6d. For small

work it is the best gas blowpipe which can be used. For a large rough flame the Bunsen heater should not be used. The advantage of the hot blast shows only when a pointed flame is required having a high temperature. Duplicate coils and jets, 1s. 6d. Same pattern Hot Blast Blowpipe only, without the bench light, 10s. 6d. For sizes of jets see inside page of cover.

The same pattern as engraved can also be supplied with Blowpipe Fig. 8d instead of hot blast.

Price 10s. 6d.

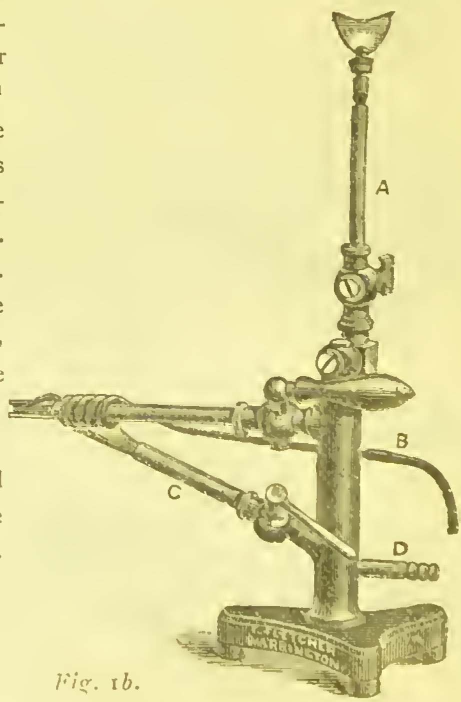


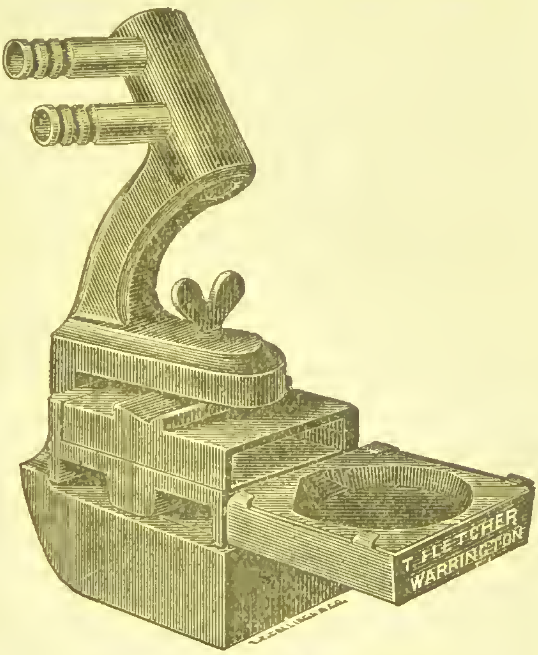
Fig. 1b.

Engraved One-Fifth full size.

FLETCHER'S NEW MELTING ARRANGEMENT for melting up to 3 ounces of gold or silver, rapidly, without the use of a furnace.

Improvement on Fig. 8.

In this arrangement the two parts of the ingot mould slide on each other, to enable ingots of any width to be cast, and the Blowpipe is part of the rocking stand. Connect the blower to the upper tube and the gas to the lower. When the metal is melted in the shallow crucible of compressed charcoal, tilt the whole apparatus over so as to fill the ngot mould. A sound ingot can be obtained in about two minutes. Thousands of the old pattern are in use, and this arrangement is far superior to any furnace for small work. Very bulky scrap should be run into a mass in one of the moulded carbon blocks before being placed in the crucible. No flux must be used with the charcoal crucibles.



Engraving slightly under half-size.

Price, as engraved - - - 10s.

Compressed Charcoal Crucibles 2d. each, 1s. 10d. per doz. Slides to carry the crucibles, 3d. each.

NEW CRUCIBLES, which do not burn away, and which will stand all fluxes, are now ready. Price 4d. each.

FLETCHER'S PERFECTED INJECTOR GAS FURNACE,

for Metallurgists, Jewellers, Chemists, iron, brass, and nickel castings, manufacturers of artificial gems, and other purposes where an ordinary furnace is useless or unreliable. THIS FURNACE IS, BEYOND COMPARISON, THE BEST AND SIMPLEST GAS FURNACE MADE.

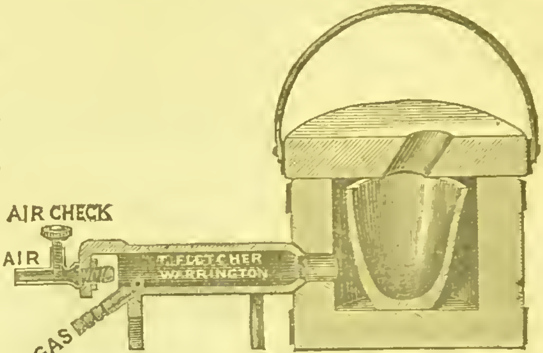


Fig. 41.

See tests made at the Exhibition of the Glasgow Philosophical Society, October 22nd, 1880.

It has been found that, in working at extremely high temperatures, the ring which holds the gauze is liable to be fused. To prevent this a new burner has been designed, in which the ring is entirely dispensed with, and the gauze cap is pushed up from the back of the burner against a small shoulder inside the nozzle of the burner. The burner is in one casting, and, therefore, there is no tendency for the nozzle to get hot, as in the former pattern. See that the gauze is pushed up from behind to within about $\frac{1}{4}$ inch of the nozzle.

Power and Speed of Working.—These are practically without limit, depending only on the gas and air supply, and are under perfect control. With $\frac{1}{2}$ in. gas pipe and the smallest foot blower, the small furnace will melt a crucible full of cast-iron scrap in 7 minutes; and steel in 12 minutes, starting with all cold.

INSTRUCTIONS.

Gas supply	required,	6 oz. size	furnace,	3/8 in. pipe=	7 to	20 ft.	of gas ℘ hour.
,,	,,	2 lb. size	,,	3/8 in. pipe=	10 to	40 ft.	,,
,,	,,	6 lb. size	,,	1/2 in. pipe=	25 to	60 ft.	,,
,,	,,	12 lb. size	,,	5/8 in. pipe=	30 to	70 ft.	,,
,,	,,	28 lb. size	,,	1 1/2 in. pipe=	70 to	200 ft.	,,

See that all gas taps have a large clear way through. High temperatures and rapid working require a free supply of gas.

To adjust a new furnace to its highest power :—Put the nozzle of the burner tight up against the hole in the side of the casing, turn on the full gas supply, light the gas in the furnace, and connect the blower, with the air way full open. If the flame comes out of the lid about 2 inches the adjustment is right. If the flame is longer, enlarge the hole in the air jet until the proper flame is obtained, or reduce the gas supply ; if smaller, or not visible, turn the air check until the flame appears.

FOOT BLOWERS. For a gas supply up to 40 ft. per hour, blower No. 3 is sufficient ; up to 75 ft. per hour, blower No. 5. For the 28lb. Furnace, Roots smallest blower, driven by power. (For blowers see page 20.)

Keep all fluxes away from the furnace jacket.

Before stopping the blower draw the burner back from the hole. Commence blowing before the lid is put on the furnace.

The old pattern blower is liable to pick up dirt from the floor, throwing it against the gauze of the burner, and stopping the proper working of the furnace until cleared away. A thin layer of silver sand on the bottom will prevent crucibles adhering when at a white or blue heat. Crucibles must be heated very slowly the first time they are used unless of the "Salamander" brand.

FLETCHER'S

PERFECTED INJECTOR FURNACE.

FOR DESCRIPTION SEE PREVIOUS PAGES.

Prices for furnaces taking crucibles of the following sizes :—

Crucibles No.——☞ (Morgan's Patent.)	00	1	3	6	14
Size of Crucibles in inches, outside measure............	Inches. 2 X 2¼	Inches. 2⅞ X 2⅜	Inches. 4 X 3½	Inches. 6 X 4½	Inches. 8 X 6¼
Capacity in lbs. iron	⅓	2	6	12	28
Price of Furnace	11/6	13/6	21/0	30/0	45/0
Foot Blower, Fig. 9b.........	22/0	22/0	30/0	30/0	Root's Blower
Grey Indiarubber Tubing...	3/0	3/0	4/0	4/0	
Black Rubber Tubing	4/0	4/0	5/4	5/4	
Price, complete, ready for use, with blower and tubing	36/6	38/	55/0	64/0	
Extra Furnace Bodies	3/6	4/6	8/6	14/0	20/0
Extra Furnace Lids	2/6	2/6	4/6	7/0	10/0
Crucible Tongs	1/6	1/6	2/0	2/0	
Bow Tongs			3/0	4/0	
Crucibles, Fireclay	/1½	/2	/5	/10	2/4
,, Salamander	/3	/4	1/0	2/0	4/8

For the fusion of pure nickel over 6lbs. at once, a small Roots blower, driven by power, is necessary, and the air jets of the burners must be enlarged to double the size. The air supply of the 28lb. size must be controlled, if necessary, by a valve or large tap.

A SIMPLE FURNACE

FOR HIGH TEMPERATURES.

(Working with either Gas or Spirit Petroleum, without alteration, and with perfect results with either Fuel.)

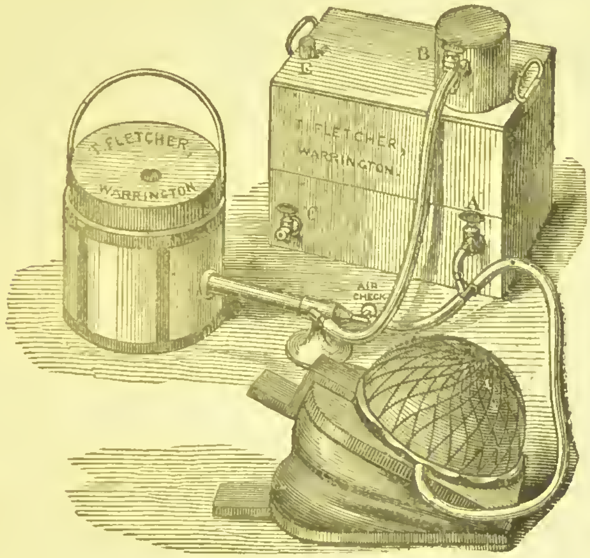


Fig. 44.

The Injector Gas Furnace is now supplied with a small, simple, and perfectly safe arrangement for burning the vapour of gasoline or benzoline, giving a power and efficiency fully equal to that which can be obtained by a large gas supply. The arrangement is in every way as simple as when gas is used, requiring no more trouble or attention.

It equals a gas furnace in every respect, and in addition, gives a heat of absolute purity, fitting it for the most delicate chemical operations where gas cannot be used owing to the presence of sulphur and other matters.

The ordinary pattern of Injector Furnace is used in precisely the same way as with gas, the only difference being that a branch pipe is taken out of the air supply and connected to the lower tap A on the generator, and a tube is carried from the upper tap B, to the side tube of the Injector burner, marked "gas." The quantity of vapour required is adjusted by the lower tap A when the furnace is working, and the flame must be just visible at the hole in the lid, exactly as when gas is used, the instructions being precisely the same for both fuels.

To charge the generator, pour benzoline, or gasoline, in the top hole until it overflows at the small tap C in the side, replace the cork firmly, and close the overflow tap. It will then work for about ten to twelve hours at the full power of the Furnace.

Benzoline varies much in quality; it must, when a few drops are poured on a plate or the hand, evaporate quickly and completely, leaving no greasy stain, and if good will produce more vapour than the furnace can burn at its maximum power. All the tubing used must be perfectly smooth inside, or the power of the furnace is greatly reduced.

At the conclusion of an operation close both taps on the generator. It can then be left for any length of time ready for instant use. For ordinary meltings the generator can be used about thirty or forty times without refilling.

I strongly recommend this arrangement, as *at least* equal in power and convenience to the best gas furnace ever constructed.

The No. 3 size will refine and perfectly fuse 6 lbs. of chemically pure nickel so that it can be poured clean, using an open crucible, a feat beyond the capabilities of any other known furnace.

Furnaces of larger size, for the commercial melting and refining of malleable nickel, &c., made to order.

Benzoline often contains heavy oils. If the generator works badly, empty it and refill with fresh.

PRICES.

Generator only for No. 00 or 1 Injector Furnace, capacity 2 lbs. metal, 27s. 6d.

Generator for No. 3 or No. 6 Furnace, 40s.

FURNACE BLOWER, TUBING, & GENERATOR complete—

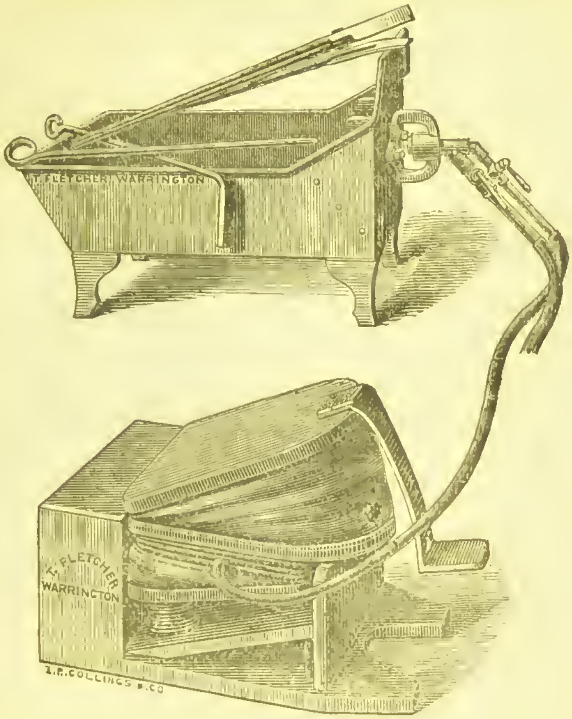
No. 1 size, capacity 2 lbs. metal, 75s.
No. 3 size, capacity 6 lbs. metal, 95s.
No. 6 size, capacity 12 lbs. metal, 105s.
If with black rubber tubing, 2s. extra.

The engraving shows the No. 3 size Furnace, Generator, and Blower, as when in use. Scale, 1 inch to the foot.

The foot blower supplied with above is No. 5 (Fig. 9 B, page 18). Not the one shown on engraving.

The Generator, No. 3 size, will work the 28lb. furnace, provided gasoline is used. If benzoline or spirit petroleum is used, an extra size generator is necessary. Price £3 10s. This size furnace requires a Roots blower, smallest pattern.

