FIREWORKS & EXPLOSIVES LIKE GRANDDAD USED TO MAKE

CONTENTS

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NOTE

Many of the chemical terms in this book are so outdated you may not understand them. If you don't already have GRANDDAD'S WONDERFUL BOOK OF CHEMISTRY, get one. It has a dictionary of over 2500 definitions and synonyms of vague and old-fashioned terms for chemicals, plants, processes, etc.

It also details the 19th Century methods of home manufacturing of most chemicals and substances you will need, from simple, easy to get raw materials.

GRANDDAD'S WONDERFUL BOOK OF CHEMISTRY can be bought from Atlan Formularies and other dealers for $22.00

INTRODUCTION

Dick's Encyclopedia of Practical Recipes and Processes was first published in 1872. It details methods for making everything from deadly poisons to high explosives, narcotics, shoe polish, all the most popular patent medicines of the day and ketchup.

When that book was published, most of those who would misuse its information were in prisons or nuthouses. The rational, lawabiding person was trusted with no end of potentially dangerous materials. He was also trusted to teach his children the dangers of anything they were permitted to use, such as fireworks. His children were trusted, not only in playing with the fireworks safely, but they were also trusted not to cause damage to property or to other children.

There were very few injuries; less than kids got from falling out of their neighbor's apple trees.

Since the governors trusted the people, the people accepted the responsibility imposed by that trust. In the same sense, the children accepted the responsibility imposed by their parents' trust.

As more people were born into our society who were mentally defective, or just naturally stupid and irresponsible, many wonderful things were made illegal. In 1934 firearm silencers were outlawed. As one of the noisiest children in Brooklyn, I didn't miss silencers. At the same time, automatic weapons were also outlawed. I didn't know about that. I took it for granted that as soon as I got bigger I would own a Tommygun.

When I was seven I remember buying firecrackers for five cents for a packet of 20. I liked to put them under tin cans. Often I would spend hours building elaborate fortifications for my toy soldiers just so I could blow them all up.

I never suffered an injury worse than a flash-burn. I never knew anyone who had been seriously hurt. When anyone was damaged the tale was passed around and elaborated on but such stories just served to make the rest of us more careful.

Later, in Chicago, I remember firecrackers were made illegal. This shot the price up to 20c for a packet of 20. The torch of Al Capone was passed down to teeny-bopper gangsters and there seemed to be more firecrackers sold illegally than had been sold when they were legal.

Then there were injuries aplenty. Many people were hurt when packs of firecrackers were set off in crowded streetcars or elevators. Since firecrackers were illegal there was no instruction or parental guidance. Also, since the normal, open, use of firecrackers was out of the question, their abnormal and destructive use was the rule of the day.

Today, the average fire marshal is dedicated to removing all fireworks from our society. I agree with most of their arguments. Fireworks *are* unsafe when used only by those who have no respect for the law.

But since the main harm is caused by the irresponsible and dimwitted in our society, then those elements must be suppressed, not the rational ones. I'm just selfish enough to want the moron or the psychotic to be confined if his freedom takes away mine. If he is not to be trusted with fireworks, guns, etc., then let him be put in a nice place where attendants or guards can control the traffic in potentially dangerous things.

Do we live in a nation-wide mental institution, where the police officer is supposed to function as a nuthouse attendant, seeing that none of us have anything sharp, lest a real sickie hurt someone? To Hell with that!

Alcoholics, improvident and violent drunks, spurred the adoption of Prohibition. This took away the freedom of the responsible social drinker and built a criminal class which is still a fixture decades after Prohibition has ended.

So enough of editorializing. When the Law comes to its senses, or is made ineffective by just too many boobs, you will be free to play with potentially dangerous materials to your heart's content.

Even if you are responsible and intelligent, knowledge of the materials and processes is necessary to avoid injuries. Such knowledge is now pretty much limited to professionals who use such technical methods and machinery that the layman is effectively barred from their field.

However, Granddad made just as good stuff with simple hand tools and such. So, since you have this book, you should be pretty safe.

You must realize that Granddad learned from the ground up and had a thorough understanding of his materials. You ought to look up each chemical and study its specific hazards, flashpoint, etc., before pulverizing it or mixing it with other chemicals.