FLETCHER'S GAS OR PETROLEUM FORGE.



—This simple arrangement is the only system by which steel tools can be forged without injury by the use of gas. It will be found a perfect arrangement for small odd forgings and repairs. It is perfectly clean, no nuisance either in lighting or use, and is always ready for instant use. Starting all cold, a slide rest tool can be repaired or shaped in two minutes.

Size of Hearth, 15 x 18 inches.

The BLOWER is FLETCHER'S New Foot Blower, dispensing with the use of the india rubber disc, and fitting it for the roughest work. It does not give so steady and powerful a blast as figure 9, or 9B, but it is perfectly adapted for forge or blowpipe use, and, not being fastened to the forge, both blowpipe and blower can be taken away and used separately for brazing, &c.

The blower, Fig. 9B, No. 5, will work the forge well, and, where already in use, there is no necessity to purchase a new one. Fig. 9 is liable to damage with sparks, &c.

INSTRUCTIONS.

Fill the hearth with coke, broken small, (cinders may be used, but are not so clean); light the gas at the blowpipe, and use the blower. In a minute turn the gas out, and then turn on again a *very small quantity*, *not enough to burn at the blowpipe jet*, but sufficiently to visibly brighten the fire. When the heat is obtained, the forge may be worked with or without gas, but a little gas doubles the power. THE GAS MUST NOT BURN AT THE BLOWPIPE JET, EXCEPT FOR THE FIRST MINUTE. If gas is not available, the vapour from the smallest size Generator, Fig. 44, page 15, may be used precisely in the same way as gas.

The Blowpipe is the ordinary pattern, fig. 8C. and can be removed for use as a blowpipe, making the whole apparatus complete for all small heating and brazing work. If a hood is required, it will be made any shape required, price about 6s. extra. It is not usually necessary if coke is used.

Price—Blower only - - -	£1	15s. 0d.
Blowpipe - - - -		7s. 0d.
Hearth - - - -		15s. 0d.
Tools, as shown on Engraving -		5s. 0d.
6ft. Grey Indiarubber Tubing		4s. 0d.
Complete - - - -	£3	6s. 0d.

THE BLOWER corresponds in capacity to No. 5 on furnace list. A similar pattern is also made corresponding to No. 3, for blowpipe work only, price 30s.

DRAFT CRUCIBLE FURNACES. Fig. 63

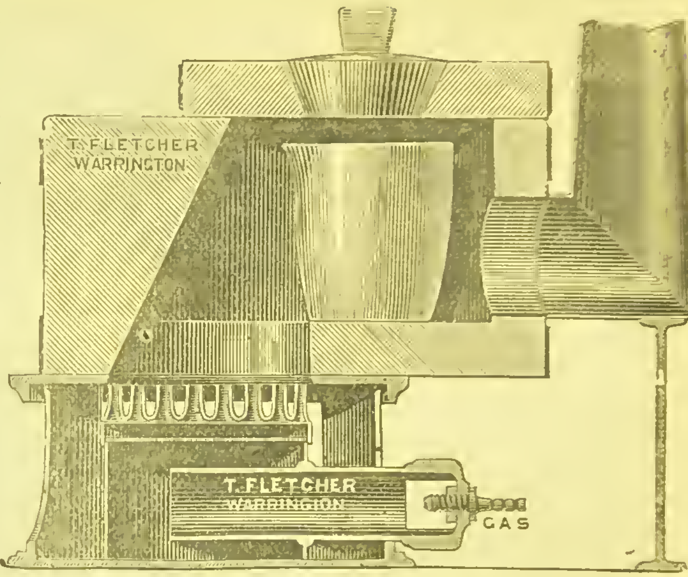


Fig. 63.

for Brass Founders, Jewellers, and general purposes. (Not for Cast Iron.)

No. 163, taking crucibles not exceeding 3 by 2⅝ in. to melt 2lb. brass, price, complete with 3 ft. India rubber tubing, £1 10s.

Extra crucibles plumbago, 4d., clay, 2d., crucible tongs, 1s. 6d.; gas supply required, 17 cub. feet per hour, = ⅜ pipe and tap.

No. 363, taking crucibles not exceeding 4 by 3½ in., to melt 6 lbs. brass; gas supply 22 cubic feet per hour = ⅜ clear bore gas pipe and tap. Price, complete with tubing, £2 5s.

Crucible tongs, 2s. Extra Salamander Crucibles, 1s. each. Clay Crucibles, 6d. each. Bow Tongs, 3s.

No 663, taking crucibles not exceeding 6 by 4½ ins., to melt 12 lbs. brass; gas supply and burner same as No. 363. Price, complete with tubing, £3.

Crucible tongs, 2s. 6d. extra. Bow Tongs, 4s.

Crucibles (Salamander), 2s. each.

This pattern, in all sizes, can be used for oxydizing in cupels or shallow dishes, instead of a muffle furnace. The lid never requires to be lifted; it can be pushed sideways sufficiently to enable the crucible to be lifted out.

It can also be supplied bored for tube operations. Price, 3s. extra.

DRAFT MUFFLE FURNACES: Fig. 61

No. 261. Space inside Muffle, 2½in. wide, 2in. high, 4½in. long. Price, complete, £1 15s.

Extra Muffles, plumbago 2s. 3d., clay, 1s. 5d.

The burner for this size is same as No. 163.

No. 461. Space inside Muffle, 3⅞ in. wide, 3 in. high, 6½ in. long. Price, complete, £2 2s.

Extra Muffles, plumbago 7s. 6d., clay 2s. 6d. Gas supply required 30 cubic feet per hour, ½ in. gas pipe and tap.

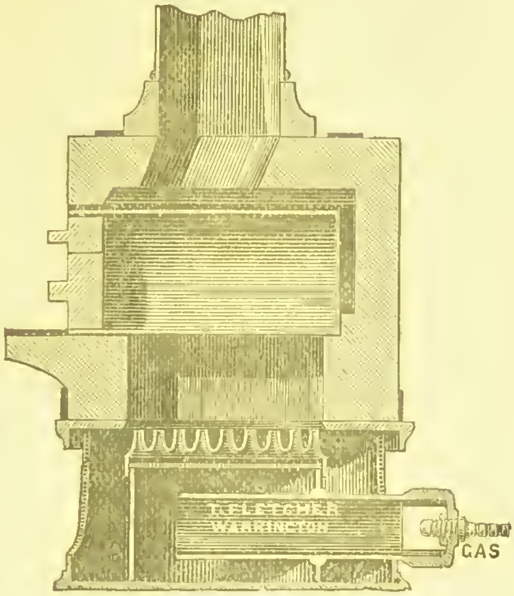


Fig. 61.

No. 661. Space inside Muffle, 5⅜ in. wide, 4½ in. high, 10 in. long. Price, complete, £3 10s.

Extra Muffles, plumbago 12s., clay, 7s. 6d.

Gas supply required 35 cubic feet per hour, ½in. clear bore gas pipe and tap. All prices include one fireclay muffle and 3ft. Indiarubber tubing. Gas taps, with large way through, 2s. each.

ALL THESE MUFFLE FURNACES CAN BE ADAPTED FOR BLAST, FOR HIGH TEMPERATURES. PRICE THE SAME AS ABOVE, BUT THE PRICE DOES NOT INCLUDE BLOWER. BLOWER FOR 261, 22s.; for 461, 30s.; FOR 661, 60s.

GENERAL INSTRUCTIONS.

It is a great advantage to the burner if the gas supply tap and pipe are large and clear, so as to give as great a pressure of gas as possible at the burner nozzle, although the actual consumption of gas is small. The indiarubber tubing used must of necessity be perfectly smooth inside. The tubing, made on wire, whether the wire is removed or not, *will not work these burners satisfactorily.* All Furnaces are sent out with a 2ft. 6in. chimney, having a cast iron foot to enable it to stand steadily, and a short handle by which it can be readily lifted with the crucible tongs. The gas supply specified is required to work each Furnace at its full power, and the flame must be visible in the chimney. If the gas supply is deficient, the Furnaces can be worked at a lower heat by partially closing the top of the chimney until the flame becomes visible, or by working without the chimney. If the burner plate becomes red hot, it is a sign that the gas supply is deficient. The points of blue flame are always visible when the burner is looked into sideways, unless the gas supply is too small to work the Furnace satisfactorily. To light the burner without removing the upper part of the furnace put a lighted taper through the burner casing up between the grooves in burner plate, then turn the gas on slowly. If the Furnace is hot it may be necessary to cover the air opening round the gas entrance to prevent the flame descending through the gauze at the moment of lighting. The burners can be easily taken apart, and must be kept clean.

Price of new pattern Burner complete, for Fig. 11, 12, or 16 (old list), 163 and 261 (current list), 10s. 6d.; for Fig. 15, No. 3 size, and 363, 12s.; for Fig. 15, No. 6 size, and 663, 12s.; for No. 4 Muffle Furnace, Fig. 43, and 461, 15s.; for No. 6 Muffle Furnace, Fig. 43, and 661, 17s. 6d.

PERFECTED LADLE FURNACE

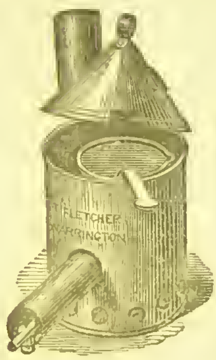
WITH FLETCHER'S NEW

SOLID FLAME HEATING BURNER.

PRICE

WITH 3FT. TUBING,

15/0



OR WITH

OVEN AND WATER

BOILER

COMPLETE,

FOR DENTISTS' USE

30S.

Engraved One-Twelfth full size.

THIS is a better ladle furnace in every respect than any yet made. It will melt a large ladle full of zinc in 15 minutes or lead in 6 minutes. The burner is simple, safe, and works equally well with any gas supply available, giving proportionate speed of working. The worst possible accident to the burner can be remedied in a minute at the cost of a few pence.

It is a great advantage to this burner if the gas supply tap and pipe are large and clear, so as to give as great a pressure of gas as possible at the burner nozzle, although the actual consumption of gas is small.

The India Rubber Tubing used must of necessity be perfectly smooth inside. The tubing, made on wire, whether the wire is removed or not, *will not work these burners satisfactorily.*

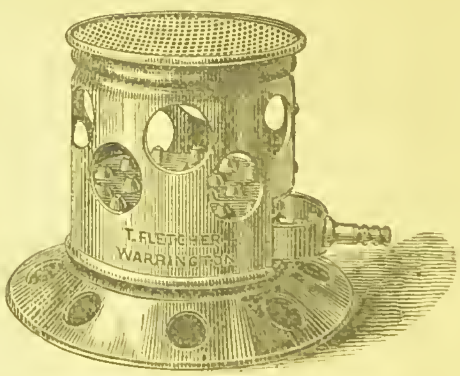
FLETCHER'S NEW EVAPORATING BURNER

FOR GLASS AND PORCELAIN VESSELS, AND GENERAL LABORATORY WORK.

This burner is a great improvement on the ordinary coil burners in use, owing to the fact that no currents of cold air, which are so fatal to glass and porcelain dishes, can reach the vessel, as is the case with all coil burners. The flames are blue and smokeless, and are not liable to be extinguished with a splash, being raised above the body of the burner. Made in solid copper, with lap joints (without solder), price 1s. 3d. per inch diameter. The total height of the burner is about 1½ inch, and is the same in all sizes. Any special size or shape can be made. This burner works also with air or gasoline gas. Stock sizes 3, 4, 6, 8, & 10 inches diameter.

Vessels must not be put in contact with the flame; half the diameter of the burner must be taken as the nearest distance at which a vessel can be placed above the top of the burner.

FLETCHER'S HOT AIR BATH, for Pharmaceutical purposes.—This is formed by the addition of a perforated cylinder covered with strong wire netting, flat or hollow as required, to the copper evaporating burner. All sizes will take any vessel from the smallest to the largest; in selecting for general work it may be taken as a rule that any burner at its maximum power will boil the contents of a porcelain dish double its own diameter, *i.e.*, a 4-inch is best for dishes up to 8-inches diameter, &c.



Price, complete with copper evaporating burner, 4-inch, 9s.; 6-inch, 14s.; 8-inch, 17s. 6d.

In the revised pattern, as now made, the lower part does not project as shown in the engraving, and is less trouble to keep clean when used for very dirty work.

Maximum gas consumption at 1-inch pressure :—

3-in.	.. .. ..	3 cubic feet per hour.
4-in.	... .	6 ,, ,,
6-in.	.. .. ..	12 ,, ,,
8-in.	.. .. ..	18 ,, ,,

The heat obtained is perfectly equal, all over quite free from cold currents of air, and safe for the most fragile vessels. The lowest temperature can be obtained with ease and perfect steadiness.

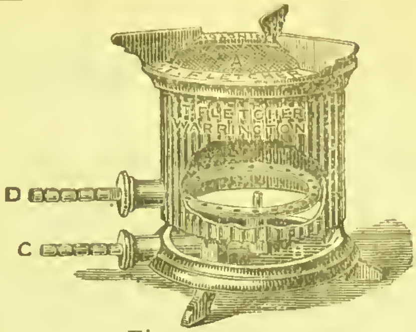


Fig. 7 B.
Engraved One-Fifth full size.

LOW TEMPERATURE BURNER—Fig. 7.

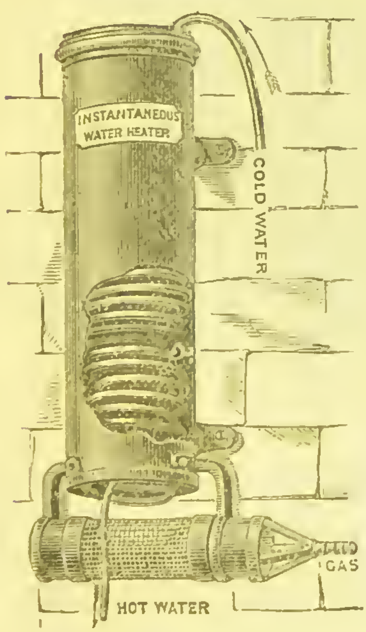
This Burner gives a complete range of temperatures from a gentle current of warm air, to a clear red heat. It is equally well adapted for drying, evaporating, boiling, and general purposes. For very ow temperatures the ring must be lighted through the opening B. For boiling, &c., the light must be applied on the surface of the gauze, thereby providing a large body of blue flame, which can be urged by the blast pipe C. Price, in galvanized iron, as Fig. 7 B 6s. 6d. or without the blast pipe C, price 5s. 6d. Duplicate gauze tops, 4d.

THIS IS ONE OF THE MOST GENERALLY USEFUL BURNERS, AND STANDS HARD DIRTY WORK WITHOUT INJURY. THE GAUZE, IF CHOKED UP WITH DIRT, CAN BE REPLACED IN A FEW SECONDS.

The new solid flame is better for quick heating or boiling purposes, having more than douhle the power, but it is not suited for very LOW temperatures.

INSTANTANEOUS WATER HEATER,

IN SOLID COPPER.



No. 1.—For Lavatory. To give one pint of hot water per minute, 40s.

No. 2.—For Scullery Sink. To give two pints hot water per minute, 60s.

No. 4.—For Baths. To give one gallon warm water per minute, 90s.

No. 6.—For Baths. To give 1½ gallons warm water per minute, 120s.

If Nickel plated and Polished, Nos. 1 and 2, 10s. extra. Nos. 4 and 6, 20s. extra.

Stock pattern made to hang against a wall; but can be made on tripod to order.

ALL SIZES SUPPLY PURE WATER FIT FOR COOKING, &c., EITHER BOILING, OR ANY TEMPERATURE REQUIRED, INSTANTLY AS SOON AS THE GAS IS LIGHTED.

INSTRUCTIONS.—Connect the upper pipe to a water tap, apply a light to the gauze burner, then turn the gas on, and immediately afterwards the water. The speed at which the water runs rules its temperature. The smallest size will heat 1 pint of water per minute from 50 deg. to 130 deg. Fahrenheit, or will boil 15 quarts per hour. The gas supply should be ½ inch pipe, and if india rubber tubing is used to connect it must be smooth inside. Consumption of gas about 18 cubic feet per hour. It will work equally well, but at a proportionately slower rate with ANY gas supply, however small.

The water, formed by the combustion of the gas, drips from the coil, and is not allowed to mix with the pure water. Provision must be made to catch this drip. It is very little in the smaller sizes, and hardly needs consideration, except in the larger patterns.

NOTE —The light must be applied to the gauze before the gas is turned on.

The engraving shows part of the casing removed, so as to show the internal arrangement.

See also Bath Heater and New Instantaneous Water Heating Attachment to Fig. 47, in Domestic Apparatus List.

BLOWING APPARATUS.

FOOT BLOWERS.

These blowers, Fig. 9, have proved themselves to be efficient, simple, strong, and able to stand hard and constant work. This pattern is now made in the following sizes:—

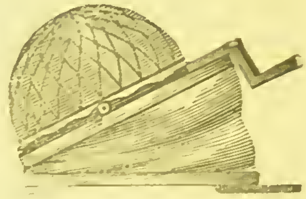


Fig. 9.

	Size over all, including step.	Pressure in inches of water.	Pressure in ounces.	Size of air pipe.	Price.
No. 3.—	13 × 10 × 6½ deep	30 in.	20 oz. on sq. in.	⅜ in.	17s. 6d.
No. 5.—	15 × 12 × 7 deep	30 in.	20 oz. „	[illegible] in.	22s. 6d.

FOOT BLOWERS—NEW PATTERN.—Fig. 9B.

This pattern, by reversing the position of the blower, does away with the risk of mechanical injury to the disc, and does away with the necessity for a wood casing or protection. It also prevents the valve from picking up dirt from the floor, keeping the whole arrangement cleaner, and the valves in more perfect order. Sizes as Fig. 9.

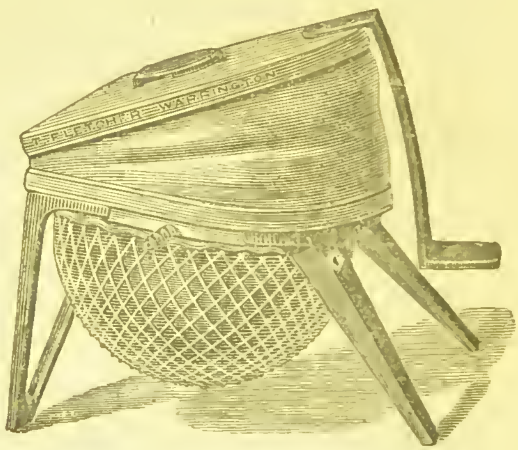


Fig. 9 B.

Prices No. 3 22s., No. 5 30s.

These are the only Blowers in existence giving absolutely steady air pressures in all positions. No. 3 is the most usual pattern for blowpipe work, and is generally used for autogenous soldering of lead chambers, being worked by the foot or under the arm as most convenient. No. 5 for the injector furnace, Fig. 41, and for large blowpipes. This will supply over 300 cubic feet of air per hour, having an available pressure of 1¼ lb. on the square inch.

Extra rubber discs for No. 3, 1s. 9d. each; nets, 1s. For 2s. 6d.; nets, 1s. 4d. (2 rubber discs used on each blower.)

These Blowers can be supplied with the reservoir separated, to hang up out of the way of mechanical injury, at an extra cost of 3s.

SPECIAL BLOWERS for exhausting gases and delivering them under heavier pressure for filling balloons, supplying oxygen and other gases, either with or without reservoir for equalizing pressure on delivery, at about same prices as above.

FOOT BLOWER FORGE PATTERN—Fig. 9c.

With spring reservoir in place of indiarubber disc. Fitted for the roughest general use, but not giving absolutely steady pressures. Sizes correspond with above. Price, No. 3 30s.; No 5 35s.

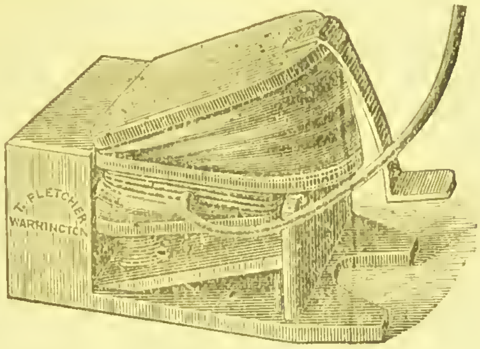


Fig. 9c.

FLETCHER'S AUTOMATIC BLOWER AND ASPIRATOR. Fig. 21, FOR CHEMICAL LABORATORIES.

With a fall of 2ft. only between the water supply and waste level, using about 2 cub. ft. of water per hour, it will supply an ordinary chemical blowpipe; with a fall of 4ft. it will supply two. Its efficiency as an aspirator is equal to its power in blowpipe work.

INSTRUCTIONS. Fasten to a wall or upright pillar: it takes practically no room, being only 2½ in. diameter Connect S with water supply, and W with the waste pipe. Turn the water on slowly, and allow no more to pass than is sufficient to work properly; E is the connecting pipe for exhausting, B for blowpipe work, R relief to prevent syphoning off if W is connected to a waste pipe at a lower level than itself. If no permanent water supply is at hand, two vessels at different levels may be used, and sufficient water for an hour's work can be lifted in less than a minute. As made, the apparatus delivers air at a pressure of about 10 oz. in the square inch. If heavier pressures are required, close R, connect W to a rubber tube and allow the water to escape at a higher level in proportion to the pressure required.

Fig. 21.

Price, complete for 2 or 4 ft. fall, 12s. 6d.

Aspirator only, E. S., Fig. 21, 1s. 3d.

Tubing and connection for higher falls, 6d. per foot extra.

The air supplied by this apparatus is sufficient only for small blowpipes with fine jets. For larger blowpipes and furnaces the Foot Blowers, Fig. 9 are especially recommended.

BLOWPIPES.

FLETCHER'S NEW SOLDERING AND BRAZING BLOWPIPE.

—Fig. 8D. An improved form of Fig. 8C. The air and gas tubes are made very short, to admit of the hand being used to compress the rubber tubes, as shown in the engraving. The air tube must rest *on the knuckle* of the little finger, and the blowpipe be held precisely as shown. A slight opening or closing motion of the hand gives the most perfect and instantaneous control over the flame, far greater than can be obtained with taps or valves. With a little practice the flame adjusts itself to the wish of the user without any apparent effort or thought.

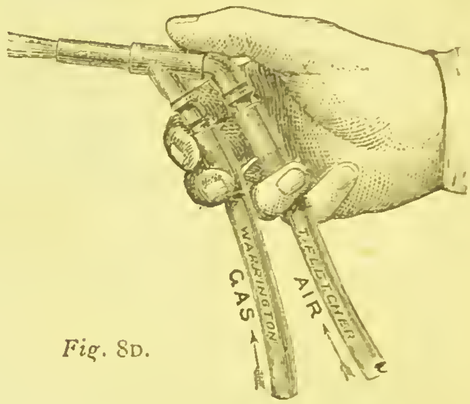


Fig. 8D.

Engraved One-Fourth full size.

The Jets fit on, and can be supplied of the sizes No. 2, 4, 6, and 8. (See inside page of cover).

Price, with one jet any size, 4s. 6d. Extra jets, 4d. Foot-blowers, see page 18. Indiarubber tubing 4½d. per foot.

This blowpipe is suited for all work, from the finest up to brazing ½-inch brass tubing.

To change the jets, unscrew at the joint where the thumb is shown in the engraving.

Fig. 8E.—The same as 8D. with the addition of taps for gas and air, to enable a steady flame of any size and power to be kept continuously without trouble Price 7s.

See also Adjustable Stand, page 21.

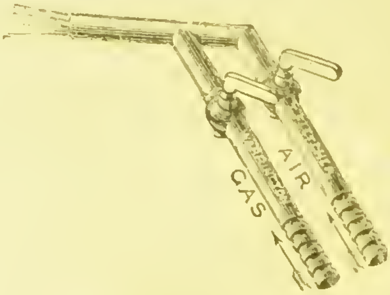


Fig. 8E.

Engraved One-Fourth full size.

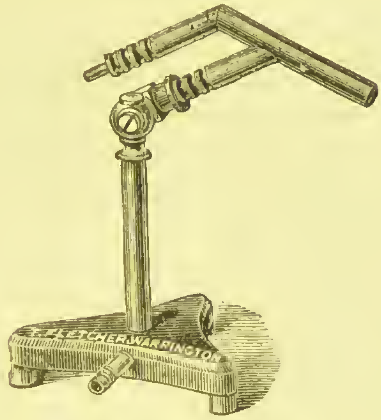
Either of the above can be supplied with an elastic tube for blowing with the mouth without extra charge.

NEW STAND with swivel joint for blowpipe. Fig. 8D. The blowpipe can be unscrewed so as to be used in the hand.

Price complete with Blowpipe 8D, as engraved . . 7s.

The same with Tap for gas. . 8s. 6d.

This is recommended in place of the Herapath, and in fact for all ordinary blowpipe use.



Engraved One-Fourth full size.

The air tube is so arranged as to take either large or small tubing, so as to be used either with mouth or foot blower.

Fig. 8c. **BLOWPIPE** for use in the hand for brazing. Price, 7s., or without taps, 4s. 6d. Size.—$\frac{3}{8}$ gas and $\frac{1}{4}$ in. air jet: requires blower No. 5 to supply it efficiently.

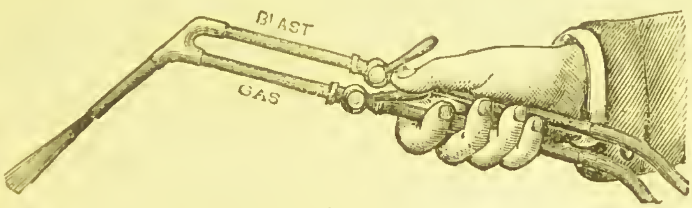


Fig. 8c.
Engraved One-Fifth full size.

Will braze up to 2-inch brass pipe.

IMPROVED
HERAPATH BLOWPIPE,

Fig. 4—adjustable at any height or angle, 7s. 6d., or without the joint A 6s. Duplicate jets, 3d. Rubber tubes, 3d. With the New Mouthpiece, 2s. extra. (See Fig. 42.)

For sizes of jets see inside page of cover.

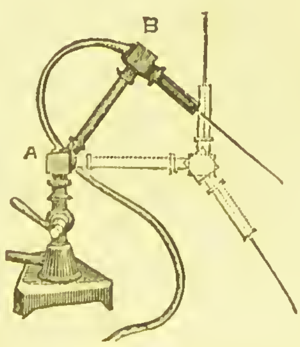


Fig. 4.
Engraved One-Eighth full size.

Fletcher's New Soldering Iron Heater.

Improved pattern for straight or hatchet bits. A useful burner for many other purposes. Fig. 70.

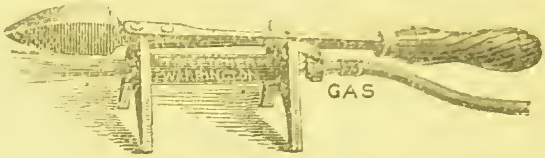


Fig. 70.
Engraved One-Eighth full size.

Price, with dome for economizing heat, 2s. 6d.

The same pattern. to take two large bits—two separate burners with taps for each gas supply—with dome, as above, 7s. 6d.

ANOTHER PATTERN is also made and preferred for some purposes. Fig. 71.

Price, single, 3s. 6d ; double, 8s. 6d.

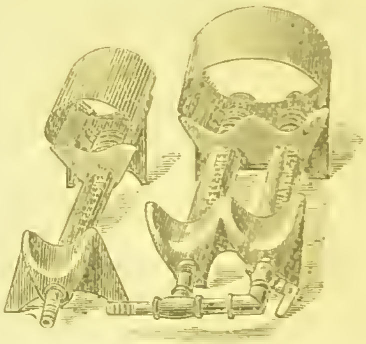


Fig. 71.
Engraved One-Eighth full size.

NEW
BUNSEN BURNER,

Fig. 5—containing a central blowpipe, which enables the temperature of the flame to be increased to any extent required. Price 8s. or without taps, 6s. 6d: A special pattern for Bohemian tube work, with double blast tube, is made at same price, but this pattern does not give a good Bunsen flame, being designed only as a very powerful blowpipe.