Always wear goggles when working with any quantity of potentially explosive material. Even a small accident can blind you. If you are not blinded, particles of matter in the eyeballs can cause agony for months. Simple goggles prevent this.

Leather gloves are useful, also, to prevent flash burns, which can be severe. The hand protectors described on page 48 are required when working with materials like potassium chlorate or other explosive substances.

When following these formulas it is suggested you make your own chemicals as shown in GRANDDAD'S WONDERFUL BOOK OF CHEMISTRY, $22 from Atlan Formularies.

Modern chemicals have a greater purity and so would probably be a lot more powerful than those described in this book. This could cause your fireworks to be far more powerful than you want or expect them to be, thus leading to a lack of control, which is a danger in itself.

KURT SAXON MAY, 1975

The Scientific American Cyclopedia 1903

Pyrotechny. — *Asteroid Rocket.* — Composition for 1 lb.: Niter, 8 oz.; fine charcoal, 3½ oz.; No. 2 charcoal, ½ oz.; sulphur, 2 oz.; meal powder, 1½ oz.

Bursting Powder.

Number	1	2	3
Meal powder	1	1	8
Grain powder F	—	1	—
Charcoal	—	—	1

Chlorate Meal Powder.

Number	1	2	3
Chlorate of potash	25	15	60
Charcoal, fine	5	3	9
Sulphur	3	2	8

To Represent Cordage in Fireworks.—Antimony, 1 part; juniper resin, 1 part; niter, 2 parts; sulphur, 16 parts. Mix and soak soft ropes with the composition.

Common and Sparkling Fires.—1. Meal powder, 4 parts; charcoal, 1 part.

2. Meal powder, 16 parts; niter, 8 parts; sulphur, 4 parts; charcoal, 4 parts.

3. Meal powder, 16 parts; very fine glass dust, 5 parts.

4. Meal powder, 8 parts; very finely powdered porcelain, 3 parts. These fires can be arranged very effectively as stars, suns, etc. For instance, provide a circular disk of hard wood, 6 in. in diameter and 1 in. thick. Nail to this 5 spokes of wood at equal distances from one another, and 15 in. long. Nail also to the back of the central disk a strip of wood about 2 feet long, 2 inches wide, and ¾ inch thick. By means of this you can screw the whole piece conveniently to your firing post. On each of the 5 spokes tie a case of brilliant fire, supported at its end, and connect the mouths of these with quick match.

Red Chinese Fire.—1. Meal powder, 16 parts; niter, 16 parts; sulphur, 4 parts; charcoal 4 parts; iron borings, 14 parts.

2. Meal powder, 16 parts; sulphur, 8 parts; charcoal, 3 parts; iron borings, 7 parts.

3. Meal powder, 8 parts; niter, 16 parts; sulphur, 3 parts; charcoal; 3 parts; iron borings, 8 parts.

4. Meal powder, 16 parts; niter, 8 parts; sulphur, 4 parts; charcoal, 3 parts; iron borings, 7 parts.

On Preparing Some Colored Fires (Bengal Lights) Used in Pyrotechny.—By Sergius Kern (St. Petersburg). — In preparing colored fires for fireworks by means of the usual formulæ given in many manuals of pyrotechny, it is often very necessary to know the quickness of burning of colored fires, as in some cases, as decorations and lances, they must burn slowly; in other cases, as wheels, stars for rockets, and Roman candles, they must burn quicker. Working for some months with many compositions of such kind, I prepared three tables of colored fires (red, green and violet), where every formula with a higher number burns quicker than a fire with a lower number. For instance, No. 5 burns quicker than No. 6 and slower than No. 4. These tables will, I think, be of much assistance in the preparation of fireworks.

Green Colored Fires.—

No.	Potassium Chlorate. Per cent.	Barium Nitrate. Per cent.	Sulphur. Per cent.
1	36	40	24
2	29	48	23
3	24	53	23
4	21	57	22
5	18	60	22
6	16	62	22
7	14	64	22
8	13	66	21
9	12	67	21
10	11	68	21
11	10	69	21
12	9·5	69·5	21
13	9	70	21
14	8·5	70·5	21
15	8	71	21