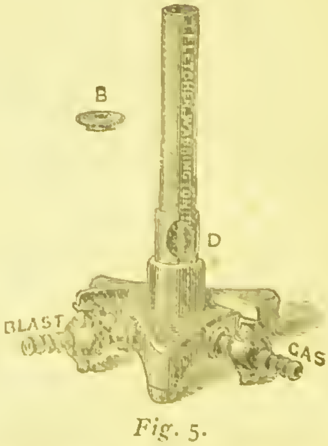
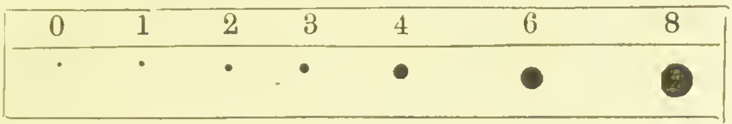


Fig. 5.
Engraved One-Fourth full size.

TERMS CASH.—Credit accounts cannot be opened for small amounts, even with known correspondents. Orders accompanied by a remittance (but not otherwise) delivered free within 100 miles, or in London and English Seaports.

IN ORDERING, if the exact apparatus required cannot be specified, the work to be done should be precisely and minutely explained. Size of blowpipe jets should be stated



ALL INDIARUBBER TUBING used must be **SMOOTH INSIDE**, made without wire, and of as large a bore as can conveniently be used. This I keep in stock, grey, $\frac{5}{16}$-inch bore, 4½d. per foot; $\frac{3}{8}$-inch bore, 6d.; ½-inch bore, 9d. per foot.

BLACK RUBBER TUBING, $\frac{5}{16}$-inch, 6d.; $\frac{3}{8}$-inch, 8d.; ½-inch, 1s. per foot.

TAPS FOR GAS should be what are known as main cocks, with a large way through. These I can supply, with nozzle for indiarubber tubing $\frac{3}{8}$ or ½-inch bore, either size, 2s. each. For the smaller heating burners, ordinary taps will do if the way through is good and clear, but high powers must not be expected with a deficient gas supply.

For New Tap see page 5.

IF THIS LIST IS THREE MONTHS OLD, please apply for a fresh one before ordering, as constant improvements are being made, and new apparatus being designed.

Crucibles and most of the plumbago fittings of furnaces can now be supplied of the "Salamander" brand (Morgan's new patent). These require no annealing or care in heating up, and stand strong fluxes better than the ordinary make. Prices same as old make.

THOMAS FLETCHER,

4 & 6, MUSEUM STREET,

WARRINGTON.

No. 50.—December, 1880.

PRICES ON FORMER LISTS CANCELLED. PRICE 2D.

List No. 52. JANUARY, 1881.

GAS AND PETROLEUM

FURNACES

FOR

CRUCIBLES, MUFFLES, LADLES,
PORCELAIN AND GLASS PAINTING, &c.

Hot and Cold Blast Blowpipes.

Blowing Apparatus.

Special Heating Apparatus
FOR GAS AND PETROLEUM.

Gasmaking Apparatus.

DESIGNED AND MANUFACTURED BY

THOMAS FLETCHER,
4 & 6, Museum Street, WARRINGTON.

Sole Agents for the United States:—BUFFALO DENTAL MANUFACTURING CO., 307 & 308, MAIN STREET, BUFFALO, N.Y.

If this List is over Three Months old, please apply for a fresh one before ordering.

PRICES ON FORMER LISTS CANCELLED.

Glasgow Philosophical Society's Gas Exhibition.

LECTURE ON GAS HEATING,

BY

THOS. FLETCHER, F.C.S.,

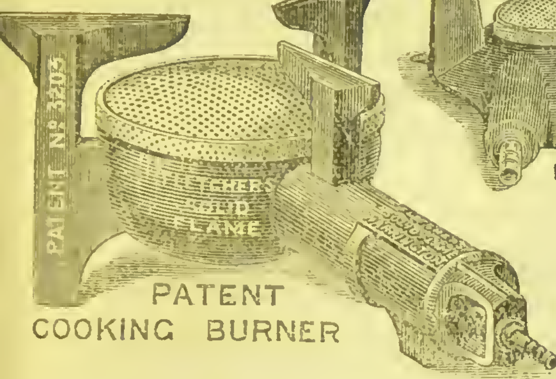
OCTOBER 22ND. 1880,

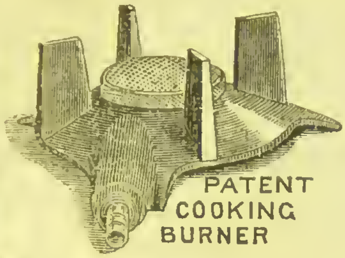
WITH THE RESULTS AND DETAILS OF THE COOKING AND FURNACE TESTS, SHOWN TO ILLUSTRATE THE LECTURE.

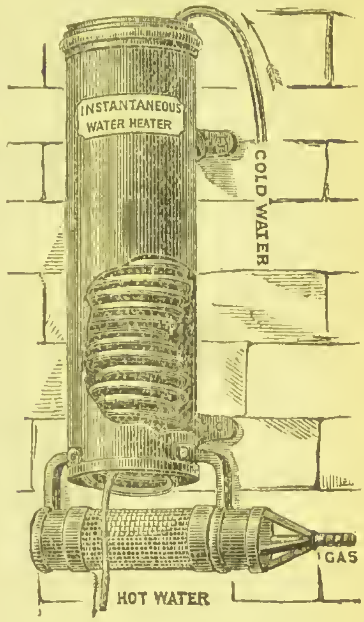
Stereotyped Edition for Distribution by Gas Companies.

PRINTED AND PUBLISHED BY
MACKIE, BREWTNALL, & CO., LIMITED,
WARRINGTON.

Apparatus Used to illustrate the Lecture.

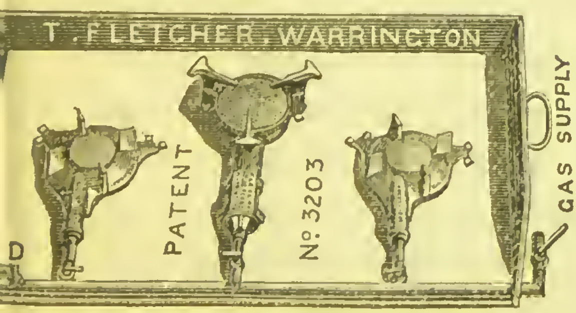




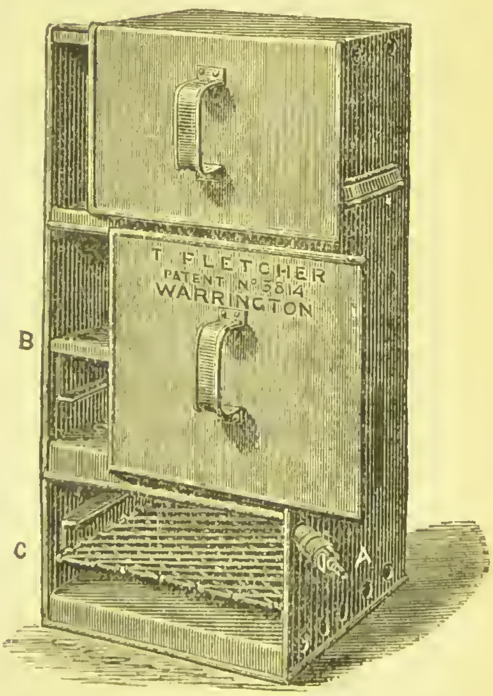


Instantaneous Water Heater, for Scullery and Bath Room.

Crucible Furnace for Gas or Petroleum Vapour, showing Gas making attachment in use.



BOILING BENCH.



Triple Oven, requiring only one Gas Burner.

GLASGOW PHILOSOPHICAL SOCIETY.

(Exhibition of Gas and Electrical Apparatus.)

RESULTS OF THE TESTS MADE IN COOKING AND FURNACE WORK, AT MR. FLETCHER'S LECTURE ON OCTOBER 22nd, 1880.

(*FOR FULL REPORT OF THE LECTURE, SEE PAGE* 4.)

Fletcher's Patent Gas Cooking Oven, 55s. size. Gas consumption in roasting meat, as tested by experimental meter during the lecture, 8 feet per hour. Gas consumption whilst cooking fish, joint, and fruit pie all at once, 14 feet per hour. Gas consumed in 1¼ hours, roasting 6 lbs. beef, baking one apple pie and grilling two herrings, 16 cubic feet; cost about one halfpenny. The time allowed for the lecture was not sufficient to finish roasting the joint: about 15 to 20 minutes more would be required, with an additional gas consumption of about 2 feet; but it was stopped at the conclusion to enable the joint and pie to be cut open and handed round to prove the absence of the slightest trace of taint from the strong smelling fish which had been cooked underneath at the same time.

In the best apparatus, *to which a silver medal was awarded* by the Manchester Corporation at the trial of cooking apparatus on September 22nd, 1880, the consumption of gas was 45 cubic feet in roasting 10 lbs. of *meat only*, being more than double the quantity of gas necessary in a perfect apparatus.

The herrings were grilled under the pie and joint, all at the same time, without a trace of taint or flavour from one to the other. The herrings were perfectly grilled, the pie was perfectly cooked, with a crisp brown crust; the meat was brown, juicy, and perfect in flavour, but, owing to the time, rather underdone. Ordinary gas was used.

FURNACE EXPERIMENTS with Fletcher's Injector Furnace, with self-acting gas-making apparatus, making its own gas from gasoline. Starting all cold, 1 lb. cast iron was fused and poured in 7 minutes; 1 lb. pure nickel was fused and poured in 11 minutes afterwards. The latter was left in the furnace a short time after the nickel was melted, and the refractory crucible was fused; but the nickel was poured out of the furnace without injury to any part, and without loss or injury to the metal.

HEATING BY GAS

(COOKING IN PRIVATE FAMILIES, AND USE IN WORKSHOPS.)

A PAPER

READ BEFORE THE PHILOSOPHICAL SOCIETY OF GLASGOW,

(EXHIBITION OF GAS APPARATUS)

ON OCTOBER 22ND, 1880.

BY

THOS. FLETCHER, F.C.S.
WARRINGTON.

It is not my intention to-night to go deeply into the theory of gaseous fuel, to do so would take more time than is at my disposal. The figures I shall give are approximately correct, quite sufficiently so as a guide to consumers. Unfortunately I am not in a position to give the practical working values of the gas of high illuminating power as used in Scotland, my knowledge of this comes to me from others, and from what I can learn it would appear to be about one-sixth worse as a fuel than the same quantity of London gas. This is not owing to its actual inferiority, but is caused simply by the greater difficulty in burning so as to obtain a compact flame of high temperature, such as is necessary for an economical gaseous fuel. The fuel value of Scotch gas is very high, if we could only succeed in getting hold of it, but the fact remains that the quick work and high temperatures obtained by furnaces and heating burners with gas of low Illuminating power, cannot be obtained with the gas used in Glasgow. Gas furnaces and burners made to do specified work in London or Birmingham are here total failures for the same purpose. An apparatus which will just melt cast iron in London, will here probably melt copper, but will certainly fail with cast iron, unless it has a very large margin of power. In the experiments made by Dr. Wallace, of which I have the results now before me, he tested only for very low powers and slow heating, for most purposes the results are misleading, as I know only too well to my cost. I am to-night practical, not theoretical, and I refer only to actual results, which I know are correct, and which do not correspond with the accepted theory, and without setting up my opinion as abslutely reliable, in the absence of sufficient practical experience, I think that as gas is now so largely used as a fuel, the Scotch gas companies would find it to their advantage to reduce their quality to the average English standard, reducing the price also in proportion. At present it is like a break in a railway gauge, and causes endless trouble and annoyance to both makers and users of gas apparatus for heating purposes, checking most seriously the consumption of gas in Scotland, and doing considerable damage to the gas companies ; the gas used for heating being almost entirely wanted when the gas works are at present almost standing idle, *i.e.*, in the day time, and in summer more than winter. The gas companies who do not seriously consider the advisability of taking every possible means to increase the consumption of gas for heating purposes are simply ignoring their most important business and neglecting their most valuable and profitable customers. I would even go beyond this, and make for all purposes a gas of about 14 candle power as a maximum, and sell it, as it very well could be sold, at about 1s. 10d. per 1,000 cubic feet, (which by the way, is the present price in Leeds.) This would be cheap, perfectly suited for all purposes, both lighting and heating, and would be very much more largely used than the present gas. Dr. Carpenter is urging the use of a cheap gas fuel in London, to put a stop to the London fogs. It certainly will not do away with these, which are caused principally by the water given off in burning all fuels containing hydrogen. It probably would lighten their consistency to something less than the usual peasoup thickness, and would also improve their peculiar peppery flavour. If the gas companies have any great future to look to it is from the use of gas for heating purposes, which can be cheaply made in large quantities at a time when the works are almost standing idle. Those who objected to the little additional heat given off from the lighting burners could well afford the expense of ventilating out of the reduction in their bills, and both makers and consumers would be benefited. At present the use of gas as a fuel is hampered in every way by the sleepy let-well-alone system of manufacturers with a monopoly, having their customers under their thumbs. The only reply I ever obtained to any remarks about creating a business in gas for cooking is " Ah, we are doing very well; look at our profits last year." These profits, bear in mind, are the result of excessive prices, in the face of a wasteful and costly system of working. If the Crystal Palace Gas Company understand their business, and we may suppose they do, it is the business of a gas company to test and know all the cooking and heating apparatus, and to fix the apparatus on hire, as they do gas meters, at a low rate, publishing and distributing constantly pamphlets explaining the advantages of gas heating and also its disadvantages, giving the whole case honestly and fairly.

In England a mixture of about 75 per cent. cannel and 25 per cent. good coal is commonly used for gas making. This produces from each ton 13 cwt. coke 13 gallons tar, 25 gallons ammonia liquor, and 10,000 cubic feet of gas of about 18 candle power. The gas, if reduced to the solid state again, would weigh

Value as fuel.

about 350 lbs. Allowing this as a fuel at a value of 1s. 2d. per cwt., which is about the average cost of the material used to produce it, we get the actual fuel value of coal gas as about 4½d. per 1,000 cubic feet. Its cost at the gas works, delivered into the mains including all expenses is about 1s. 2d. per 1,000 cubic feet.

Value of Petroleum as fuel.

Gasoline, benzoline, and petroleum, which are all hydrocarbons, and very similar in composition to coal gas, may be taken as fuel as equal to coal gas in value. A little calculation shows them to be worth as fuel about 10½d. per gallon, coal gas being 3s. 6d. per 1,000 cubic feet—one gallon being equal to about 250 feet of gas. To get this duty from the petroleums it is necessary that they shall be burnt in the state of vapour. When burnt in spray or as a simple flame in a lamp with a wick it is exceedingly difficult in practice to obtain a fair proportion of the work out of them, and they become very expensive. When burnt as vapour, such as is produced from benzoline or gasoline in any of the well-known air gas apparatus, or in the simple little generator I will show you at the conclusion, there is no practical difference between the cost of these and of coal gas as fuel, and my remarks will apply in almost every point equally to coal gas, and the vapour or air gas made by passing air through gasoline or spirit petroleum. The generator which I shall use at the conclusion is simply a tin box divided lengthways, so as to secure a long passage for the air through a number of cotton screens, saturated with spirit petroleum. If I use the more volatile gasoline instead of spirit petroleum the supply of vapour from a generator of about 1 cubic foot capacity, is equal to a coal gas supply through a 1¼ or 1½ inch main at ordinary pressures, and will work two of my largest furnaces —each melting 28lbs. of steel—at the same time. This generator being specially designed for blast furnaces, has no blowing apparatus, and is therefore unfit for use except where a supply of air under pressure is available.

It will be at once seen that gas and petroleum, at present prices, can never approach coal or coke as a competitor for large or continuous work where the cheaper fuel can be burnt without great waste. When, however, we come to the cooking for private families, and almost the whole of the heating work required in small workshops, the conditions are completely altered, and gas fairly used becomes a very economical fuel.

Cost of Cooking.

Take as an example our own cooking for a family of eleven. The cooking each morning is done in about ten to fifteen minutes, frequently in less than ten minutes. The dinner, including roast joint, pastry, two or three different vegetables, sauces, &c., requires one burner only for 1½ hours and three others from 10 to 30 minutes, say an average of 30 minutes for four burners. Tea and supper may be taken at a maximum of ten minutes each. We here have about an hour during which the burners are in use, at a total cost of about three half-pence to twopence per day, if we had a fire it would probably be burning 15 or 16 hours, burning almost the whole time many times more fuel than would be necessary to do treble the work required.

The same remark applies to general workshop use. To braze a joint a fire has to be kept going the whole day, or a man has to spend perhaps 20 minutes lighting a forge, whereas with gas he could do his work in two minutes. If 3lbs. or 4lbs. of metal is required for a casting, a large fire has to be lighted, burning probably 20lbs. of coke and requiring one to two hours before the crucible can be put in. After melting, the fire has to burn itself out. With gas the metal can be melted in 10 to 15 minutes, with a consumption of about eight or nine cubic feet of gas, the actual cost of fuel being far less than coke, and the value of the workman's time saved being more than ten times the cost of both coke and gas put together. In a foundry where pots are in the furnaces all day gas would be, as compared with coke, excessively costly; and in cooking for large hotels and institutions, where the work is almost continuous and on a large scale, gas is far too costly a fuel for the bulk of the work; but both in the hotel and in the large workshop or foundry, gas, although not the main fuel, is most valuable, and in many cases absolutely necessary as an assistant.

Cost in Workshops

To have gas fuel at command is to be always the master of the situation, as it is ready for instant use when the fires are out of condition or extinguished, and hardly a day passes when gas in both places would not be a cheap fuel for some purposes.

I am frequently asked, "Is gas a cheap fuel as compared with coal?" This is not easy to answer. For family cooking it is, I think, even with the usual wasteful ovens and burners rather cheaper than coal. In saving of work and time in cleaning and attention it pays for itself in most cases ten times over. I know in our own case the absence of gas for cooking would entail our having an extra servant, and a greatly increased wear and tear caused by the dirt and mess of fires. In the routine work of my own laboratory the absence of gas for odd work would entail an additional expense in wages of nearly 50 per cent., but in addition to this, my special work, which in fact has created all the gas apparatus I have ever devised, could not be carried on at all without gaseous fuel. I refer to the production of some special alloys of the rarer metals which can only be produced with certainty under the most exact conditions of temperature and time. For my own work all furnaces and burners must be as exact in results as a chemical balance, and must be under the most perfect and instantaneous control; they are, in fact, instruments of precision working with the certainty of a chronometer. Here we have a business of some importance, the very existence of the good reputation of which is absolutely dependent on gaseous fuel.

Economy of Gas as fuel.

For cooking in ordinary families, for workshops where soldering, brazing, melting small quantities of metals in crucibles, &c., are required, and as an accessory in larger workshops, hotels and public institutions, I consider gas fuel an absolute necessity for convenience and economy. It cannot be approached by any other fuel known. At the same time we must not forget that on account of its cost we cannot afford to waste it by using imperfect apparatus, and it pays better to throw away a faulty burner than to attempt to continue its use and make shift with it.

The question of the possibility of a good gas fire is frequently

PRICES ON FORMER LISTS CANCELLED.

raised. I know many cases where gas fires have been fixed, and I know none where they have remained in use twelve months. They are far too costly in fuel, and I don't see how a good gas fire is to be made at a cost of less than 1d. to 4d. per hour. If a gas fire is to be used I have no possible doubt that the proper material to be heated is most certainly not asbestos, or fire clay, but rings of thin hoop iron such as I have used here. It burns away slowly, but is very easy and cheap to replace, and gives off far more radiated heat than any substance I hav eyet met with, although iron is one of the worst radiators of heat known. The reason of this is simply that iron takes up heat much more rapidly than asbestos or fireclay, and becomes very much hotter. It is very probable that by forming the magnetic oxide of iron on the surface by Barff's process, the scaling and burning away may be entirely prevented. From some rough experiments made, it would appear that the increase of heating power by radiation from incandescent iron as compared with asbestos is about 70 per cent.; but my experiment was made in a rough and hurried manner by simply hanging up a thermomometer in front of each at 12 inches distance. This matter requires further testing before any precise results can be obtained.

Gas Fires.

With regard to Gas Stoves, and giving my own personal opinion, the old style, be they reflectors or non-reflectors, are a horrible abomination, not to be tolerated by anyone whose nose and feelings are in anything like working order. I have a stove in use which is really a boiler with hot water pipes heated by gas, and which I shall again refer to ; but the convected heat from warm metal whatever the temperature of the metal, is to me so decidedly disagreeable, that it would be only a matter of pure necessity that would make me bear the annoyance. Still speaking of my own feelings I greatly prefer, both for comfort and economy, to heat any room by gas by keeping the ordinary lighting burners at work without a glass globe. The radiated heat from these is, to myself, beyond comparison preferable to the convected heat from a surface of warm metal. You will clearly understand I speak now only for myself and my own feelings, having a strong dislike to any and every stove for gas or solid fuel, and also to the system of heating by hot water pipes when it can be avoided.

Gas Stoves.

I have here a new form of oven for gas cooking, which so far as our own experience goes, is apparently destined to rule the pattern and principle of the gas ovens of the future. Using a line of solid flame so as to distribute the heat equally, the bottom of the oven is first heated. The whole of the radiated heat from the bottom is used underneath for toasting bread, grilling chops and steaks, making Yorkshire puddings, roasting potatoes, apples, &c. The hot air is then, after doing its work underneath, passed in a layer round the sides of the oven inside in such a manner that the products of combustion, although inside the oven, pass up round the sides and under the top so as not to come into contact with the food. Here meat can be roasted, (not baked,) to perfection, also pastry, bread, and all cooking which requires browning and a dry sharp heat with plenty of ventilation. After doing its work here the heat is again taken into an upper oven in a precisely similar manner, but has become rather

Oven for Cooking.

too moist to brown and roast well. This upper oven is specially adapted for rice puddings, stews, and work of this class. On the top of the oven, and also round the sides, plates and dishes can be warmed.

With the assistance of burners for boiling, this oven, which is about as simple and cheap in form as an oven well could be, will do in the most perfect manner everything which can possibly be done with a first rate open fire range, and, as it is fully hot in half a minute after lighting the gas, and therefore always ready for anything and everything at half a minute's notice, it overcomes the one great objection to a fire range. The one I show you, which measures 14 by 12 inches on the bottom, and costs on an average one penny for three hours' work, will do the whole of the cooking, boiling excepted, for a family of 12 or 14 people.

Heating Greenhouses.

There is one purpose for which gas is frequently required, the heating of small greenhouses. The fumes of gas, burnt or unburnt, are seriously injurious to plants. My own tropical stove and orchid house is a very small one, too small to heat steadily with coke, and I have in it 40ft. of 4½ inch pipe heated by gas. The burner is placed in a boiler inside the house, but is lighted from the outside, and the flue runs inside the water pipes for a distance of 20ft. The products of combustion leave the house over the lighting hole at a temperature of from 75degs. to 85degs. The house is well built and well glazed. To keep a minimum temperature of 60degs. in the summer and 50degs. in the winter costs about ten pounds per annum. To keep a minimum of 40degs would cost about 25s. This is a further proof of the heavy cost of continuous work with gas; at the same time I could not do the same work with any other fuel, as the house is separate, and cannot be heated from the other boiler which is worked with coal, and which does ten times the work at a smaller cost. With gas it may be taken as an average that a rise of one degree in temperature costs about one penny for 24 hours in a plant house 12ft. square 12ft. high.

Iron Melting.

Nickel Melting.

Solid and Hollow Flame.

I will now proceed with my experiments and will show you the fusion of cast iron in a crucible which, starting all cold, will require 7 or 8 minutes. I will then replace the crucible with one containing pure nickel which I will melt in about 20 minutes. I may say that the fusion of pure nickel is a feat rarely attempted, and still more rarely successful, in any furnace except the injector which I shall use. For the sake of rapid working I will only melt about a pound in a small crucible. The heat required is so tremendous and the loss by radiation is so rapid the instant the crucible is removed from the furnace that I doubt whether I shall be able to pour it before it sets hard in the crucible, and I dare not exceed the heat required to melt the nickel, as no crucible will stand a higher temperature. Whilst these rather noisy operations are going on I will show you the difference between a solid and a hollow flame, both having the same appearance, by putting my bare finger in the centre of the hollow flame, my hand being protected from the outer film of flame by a wet cloth. I will then put a ball of gun cotton in the centre of the hollow flame, and afterwards explode it by making the flame solid.

I asked my wife to be my head cook for to-night, intending to give

Cooking.

you a practical illustration of cooking on a variety of substances; but she refused, and as you see here I am, the unhappy victim of a monopoly, as she, like the gas companies, has no fear of opposition and does as she likes. We must, therefore, omit our intended extensive supper: I offer no apologies, we are all present the victims of this monopoly, and we must make the best of it. To assert my independence I will, however, roast you a small joint, bake a fruit pie, and cook two strong salt herrings underneath, so that the vapours from the fish will have to pass completely round both the roasting meat and the pie. If the herrings flavour either, no doubt someone present will be sharp enough to discover it.

I wished to show you the actual working of a four-course dinner for twelve people, *i.e.*, soup with dry toast, fish, joint with three vegetables, sauces, pastry, custards, &c; warming about fifty plates and dishes, and boiling three or four gallons of water for washing up, all of which we can easily do with the oven and three small boiling burners now before you. When I was a bachelor, and before I came under petticoat government, I never dreamt of such a thing as a four or five course dinner, more especially when, as often happened, I had to cook it myself: there is no telling what one may come to when somebody else has to do the cooking.

GAS APPLIANCES.

INDUSTRIAL EXHIBITION, MANCHESTER,
SEPTEMBER 22ND, 1880.

At the trial of Cooking Stoves as above, a Corporation Silver Medal was awarded to a Patent Gas Kitchener, price £6, the oven test being the roasting of 10lbs. of mutton, which was done in 1 hour 41 minutes, with a consumption of 45 cubic feet of gas. The trial, which was simply the roasting of a joint of meat and boiling vegetables, was an absurdity not worth the consideration of a practical cook.

Fletcher's Patent Gas Oven will, with ONE HALF THE GAS USED FOR ROASTING THE MEAT ALONE in the above contest, not only roast the same weight of meat in the same time (or quicker or slower as desired), but with the spare heat will also roast 5lbs. of potatoes or fish, bake a large fruit pie or two small ones, and warm all plates and dishes necessary. The cooking in every trifling detail shall be faultless. See tests made at the lecture at the Glasgow Philosophical Society's exhibition.

The work done is therefore practically DOUBLE that of the best apparatus in the most recent contest, and with ONE HALF the cost for gas.

Not only is the first cost of the apparatus far lower, but it will do work, such as grilling chops, steaks, bacon, &c., toasting bread, and ALL THE REQUIREMENTS OF A FIRST-RATE COOK, which can be done only in very few gas kitcheners, and in these only at a tremendous cost for gas.

Illustrated List of Gas Apparatus for Domestic Use, free by post.

Illustrated List of Gas and Petroleum Heating Apparatus for Laboratory use, Furnaces for all purposes and temperatures, Foot Automatic, and Hand-blowers, Hot and Cold Blast Blowpipes, Ingot Moulds, and Special Apparatus for Chemical Laboratories—price 3d. free by post.

Both these Lists are published at short intervals (2 or 3 months) with additions and improvements.

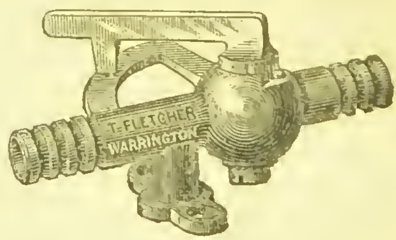
PRICES ON FORMER LISTS CANCELLED.

FLETCHER'S PATENT OVEN.

COPY OF LETTER RECEIVED:—

"*We have delayed acknowledging receipt of the Oven until it had been thoroughly tried. We are much pleased with it, and can do anything; roast meat, bake pies, puddings (including a deep potato pie), cakes, toast, loaves, potatoes, Yorkshire pudding, bacon, chops, in fact anything, and in first-rate style.*"

The Oven referred to above is used without any special gas supply. The ⅜-lead gas pipe in the kitchen has been cut through with a knife, and one of *Fletcher's* supply taps, price 2s., fastened to the wall and connected by a few inches of india-rubber tubing. No gas fitter is required. If more than one tap is required they can be supplied fitted on a board side by side and ready for fixing in the same manner, without requiring a gas fitter, and ready for fixing with india-rubber and screws or nails, without trouble. In reply to several inquiries: I do not supply boiling burners fixed on the top of the Oven. To do good work in the Oven it must be at a convenient height, so that the whole of the contents can be seen instantly, and easily handled. It must therefore be too high for burners on the top. Further than this boiling burners never work well on the top of an Oven in use; they are very liable to smell, and never do the work they ought for the gas consumed.



GAS-COOKING ARRANGEMENTS.