Red Colored Fires.—

No.	Potassium Chlorate. Per cent	Strontium Nitrate. Per cent.	Sulphur Per cent.	Carbon Powder. Per cent.
1	40	39	18	3
2	32	46	19	2
3	27	51	20	2
4	23	55	20	2
5	20	58	20·5	1·5
6	18	60	21	1
7	16	61 6	21 2	1·2
8	15	63	21	1
9	13	64	22	1
10	12	65	22	1
11	11	66	22	1
12	10	67	22	1
13	10	67 25	22	0·75
14	9·25	68	22	0·75
15	9	68·35	22	0·65

Violet Colored Fires.—

No.	Potassium Chlorate. Per cent.	Calcium Carbonate. Per cent.	Malachite powdered. Per cent	Sulphur. Per cent.
1	52	29	4	15
2	52	28	5	15
3	52	26	7	15
4	52	24	9	15

5.......52	23	10	15
6.......52	21	13	15
7.......51	20	14	15
8.......51	18	16	15
9.......51	16	18	15
10 51	15	19	15
11 51	13	21	15
12 51	11	23	15
13... ...51	10	24	15
14.......51	8	26	15
15.......51	6	28	15

Colored Fires for Theaters.—We give below a table of the composition of the mixtures commonly employed for colored fires in tableaux, etc. These fires, however, should never be used within doors, as the gaseous products of some of them are extremely poisonous. The lime light lanterns and lenses of suitably colored glass have now been generally substituted for these fires, and give much better results.

	1 Green	2 Red	3 Yellow	4 Blue	5 White
Chlorate of potash... ...	32·7	29·7		54·5	
Sulphur......	9·8	17·2	23·6		20
Charcoal.. ..	5·2	1·7	3·8	18·1	
Nitrate of baryta	52·3				
Nitrate of strontia... ..		45·7			
Nitrate of soda			9·8		
Ammonium sulphate of copper				27·4	
Saltpeter......			62·8		60
Black sulphide of antimony......		5·7			5
Floury gunpowder					15

It is hardly necessary to mention that great care is required in mixing these materials, and that each should be pulverized separately.

Fires or Lights, Colored.—These fires serve to illuminate; hence intensity of light with as little smoke as possible is aimed at. In the preparation of such mixtures the ingredients, which should be perfectly dry, must be reduced separately, by grinding in mortar or otherwise to very fine powders, and then thoroughly but carefully mixed together on sheets of paper with the hands or by means of cardboard or horn spatulas. The mixtures are best packed in capsules or tubes about 1 in. in diameter and from 6 to 12 in. long, made of stiff writing paper. Greater regularity in burning is secured by moistening the mixtures with a little whisky and packing them firmly down in the cases by means of a wooden cylinder, then drying. To facilitate ignition a small quantity of a powder composed of mealed powder, 16 parts; niter, 2 parts; sulphur, 1 part, and charcoal, 1 part, loosely twisted in thin paper, is inserted in the top. The tubes are best tied to sticks fastened in the ground.

White Lights.—

Saltpeter.......... .... 4 oz.
Sulphur....... ... . 1 oz.
Black sulphide of antimony..... 1 oz.

Yellow Lights.—

1. Chlorate of potash... .... 4 oz.
Sulphide of antimony............ 2 oz.
Sulphur .... 2 oz.
Oxalate of soda..... .... 1 oz.

2. Saltpeter..........................140 oz.
Sulphur........ ....45 oz.
Oxalate of soda............ .....30 oz.
Lampblack......................... 1 oz.

Green Lights.—

1. Chlorate of baryta................ 2 oz.
Nitrate of baryta................ 3 oz.
Sulphur.............................. 1 oz.

2. Chlorate of potash...............20 oz.
Nitrate of baryta .. ..21 oz.
Sulphur............. ....11 oz.

Red Lights.—

Nitrate of strontia...............25 oz.
Chlorate of potash................15 oz.
Sulphur ....18 oz.
Black sulphide of antimony. ... 4 oz.
Mastic............................. 1 oz.

Pink Lights.—

Chlorate of potash...............12 oz.
Saltpeter.......................... 5 oz.
Milk sugar......................... 4 oz.
Lycopodium........................ 1 oz.
Oxalate of strontia.............. 1 oz.

Blue Lights.—

Chlorate of potash............... 3 oz.
Sulphur.... .... 1 oz.
Ammonio-sulphate of copper... 1 oz.