SIR,

The subject of cooking by gas appears to be coming into great prominence, and to be attracting attention in many quarters. I believe I am right in saying that a really good gas-cooking arrangement, free from the characteristic nuisances, is a want which has long been felt, and I for one am very glad to find that your contributor, Mr. Fletcher, of Warrington, is turning his attention in this direction. Having some practical acquaintance with the many improvements which we owe to him in workshop apparatus, I confidently anticipate that domestic gas appliances will now undergo a similar process of development. I have had one of his cooking arrangements for a fortnight or so, and, with the special object of stating the result in DESIGN AND WORK for the benefit of those correspondents who are interested, have tested it on the lines laid down by "A Visitor" in your issue of October 2nd, being decidedly of opinion that any apparatus which would only *approximately* fulfil those conditions would not leave much to be desired. I find that all he stipulates for, and more, can be done, and done well, and at a first cost considerably below the £7 or £8 mentioned by "A Practical Student" on page 315. The cooking of the establishment is now no longer the source of anxiety to my wife that it used to be, as anything and everything can now be "done to a turn" with absolute regularity. If required, the broiling of fish and the baking of custards and tarts (or any other equally incongruous processes) can be carried on at the same time without detriment to either; while those who are familiar with the vile odour given off by most gas-ovens will not fail to appreciate the utter absence of this intolerable nuisance.

B. A. C.

Lozells, Birmingham.

PRICES ON FORMER LISTS CANCELLED.

Glasgow Philosophical Society's Gas Exhibition.

LECTURE ON GAS HEATING,

BY

THOS. FLETCHER, F.C.S.,

OCTOBER 22ND. 1880,

WITH THE RESULTS AND DETAILS OF THE COOKING AND FURNACE TESTS, SHOWN TO ILLUSTRATE THE LECTURE.

Stereotyped Edition for Distribution by Gas Companies.

PRINTED AND PUBLISHED BY
MACKIE, BREWTNALL, & CO., LIMITED,
WARRINGTON.

PRICES ON FORMER LISTS CANCELLED.

List No. 53. JANUARY, 1881.

DOMESTIC

HEATING AND COOKING APPARATUS.

GAS.

FLETCHER'S PATENT

Ventilated Hot Air Oven,

Instantaneous Water Heaters,

Bath Heaters,

Boiling Arrangements, &c.

DESIGNED, PATENTED, AND MANUFACTURED ONLY BY

THOMAS FLETCHER,

4 & 6, Museum Street, WARRINGTON.

PRINTED AT THE "GUARDIAN" WORKS, WARRINGTON.

PRICES ON FORMER LISTS CANCELLED.

APPARATUS IN THIS LIST.

PATENT OVEN FOR ROASTING, BAKING, GRILLING, &c.

PATENT SOLID FLAME BOILING AND COOKING BURNERS.

INSTANTANEOUS WATER HEATERS.

PATENT SOLID FLAME BATH HEATERS.

CRITICISMS OF SCIENTIFIC PAPERS AND COPIES OF LETTERS RECEIVED.

*** *Experiments are now in hand with a new Apparatus for Heating Greenhouses by Gas, and a small Coffee Roaster, which will in a few minutes roast coffee perfectly and fresh every day. If these prove satisfactory after continued practical use, they will be included in future lists.*

LISTS, &c.,

ISSUED BY

THOMAS FLETCHER, F.C.S.

ILLUSTRATED LIST OF GAS COOKING AND DOMESTIC HEATING APPARATUS. Post free. Published with additions, at intervals of 2 or 3 months.

ILLUSTRATED LIST OF GAS AND PETROLEUM APPARATUS FOR LABORATORY USE. Furnaces for all purposes, Hot and Cold Blast Blowpipes, Ingot Moulds. Blowing Apparatus, Soldering-Iron Heaters, &c. Price 2d. Published at intervals of 2 or 3 months.

GASEOUS FUEL. A Paper read before the Society of Arts, April 30, 1880, for which the Society's Silver Medal was awarded. Price 3d.

GAS HEATING (Cooking in Private Families and Use in Workshops). An experimental Lecture delivered at the Glasgow Philosophical Society's Exhibition, October 22nd, 1880 Price 2d.

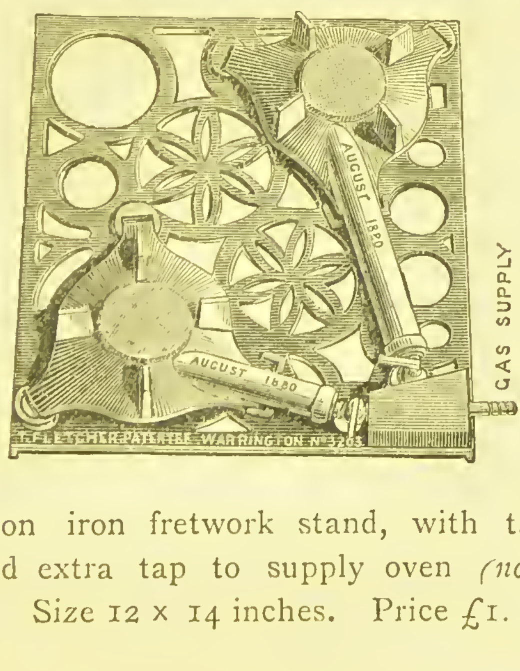
FLETCHER'S

PATENT

Solid Flame Boiling Arrangements.

NEW PATTERNS READY FEBRUARY 1, 1881.

TWO SMALLER BURNERS, similar to Fig. 48.

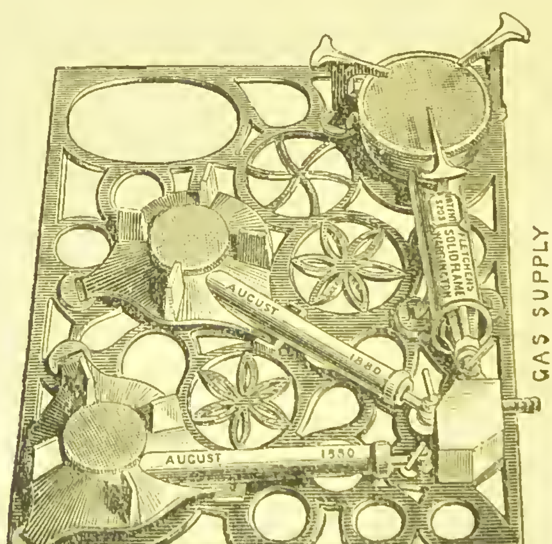


Complete on iron fretwork stand, with tap to each burner, and extra tap to supply oven *(not shown on engraving)*. Size 12 x 14 inches. Price £1.

This is recommended to be used on a tray at the side of the oven, but it can be fitted on the top of either the 45s. or 63s. size of Fletcher's Patent Oven, at an extra charge of 7s. 6d. The fitting in every case will be done in such a manner that the whole can be taken apart and cleaned without trouble.

Fletcher's Patent Solid Flame Boiling Burners.

Size No. 3, with two small and one large Fletcher's Patent Solid Flame Burners and Taps, complete; with taps to each burner, and extra tap to supply oven.



Size No. 3, 14 × 18 inches. Price 30s.

This can be fitted on the 84s. size of oven if required, at an extra cost of 7s. 6d.

SIZE, No. 5.

ENGRAVING

IN PREPARATION.

With 3 large and 2 small Fletcher's Patent Solid Flame Burners. Size 2 ft. 10 in. x 17 in. Price, complete as above, £3.

This can be fitted on the top of the new large oven now in preparation, at an extra cost of 15s.

When fitted on an oven all the above are supplied with a water-tight tray, to prevent, as far as possible, the boiling over of pans on to the oven; but no care will entirely prevent this annoyance, and it is therefore recommended that they should, where possible, be used in a larger tray at the side of the oven. In any case they are made and fixed so that they can readily be taken apart and kept clean. When fixed so that this cannot be done, as is usually the case with boiling burners on ovens, they are liable to be choked up with filth, and to become a source of offensive smells.

Fletcher's Patent Gas Stove for Warming Rooms.

It is well known that there is not a good Gas Stove in the market which can be used without a flue, and which is at the same time simple, safe, and portable.

The only heat which is pleasant and comfortable is that radiated direct, *not by reflection*, from an open *white* flame. This direct radiated heat is entirely lost in the ordinary reflected gas stoves; they are, in fact, of less service than a common lighting burner in a room.

In Fletcher's Patent Stove the same effect and appearance is obtained as in the common reflector stoves, but in addition they give the whole of the direct radiated heat from the flame, which is itself visible and adds to the brightness and cheerful appearance. They are made so as to be used with or without a flue, as convenient. If a flue is used it should be of sheet iron, and should be as much as possible in the room, so that the heat given off from its surface shall be utilized. Several patterns are in preparation. The first, for office and nursery use, has a flat openwork top, on which vessels or food can be kept hot. Others and more ornamental patterns, for shops and public offices, &c., are in hand. The stock patterns will be of iron, electro bronzed, or nickel plated, with polished copper reflectors.

Engravings and full particulars are expected to be ready about the middle or end of February, 1881.

THOMAS FLETCHER,

MUSEUM STREET,

WARRINGTON.

IN PREPARATION,

(EXPECTED TO BE READY EARLY IN FEBRUARY,)

A

NEW DOUBLE OVEN,

3ft. wide, 18in. deep, 28in. high.

For Clubs, Refreshment Rooms, &c.

BOILING ARRANGEMENTS.

Two small Solid Flame Burners in one frame, with taps complete. Square, to fit on small ovens. PRICE ABOUT 20s.

Three Burners, as above, to fit on 84s. size oven, without projecting, with taps, &c., complete. PRICE ABOUT 30s.

The new large oven will be fitted with six boiling burners.

All the above can be used on or off the Oven, and are recommended to be used separate.

The boiling over of cabbage water or soup on a hot oven gives a flavour to the kitchen far from desirable.

THOS. FLETCHER,
Museum Street,
WARRINGTON.

January 3rd, 1881.

See other side.

NOTE.

Many who have not used or seen Fletcher's Patent Oven imagine there is great loss from radiation from a single iron casing. The fact is that not only is unvarnished iron one of the worst radiators of heat known (its good conducting power is no objection), but also that it is really a Hot Air Oven, the casing having no use or action whatever except to prevent loss of heat by draughts. The hottest part of the Oven is in the centre, and at the greatest distance from the casing. The fact that it is the quickest Pastry Oven ever made, and that it works with a gas supply so small as to be utterly useless for any other oven known, are quite sufficient to silence any theoretical objectors who have not taken the trouble to study the perfect and direct manner in which the whole of the heat is utilized. The average cost for gas for this Oven, in an ordinary family, does not exceed One Halfpenny per day.

THOS. FLETCHER.

Museum Street, Warrington.

TERMS.—Orders over 20s. accompanied by a remittance (but not otherwise) carriage paid within 100 miles, or to London. Packing Cases to be returned the day received, or will be charged.

FLETCHER'S PATENT

Gas Cooking and Heating Apparatus for Domestic Use.

PATENTED AND MANUFACTURED ONLY BY

THOMAS FLETCHER,

4 and 6, MUSEUM STREET, WARRINGTON.

I have been so constantly asked for cooking apparatus, and repeatedly consulted with regard to apparatus in use, and the advisability of making alterations, that I have decided to make cooking apparatus in addition to the special laboratory arrangements now so well known.

We have used gas to the *total* exclusion of fires for cooking for the last 18 years. During that period constant experiments have been made, and the system repeatedly remodelled, with the object of getting the most perfect results with the least trouble and expense, for our own convenience. The matter is, therefore, so far as practical necessities are concerned, by no means new, although I have never up to the present time attempted to create a business for cooking apparatus.

The burners and oven, specially designed, are patented in all details, and are the same precisely as we have now in daily use. They are both *simple, cheap, and within the capacity of an ordinary servant.* The actual cost of gas cooking with the old forms of apparatus is about the same as that of coal ; with this, it is about half the cost of coals, and in addition, the absence of gas for cooking in our own house would entail, in labour and dirt, at least an extra servant, and a greatly-increased wear and tear in cleaning. For 18 years our cooking has been done on a table under the kitchen window. The oven and three boiling burners are all the apparatus necessary for 6 to 14 people. The smaller oven and two boiling burners are sufficient for small families.

The oven is fully hot in less than one minute. To work the whole of the burners and the largest oven at their fullest power all at once requires a $\frac{5}{8}$ inch gas supply pipe and tap, which can in almost every case be fixed by a plumber for a few shillings. In case of removal, the pipe can be taken and refixed in a new house with little expense. Our own fittings have travelled through four houses in 18 years.

The oven is the most important point ; underneath the burner small joints of meat, fish, potatoes, apples, &c., can be roasted perfectly, and toast quickly made. In the lower oven, pastry can be baked quickly and perfectly, and meat can be *roasted*, not baked as in an ordinary oven. In the upper oven, meat can be stewed, custards, rice puddings, &c., made, and the hundred odd things done which are so constantly required. This upper oven is not fitted to the small size apparatus, and is not necessary in the ordinary cooking for small families. It utilizes the little waste heat only, and can never be got hot. Puddings can be slowly cooked, but must be finished and browned in the lower part.

With regard to the system by which the oven is heated, the burner is at the top of the lowest part, where the gas is perfectly burnt, thereby heating the bottom of the lower oven, which radiates heat downwards for grilling, toasting, &c. The burnt air is taken in at the sides and carried up round the food as a hot jacket; the same thing is done again in the upper oven with the heat not already utilised.

By this system fish can be cooked underneath joints or fowls, and pastry, *all at once with one burner*, without the slightest alteration in the most delicate flavours. All are as perfect as they can be, and by this system the consumption of gas is reduced to less than one-half what is usually burnt, whilst any character of heat, dry or moist, quick or slow, can be got instantly without trouble.

The whole of the products of combustion and the vapours and smells of cooking are led up to one opening in the top, which, if desired, can be connected with a pipe to any convenient flue, although this will not be found necessary except in very confined kitchens.

In reply to several enquiries: I do not supply boiling burners fixed on the top of the Oven. To do good work in the Oven it must be at a convenient height, so that the whole of the contents can be seen instantly, and easily handled. It must therefore be too high for burners on the top. Further than this, boiling burners never work well on the top of an Oven in use; they are very liable to smell, and never do the work they ought for the gas consumed.

The new boiling table can be used if necessary on the top of the oven; but I do not recommend it to be so used, as one burner never works properly if placed over another.

The boiling burners are two sizes: the largest, whilst at its fullest power, will burn 25 cubic feet of gas per hour, is for large pans and quick heating. It will boil quickly four or five gallons of water for children's baths, and will, when required, keep a small pan boiling steadily by simply turning the gas low. The small burners at their fullest power burn 10 cubic feet of gas per hour, and are for general work. It is advisable to use the large burner only, as far as possible, for very large or very small work, as it is not so economical as the small burners for medium work, although the difference is not great. As soon as boiling heat is reached, turn the burners low; about 2 feet of gas per hour will keep a pan boiling.

The statement as to the very unusual power of Fletcher's patent burners has been so repeatedly denied by those interested in the older forms, that the following tests made, without my knowledge, by R. Briggs, Esq., C.E., and published in the "Journal of the Franklin Institute," will set the matter finally at rest :—"A cooking stove, fitted with the Bunsen Burner, formed by a ring of 1¼ in. iron pipe, with jet holes 1 inch apart, gave 244 units of heat for each cubic foot of gas.

Fletcher's patent solid flame burner gave 450 units of heat for each cubic foot—nearly double the work for the same cost."

PANS AND KETTLES.—The stamped wrought iron pans of Hopkins & Co. and copper or tin kettles are strongly recommended as the best for gas cooking. It does not pay to use cast iron pans and kettles.

Smoothing irons can be quickly heated on one of the small burners.

INSTRUCTIONS FOR OVEN.—Hold a light near the tube running crossways under the oven, and turn on the gas. If, by accident, the gas ignites at the jet in the open end of the tube, turn it out, and light again until a line of greenish blue flame is seen under the oven. A good gas supply is quicker and cheaper to use than a poor one, and is also necessary to do first-rate pastry. At its greatest power it requires about 14 feet of gas per hour, but for roasting meat only half this is necessary.

UNDER THE OVEN.—Toast bread on the toasting tray placed on the top slide. Roast potatoes, apples, grill steaks, chops, fish, sausages, or bacon ; bake Yorkshire puddings, cakes, &c.

LOWER OVEN.—Roast joints, pastry (which, if preferred, can have the crust dried, and made as crisp as wished in a few minutes under the oven). All pies must be raised on the loose shelf until about two inches is left between the top of the pie and top of oven.

Upper Oven, not fitted to smallest size apparatus).—Remove for joints when lower oven is wanted for pastry; bake custards, rice puddings, &c. This is a very cool oven, using only the little waste heat, and cannot be got hot at any time.

Top of Oven.—Warm dishes. Plate warmers are on each side of oven.

FISH, EVEN IF PUTRID AND UNFIT FOR FOOD, MAY BE COOKED UNDERNEATH WITHOUT ANY TAINT TO THE MOST DELICATE FLAVOURS OF FOOD IN THE UPPER OVENS.

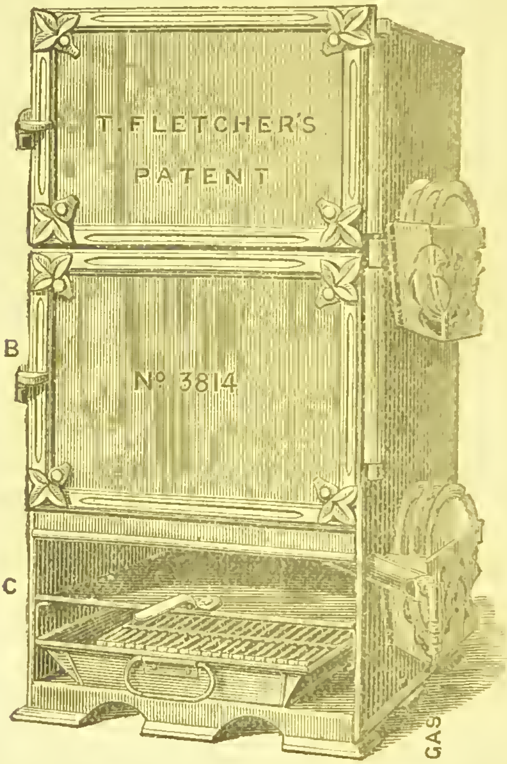
The Instantaneous Water Heater, which is best fixed over the scullery sink, will, with the assistance of the oven and boiling burners, do everything required (except for drying clothes) in any private house, in the most perfect manner without the assistance of a fire, throughout the year, and with less than one quarter the trouble of a first-rate fire range.

All india-rubber tubing must be smooth inside, made without wire. 6d. to 9d. per foot.

The sizes of ovens, &c., given are those required for ordinary domestic use. They can be made equally well any size to order at a price in proportion, and prices will be given at any time for any special size preferred. It must, however, be remembered that ovens should be no larger than *really necessary* for the required work, as the cost of gas for heating is in exact proportion to the size of the oven, and irrespective of the size of the food to be cooked.

An oven 12 by 14 inches on the bottom is large enough for any ordinary family, and costs on an average one penny for two and a half to three hours' work.

FLETCHER'S PATENT VENTILATED HOT AIR OVEN.



Prices, including meat dish, grid, toast plate, and four plate warmers:

Any of the sizes can be supplied with the doors and toast plate nickel-plated, at 15s. extra.

Double Oven, with the parts B and C only, 12in. wide, 14in. deep, 18in. high £2 5 0

Both these ovens can be used for roasting at the same time, if required (one burner only.)

TRIPLE OVEN, AS ENGRAVED.

12in. wide,	14in. deep,	26in. high	....	£3	3	0
14in. ,,	18in. ,,	28in. ,,	....	£4	4	0

Larger sizes in preparation.

FLETCHER'S PATENT SOLID FLAME BOILING BURNERS.

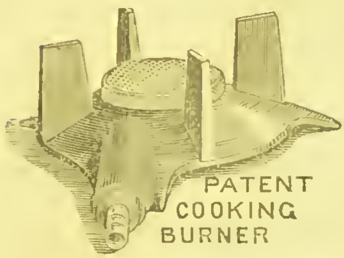


Fig. 48.

PATENT COOKING BURNER.

For general use, same as side burners in boiling bench. Price 4s., or nickel-plated, 5s. 6d.

Large size for large pans, &c. This is same as centre one in boiling bench. Price 6s. 6d., or nickel-plated 8s. 6d.

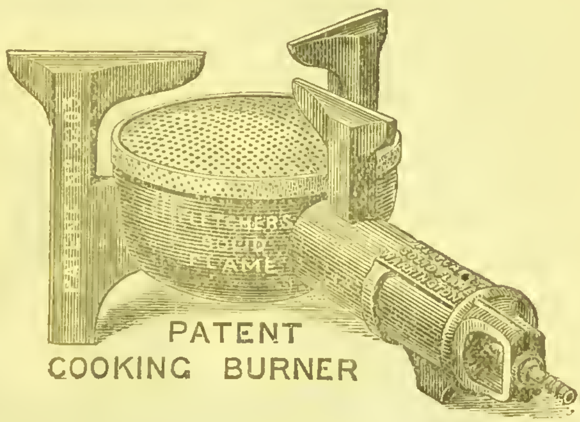
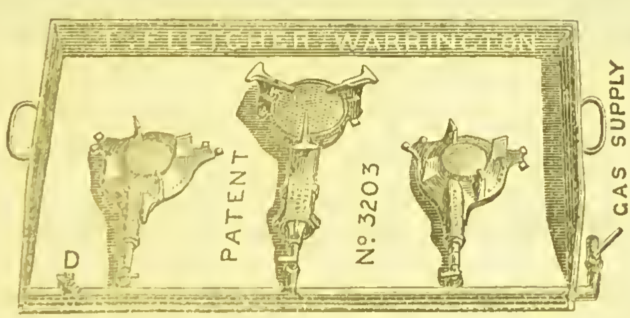


Fig. 47.



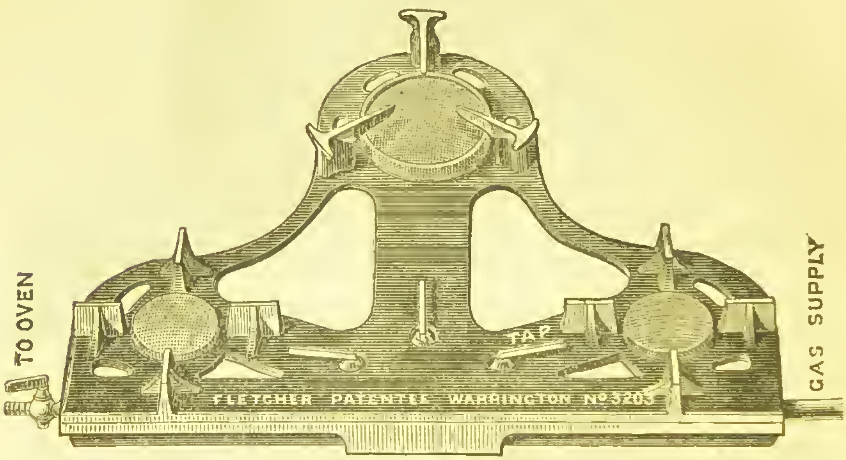
BOILING BENCH, WITH THREE FLETCHER'S PATENT SOLID FLAME BURNERS:—Two small and one large, as shown above.

Size, 3 feet by 21 inches, Price .... 42s.

This can be used without mess on an ordinary table.

Fletcher's Patent Triple Solid Flame Boilers.

Same Burners as Last, but arranged in a Compact Form so as to be used in Confined Spaces or on the Oven, if necessary :—



Size, 21in. wide, 15in. back to front.

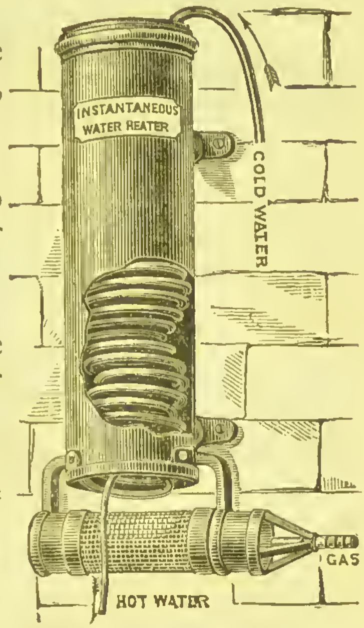
Price, as engraved : Japanned, 30s. ; nickel-plated, 42s.

This is best used on a table in an ordinary tray, to prevent mess in case of boiling over.

Both these boiling arrangements have a tap to supply the oven, in addition to separate taps for each burner.

INSTANTANEOUS WATER HEATER.

IN SOLID COPPER.



No. 1. For Lavatory. To give one pint of hot water per minute, 40s.

No. 2. For Scullery Sink. To give two pints of Hot Water per minute, 60s.

No. 4. For Baths. To give one gallon warm water per minute, 90s.

No. 6. For Baths. To giye 1½ gallons warm water per minute, 120s.

If Nickel-plated and Polished, Nos. 1 and 2, 10s. extra. Nos. 4 and 6, 20s. extra.

Nos. 4 and 6, see special Bath Heater.

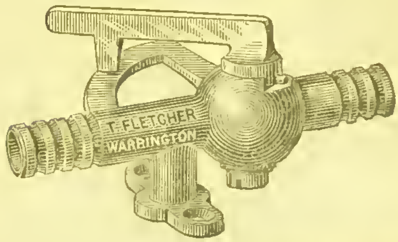
Stock pattern made to hang against a wall; but can be made on tripod to order.

All sizes supply pure water fit for cooking, &c., either boiling, or any temperature required, instantly as soon as the gas is lighted.

Except the smallest sizes, it is necessary that provision is made for the free exit of products of combustion by a flue or other means. If not placed over a sink or bath, the drip of condensed water from the products of combustion must be collected in a tray or dish under the burner. For baths or washing this condensed water is not objectionable, but it is quite unfit for any cooking purposes even in the smallest quantity.

GAS SUPPLY TAPS.

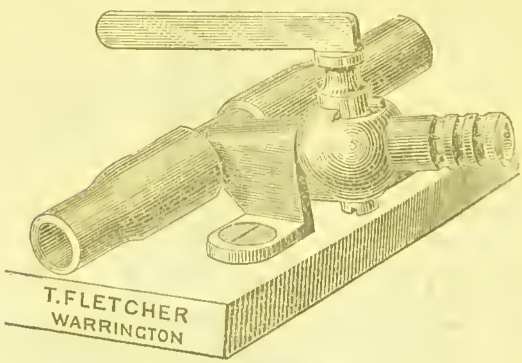
For connecting with india-rubber tubing.



Can be attached to a gas pipe by any person without soldering or trouble.

Price with $\frac{3}{8}$in. clear bore .. 2s.
do. $\frac{1}{2}$in. .. 3s.

These can be supplied in sets of any number connected to one supply and fixed on a mahogany board, so that several taps can be used from one supply pipe without the assistance of a gasfitter. Price for each tap, double the above rates.



ANOTHER PATTERN for obtaining a supply out of a Gas Pipe without interfering with other lights. To fix this, cut about 3 inches out of the lead pipe with a sharp knife, and connect the cross tube with short bits of india-rubber tube, so as to make up the pipe as before, but with the tap leading out of it.

Price for $\frac{3}{8}$ size .. 2s.

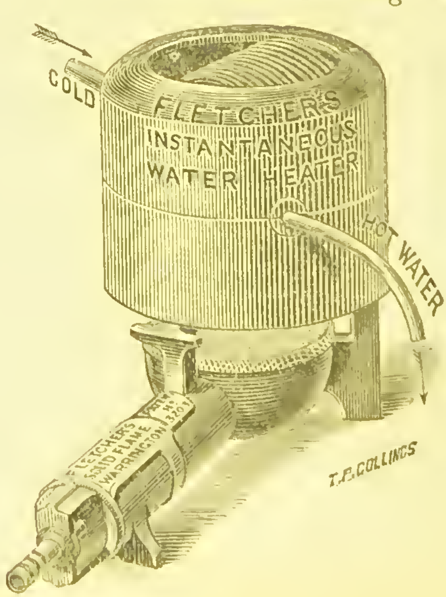
Can be supplied in sets on a board as above, any number, at 4s. each tap.

Fletcher's New Instantaneous Water Heater,

FOR LAVATORY, SCULLERY, WORKSHOP, AND COOKING PURPOSES,

An Attachment to Fletcher's Patent Cooking Burner. Fig. 47.

Price without Burner ... 12s. 6d.



Price with Burner, as engraved, 19s. 0d.