For colored fires, where the mixtures are ignited in shallow pans and maintained by additions of the powders, the compositions are somewhat different.

White Fire.-

Niter.... ....16 oz.
Mealed powder.............. .... 4 oz.
Sulphur.................. .... 8 oz.

Yellow Fire.—

Niter .... 2 oz.
Sulphur.................. ...... 4 oz.
Nitrate of soda....................20 oz.
Lampblack......................... 1 oz.

Red Fire.—

Niter .... 5 oz.
Sulphur............................ 6 oz.
Nitrate of strontia................20 oz.

Lampblack	1	oz.

Blue Fire.—

Niter	8	oz.
Sulphur	2	oz.
Sulphate of copper	4	oz.

Green Fire.—

Niter	24	oz.
Sulphur	16	oz.
Nitrate of baryta	48	oz.
Lampblack	1	oz.

Bengal Fire.—

Sulphur	4	oz.
Mealed powder	4	oz.
Antimony	2	oz.
Lampblack	16	oz.

From the *Western Druggist*:

Red Fire.—

Strontium nitrate	3	parts.
Potassium chlorate	1	part.
Shellac, in coarse powder	1	part.

Mix.

Green Fire.—

Barium nitrate	3	parts.
Potassium chlorate	1	part.
Shellac	1	part.

Mix.

Violet Fire.—

Calcium carbonate	2	parts.
Malachite	2	parts.
Sulphur	2	parts.
Potassium chlorate	6	parts.

Mix.

Purple Fire.—

Copper sulphide	1	part.
Strontium nitrate	14	parts.
Calomel	14	parts.
Potassium chlorate	15	parts.
Shellac	5	parts.

Mix.

On account of the calomel, this must not be burned indoors.

Yellow Fire.—

Sodium nitrate	3	parts.
Potassium chlorate	1	part.
Shellac	1	part.

Mix.

Blue Fire.—

Copper ammonia sulphate	6	parts.
Potassium chlorate	1	part.
Shellac	1	part.

Mix.

Five-Pointed Star.

Number.	1	2
Meal powder	3	—
Sulphur	8	2
Niter	12	5
Sulphide of antimony	1	1

Spur Fire, for Flower Pots and Star Candles.

Number.	1	2	3	4	5	6	7
Vegetable black	7	2	3	4	2	4	3
Sulphur	14	5	4	16	6	9	7
Realgar, or sulphide of arsenic	2	1	1	2	1	1	1
Niter	32	16	10	32	11	20	15
Meal powder	—	3	—	17	4	5	4
Charcoal	—	—	—	4	1	1	1

Flower Pots, Composition for.—Niter, 18 parts; sulphur, 8 parts; lampblack, 6 parts.

Gerbe.

Number	1	2	3	4	5	6	7	8	9	10	11	12
Sulphur	2	3	—	1	—	2	3	2	2	2	—	—
Niter	2	2	—	—	—	10	6	4	9	4	—	—
Meal powder	16	36	4	8	16	—	9	16	2	2	8	8
Steel filings	1	6	—	—	—	—	—	—	—	—	—	—
Cast iron borings	.5	8	1	3	8	7	5	8	5	3	—	—
Charcoal	—	—	—	—	1	2	2	1	2	2	—	—
Coke grains	—	—	—	—	—	—	—	—	—	—	1	—
Porcelain grains	—	—	—	—	—	—	—	—	—	—	—	1

The Mixture for Golden Rain is Composed of.—

Niter	16	oz.
Sulphur	11	oz.
Mealed powder	4	oz.
Lampblack	3	oz.
Flowers of zinc	1	oz.
Gum arabic	1	oz.

All the materials used in fireworks must be in the state of fine powders and perfectly dry.

Gunpowder.—The component parts of gunpowder are saltpeter, sulphur, and charcoal, used in the following proportions:

1. English war powder.—Saltpeter, 75 parts; sulphur, 10 parts; charcoal, 15 parts.
2. French war powder.—Saltpeter, 75 parts; sulphur, 12·5 parts; charcoal, 12·5 parts.
3. French sporting powder.—Saltpeter, 76·9 parts; sulphur, 9·6 parts; charcoal, 13·5 parts.
4. French blasting powder. — Saltpeter, 62

parts; sulphur, 20 parts; charcoal, 18 parts.