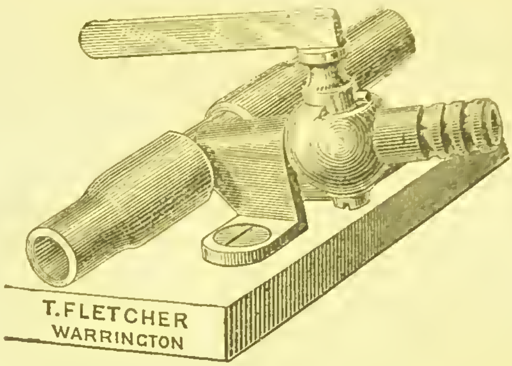
This gives, when connected with a cistern or water tap, hot water in three seconds after the gas is lighted, either boiling, hot, warm, or cold, the water being pure, and fit for cooking purposes. It will deliver sufficient hot water for washing hands in one minute, and, giving a stream at any temperature, steadily and instantly, when required, it will be found particularly valuable for many workshop purposes, washing crockery, public lavatories, &c. It is simple, cheap, not liable to get out of order or wear out, and is equal in power to the small-size Instantaneous Water Heater. Gas supply required 27 feet per hour—3-8th clear bore pipe and tap, to obtain the maximum power. It will work at a proportionate rate with any gas supply, however small.

It may be attached permanently to the cold water tap, as cold water can be obtained through it just as readily as hot if the gas is not lighted, and therefore it requires no fixing, and may be connected permanently with the ordinary cold water tap with an india-rubber tube.

Fletcher's Patent Solid Flame Bath Heater.

Price complete for warm Baths up to 30 gals., 27s.; or Japanned Oak, 31s. 6d.

HEATER, ONE-TWELFTH FULL SIZE.



Gas Supply Tap, One-half Full Size.

A Hot Bath of soft water, and a warm room in any place, at any time, for one penny. No town's water required, can be kept in case of sickness ready for instant use, either day or night, in any room, at a cost of less than one penny for 12 hours. Does not interfere with any existing arrangements, and requires no fitting or Fixing.

Although I make instantaneous water heaters, giving a continuous stream of hot water instantly, for lavatory, scullery, cooking and commercial purposes, this system of heating Baths, whatever the form of the apparatus, has proved itself unsatisfactory, or a total failure in most or all of the following important points.

Fletcher's Patent Solid Flame Bath Heater has these special advantages :—

It requires no special fixing or gas main. Any gaspipe, however small, will supply it. Fittings are sent, which, by cutting a short piece out of any lead gaspipe near, can be made to supply the apparatus, without requiring a gas-fitter, and without interfering with any existing lights or arrangements. It can be used in any room, and can stand as a permanence on the corner of the bath, or on a small shelf.

Its cost for gas for *daily use* for five years (*over seventeen hundred times*), including the first cost of the apparatus complete, is less than the first cost alone of any other bath heater known.

It is better and costs less in use than the ordinary fire boiler and hot water cylinder. Our ordinary fire boiler has been entirely discarded as inferior to this in every respect for practical daily use as a general hot water supply.

The old system of fire boilers and cylinders is dangerous and clumsy ; excessively costly in fitting, repairs, and fuel, and is in every respect inferior to this as a hot water supply for general purposes. It can easily be made to do everything which can possibly be done with any fire boiler in any place.

It makes no smell or steam in a small bath room ; on the contrary, it is a good and pleasant stove, warming the bath room comfortably, also warming under clothing and drying towels. It will supply any quantity of warm soft water every morning for washing in winter, and will supply boiling water, if needed, with equal ease.

It is simple, may be safely left to the management of a servant or child, and may be forgotten whilst working, without danger or risk. It is perfectly safe *always*, and may be frozen solid every day without harm. Either town's or rain water may be used at any time.

It can be kept ready for INSTANT use, day and night, in hospitals or in case of sickness, at a cost of less than one penny for twelve hours. The quickest instantaneous water heater requires about 15 minutes to get a bath ready, poisoning the atmosphere of the bath-room, and filling it with steam.

The price includes gas tap, tubing, and all complete, ready for fixing with or without a gasfitter.

INSTRUCTIONS.

Fill the cistern (about 8 gallons) with water, remove the burner, light it, and replace it in the recess under the cistern. For a child's bath half fill the cistern ; this will be ready in about half-an-hour. For a full-size bath it will be ready in two hours, and will keep hot two hours after the gas is turned out, or the gas, if required, may be turned low. When wanted, open the tap and run the water into the bath. The apparatus is only 14 inches in diameter, and will stand in any corner, or can be made to fit any recess at about the same cost.

It will supply sufficient hot water to make a 30 gallon warm bath in 2 to 2½ hours.

Price complete, in strong galvanized iron	... ...	£1 7 0
,, Japanned Oak	...	£1 11 6

Larger sizes for hospital use and continuous working, with self-filling arrangement, made to order, in galvanised iron or copper.

ILLUSTRATED LIST of Gas Apparatus for Domestic Use, free by post.

ILLUSTRATED LIST of Gas and Petroleum Heating Apparatus for Laboratory use, Furnaces for all purposes and temperatures; Foot, Automatic and Hand-blowers; Hot and Cold Blast Blowpipes, Ingot Moulds, and Special Apparatus for Chemical Laboratories. Price 2d., free by post.

Both lists are published at short intervals (2 or 3 months).

Reprint of Mr. Fletcher's Lecture on Gas Heating (Glasgow Philosophical Society Exhibition); with results and details of cooking and furnace tests, shown to illustrate the lecture.—(October 22nd, 1880.) Price 2d.

Reprint of Mr. Fletcher's Lecture on Gaseous Fuel, for which he was awarded the Society of Arts Silver Medal, in June, 1880. Price 3d.

FLETCHER'S PATENT OVEN.

COPY OF LETTER RECEIVED:—

"We have delayed acknowledging receipt of the Oven until it had been thoroughly tried. We are much pleased with it, and can do anything; roast meat, bake pies, puddings (including a deep potato pie), cakes, toast, loaves, potatoes, Yorkshire pudding, bacon, chops, in fact anything, and in first-rate style."

(From the "Review of Gas and Water Engineering," Sept. 10th, 1880.)

FLETCHER'S SOLID FLAME GAS COOKING BURNER.

This is THE BEST COOKING BURNER WE HAVE EVER SEEN, and will command from all interested in gas consumption, both buyer and seller, substantial support. We have tried the burner and can, from our experience, most warmly endorse the inventor's remarks, that "It cannot be spoiled by any accident, gives a perfectly solid flame, free from smell, and does more work than the theoretical maximum duty (as at present accepted) of the gas consumed." The price at which they are offered is so low that they are within the reach of the poorest gas consumers; whilst to those officials who are anxious to increase the day consumption no surer means can be found than by the introduction of these excellent cooking stoves."

In the construction of this burner the severely practical has been studied effectually. The casting, of which the burner consists, is perhaps as great a curiosity as the burner itself. How such a casting can be produced commercially is a puzzle to many practical workers in iron, combining as it does extreme difficulty in moulding, perfect finish, and a singularly perfect adaptation in every little detail to the exact purpose required. The iron-founder (H. Wallwork, of Manchester), who can produce such castings as these by the thousand is to be congratulated not only on his own skill but on the efficiency of his workmen. As a single casting, untouched by a tool after it left the foundry, it is a specimen of the founder's art well worthy of careful examination, and one to teach a lesson to many moulders and pattern makers.

"Pharmaceutical Journal," Dec. 4, 1880.

"Heating by Gas. Cooking in Private Families and Use in Workshops." By Thomas Fletcher, F.C.S. 1880.

This pamphlet, although evidently issued for trade purposes, is none the less worthy of perusal by any person interested in the relative usefulness and economy of coal gas as a heating material. Mr. Fletcher has done so much towards the development of the use of gas in this direction that he is sure to secure attention to what he has to say upon the subject, and the confidence is increased by outspoken opinions that might hardly have been expected from such a quarter, and he shows that he is not a mere hobby-rider.

Concerning Mr. Fletcher's numerous and excellent apparatus for these purposes, full information can be obtained from himself by those who desire it, and nothing need be said here unless exception be made in favour of the solid flame cooking burner, which is really of wide application, and for efficacy and cleanliness leaves nothing to be desired.

"Chemical News," Oct. 8th, 1880.

NEW GAS HEATING BURNER.

We have recently been using a new gas heating burner made by Mr Thomas Fletcher, of Warrington, which is specially adapted for many laboratory purposes. It has from three to four times the power of any burner similar in appearance. The flame is solid, intensely hot, and perfectly free from smell. It cannot be damaged by the dirtiest work.

"Mining World," Oct. 23rd, 1880.

FLETCHER'S SOLID FLAME BURNER.

These burners, of which thousands are in use, claim to be and no doubt are the first high power heating burners constructed. It is decidedly the most useful apparatus of the kind we have yet seen. It is simple and effective, and would find a place in most homes were its advantages generally known.

"Nature," Oct. 28, 1880.

Mr. Fletcher, of Warrington, has sent us a specimen of a new gas heating burner which seems well adapted for many purposes and trades which are as yet unsupplied with satisfactory heating apparatus. It seems to us to have all the advantages claimed for it. It has from three to four times the power of any burner similar in appearance; the flame is solid, intensely hot, and perfectly free from smell; it gives a duty higher than the calculated theoretical maximum for the gas consumed, and it cannot be damaged by the dirtiest work. Altogether this burner seems to be one of the greatest advances yet made in the practice of heating by gas.

"Graphic," Sept. 24, 1880.

Mr. Fletcher, F.C.S., whose lecture in June last "On the application of gaseous fuel to laboratory work," won for him the silver medal of the Society of Arts, has patented a high power heating burner which promises to be of great use both in the arts and for domestic purposes. Cast in one solid piece, it is furnished with a perforated copper dome, which can easily be removed for cleaning purposes. This dome takes the place of the wire gauze common to older forms of burners. The flame is solid, smokeless, and intensely hot, and is so under control that it will boil an egg, melt half a hundredweight of metal, or get up steam for a half-horse engine. Faint-hearted holders of gas shares troubled by the electric light will welcome an invention which will go far to make the use of gas, if not compulsory, at least very desirable for many unlooked-for purposes. T. C. H.

"Jeweller and Metal Worker," Nov. 1, 1880.

FLETCHER'S SOLID-FLAME GAS BURNER.

We have received from Mr. Fletcher, of Museum-street, Warrington, one of his cooking burners, which will boil an egg, cook a chop, or boil a quart of water in much less time than similar articles, and with considerable saving in gas. Indeed, we have discarded the burner previously in use for the one received from Mr. Fletcher, solely because it is cleaner, more economical, and quicker in its action, in addition to being devoid of the disagreeable odour characteristic of cooking apparatus. This article is a strongly made one, calculated to resist the roughest wear without injury, and works with any gas supply, small or large.

From "Exchange and Mart."

HOUSEKEEPER'S ROOM.

FLETCHER'S SOLID FLAME BURNER.

A simple, effective, substantial, and inexpensive gas burner for boiling water and other household purposes is frequently asked for, and we can now refer such enquiries to the Solid Flame Burner, manufactured by Mr. T. Fletcher, of 4 and 6, Museum-street, Warrington.

That its name, Solid Flame, well describes it we can testify, as also that it accurately answers the maker's description. We boiled two quarts of cold water in eight and a half minutes, and housewives will agree that they rarely obtain such good results even with a brisk fire. From this experiment we see no reason why it should not with equal ease melt ½cwt. of lead, as stated by the maker.

"Design and Work," Sept. 25th, 1880.

FLETCHER'S GAS BURNERS FOR HEATING AND COOKING.

Mr. Thomas Fletcher, of Warrington, as most of our readers know, is a well-known authority on the consumption of gas for heating purposes, and we have therefore pleasure in describing a heating and cooking burner he is now introducing to the public. It is curious to note how often considerable progress is made in certain directions by individuals whose occupations and inferentially knowledge and skill, lie in other directions; and of this Mr. Fletcher, in giving his attention to the manufacture of appliances for heating by gas, is a good illustration. His principal business until about six years ago was as a metallurgist of the rarer metals. Some of these, like platinum, are very infusible and difficult to manipulate with the apparatus then in vogue; and to make them more tractable Mr. Fletcher was led to thoroughly investigate the subject of heating by gas. As a consequence he devised various gas furnaces adapted to his own business, and afterwards a number of appliances for heating by gas, several of which are to be found in nearly every laboratory in the kingdom, and in many industrial establishments. We only allude thus generally to these apparatus, for a detailed description of them appeared in our last volume.

More lately, and up to the present time, Mr. Fletcher has given more attention to gas-heating burners for domestic purposes, and the latest patent he has taken out is for the burner shown in the annexed illustration. This burner contains improvements suggested by the use of his original solid flame burner, the flame of which burned above a piece of gauze held in position on the burner proper by a cap or ring. This old burner, like the one we are noticing, was intended for cooking, boiling, and the usual dirty work of the kitchen, and when thick and greasy liquids got spilled over the gauze it was noticed that servants were negligent in removing and replacing the gauze after cleaning, frequently breaking the ring that kept it in place. In the new burner the gauze is replaced by a cap of perforated sheet copper, no ring being required to retain it in position. In the old burner, further, the base was considered rather small for supporting with safety large saucepans and such articles; in the new one the feet are further apart, and consequently the burner is more stable. There are three feet, and therefore the burner is steady on surfaces however uneven. The gas enters from an india-rubber pipe into the mixing chamber on the right hand. It here forms an explosive mixture with the abundant supply of air—the mixture burning with a steady, solid, and intensely hot flame on the surface of the perforated copper cap. The flame is not so sensitive—that is, not so easily extinguished by draughts, &c. —as that of the old burner, and it gives a high heating effect for the quantity of gas consumed, which we understand is about 27 cubic feet per hour; but, of course, smaller quantities can be burnt when large flames are not required.

PRICES ON FORMER LISTS CANCELLED.

List No. 53. JANUARY, 1881.

DOMESTIC

HEATING AND COOKING APPARATUS.

GAS.

FLETCHER'S PATENT

Ventilated Hot Air Oven,

Instantaneous Water Heaters,

Bath Heaters,

Boiling Arrangements, &c.

DESIGNED, PATENTED, AND MANUFACTURED ONLY BY

THOMAS FLETCHER,

4 & 6, Museum Street, WARRINGTON.

PRINTED AT THE "GUARDIAN" WORKS, WARRINGTON.

PRICES ON FORMER LISTS CANCELLED.