There are a number of variations of the above receipts, but the difference, which is purely a matter of opinion, consists principally in varying the quantity of sulphur or charcoal employed.

Inflamant.

Number	1	2	3
Charcoal	1	1	1
Meal powder	8	16	24
F. F. F. grain	4	8	12

Lances.—1. Lances are small paper cases, two to four in. in diameter, filled with composition, and are used to mark the outlines of figures. They are attached endwise to light wooden frames or sticks of bamboo and connected by streamers or quick match. The following are some of the compositions used in these:

	White	Yellow	Red	Blue	Green
Niter	28	—	16	8	96
Sulphur	9	4	10	2	64
Mealed powder	5	4	7½	—	—
Nitrate of soda	—	16	—	—	—
Lampblack	—	2	—	—	8
Nitrate of strontia	—	—	30	—	—
Sulphate of copper	—	—	—	4	—
Nitrate of baryta	—	—	—	—	192

2. Lances are used in making up devices, such as names, mottoes, wreaths, and so on. They consist of small cases, generally made about 3/16 of an inch in diameter, that is, round a piece of glass or brass rod or tube of that size; tubes are always best for these small formers. The cases are about 2 or 2½ in. long, with one end pinched or turned in. Two rounds of thin demy or double crown white paper, pasted, will give sufficient thickness and substance for the case. The cases, when dry, are to be filled with either of the compositions in the same way as golden rain:

Compositions for Lances. White.—1. Niter, 16 parts; sulphur, 8 parts; meal powder, 6 parts.

2. Niter, 16 parts; sulphur, 4 parts; meal pow-6 parts.

3. Niter, 12 parts; sulphur, 4 parts; sulphide of antimony, 3 parts.

4. Niter, 72 parts; sulphur, 18 parts; regulus of antimony, 33 parts; realgar, 1 part; shellac, 1 part.

5. Niter, 96 parts; sulphur, 24 parts; regulus of antimony, 48 parts; realgar, 6 parts; shellac, 1 part. These for the most part give a bluish white flame, and when employed in cases of the size mentioned above, burn slowly, and will last as long as this species of firework is required to last.

Yellow.—1. Chloride of potash, 72 parts; oxal. soda, 60 parts; stearine, 6 parts; sulphur, 6 parts.

Pin Wheels.

Number	1	2	3	4	5	6	7	8	9	10	11	12	13
Sulphur	1	3	5	3	7	14	4	4	2	2	3	2	—
Niter	1	4	9	5	9	16	8	4	5	2	3	2	—
Meal powder	2	9	15	8	20	32	26	16	36	26	35	18	3
Sulphuret of Antimony	—	—	—	—	1	3	1	—	—	—	—	—	—
Beech sawdust, fine	—	—	—	—	—	—	1	—	—	—	—	—	—
Oxalic acid	—	—	—	—	—	—	—	3	—	—	—	—	—
Litharge, fine	—	—	—	—	—	—	—	—	2	—	—	—	—
Orpiment, or realgar	—	—	—	—	—	—	—	—	—	2	3	—	—
Vegetable black	—	—	—	—	—	—	—	—	—	1	2	—	—
Nitrate of lead	—	—	—	—	—	—	—	—	—	—	—	3	1

Compositions for Pin Wheels, etc.—

	Common.	Brilliant.	Chinese.	White.
Niter	6	1	1	6
Sulphur	1	1	1	7
Mealed powder	16	16	7	16
Charcoal	6	—	—	—
Steel filings	—	7	—	—
Cast iron filings	—	—	7	—

Port Fire.

Number	1	2	3	4
Meal powder	3	1	1	5
Sulphur	4	2	2	8
Niter	12	4	6	25

Quick Match.—Make a thick paste of gunpowder and hot water, with a small quantity of gum in it. Take about four strands of cotton, such as is sold in balls and used for making the wicks of lamps, steep this in the solution of niter used for making touch paper, and wring it as dry as possible; then rub it well in the gunpowder paste till it is thoroughly covered with it. One end of the cotton may be passed through a small funnel, whose mouth is not more than ⅛ in. in width. By this means, if the whole length of the cotton is drawn through it, the superfluous paste will be removed, and the match will be of a nice round form. Hang it out of doors on a dry day, and when it is nearly dry coil it upon a tray or paper, and dust it over with meal powder. In winter it will not be sufficiently dry for use under a week. When thoroughly dry it should be stiff and hard, and the less it is bent or doubled the better. To use this match for connecting the mouths of different fireworks, or clothing them, as it is termed, make some long paper tubes round a wire former which has a diameter of not less than 3/16 in. These pipes are threaded on the match, and have a piece cut away at their sides wherever they are inserted into the mouth of a case, in order that the match may be laid bare and convey its fire to the priming of the cases.

Silver Rain.

Number	1	2	3	4
Steel filings	1	2	2	3
Meal powder	4	7	8	—
Niter	—	1	—	2
Sulphur	—	—	1	—
Charcoal	—	—	—	3
Nitrate of lead	—	—	—	10

Gold Rain.

Number	1	2	3	4	5
Sulphur	1	1	1	—	—
Niter	2	2	2	—	—
Charcoal	6	1	5	1	3
Meal powder	16	6	18	4	8

Rockets, 1/8-lb.—Composition for.—1. Niter, 9 oz.; sulphur, 2 oz.; meal powder, 1½ oz.; fine charcoal, 2 oz.; No. 2 charcoal, 2 oz.

2. Niter, 8 oz.; sulphur, 2 oz.; meal powder, 1½ oz.; fine charcoal, 4 oz.

3. Niter, 8 oz.; sulphur, 1½ oz.; fine charcoal, 3 oz.; No. 2 charcoal, 1½ oz.

Rockets, ¼-lb.—Composition for.—1. Niter, 8 oz.; sulphur, 1½ oz.; meal powder, 2 oz.; fine charcoal, 2½ oz.; No. 2. charcoal, 1½ oz.

2. Niter, 8 oz.; sulphur, 1½ oz.; meal powder, 2½ oz.; fine charcoal, 2 oz.; No. 2 charcoal, 2 oz.

3. Fine fire.—Niter, 8 oz.; sulphur, 2 oz.; meal powder, 2½ oz.; fine charcoal, 4 oz.

Roman Candle.

Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Sulphur	4	2	3	1	1	2	7	3	4	6	8	3	8	—
Charcoal	3	3	3	2	1	3	8	1	1	7	9	3	11	2
Niter	8	2	8	4	3	9	21	4	5	18	18	10	32	1
Meal p'wder.	8	8	3	3	2	4	12	5	4	4	4	7	—	3

Rockets.

Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Sulphur	1	1	12	4	8	4	2	4	2	2	1	1	8	1	1	1	2	—
Charcoal	4	2	17	5	11	7	4	8	12	8	2	2	27	2	2	4	4	1
Niter	8	5	50	16	32	16	9	16	20	16	4	4	36	4	4	8	8	—
Meal powder	—	—	—	—	—	—	—	3	1	1	1	2	6	2	1	1	1	4
Steel filings	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	2	—	—

Roman Candles.—**To Make a ⅝ Roman Candle.**—Procure a straight piece of brass tube, ⅝ of an inch external diameter and 16½ inches long. Saw or file off a piece, 1½ inch long, **Fig. 1.** This is for the star former, and is drawn of the correct size.

In the other piece, of 15 inches, fix a handle, as shown, in diminutive, in **Fig. 7.** This is for the case former. It should be filed smooth at the end.

Take another piece of brass tube, 3/16 of an inch external diameter and about 16½ inches long. In this also fix a handle, or fix it into a handle, Fig. 4. Invert it, and set it upright in a flower pot, filled with sand or loose mould. Melt some lead in a ladle, and pour it slowly into the tube, leaving room for the air to escape up the side, till it is full. If the lead is poured in rapidly, the confined air, expanding, jerks the metal up, and may cause serious injury. A pound or more of lead will be required. When cold, drive the end of the lead in with a hammer, and file in smooth. This is for a rammer.

Take a piece of deal, Fig. 6, about 12 inches long, 6 inches broad, and ¾ inch thick; and, on the top, screw a handle, like one on a scrubing brush. This is for a rolling board. An iron door handle would answer. A wooden one, however, about an inch thick, not cylindrical, but slightly flat, and rounded at the edges, is preferable, as it gives more purchase for the hand.

Cut a piece of tin, or zinc, or thin board into the shape of figure 8, in which the distance between the arms, *a* and *b*, across the dotted line, shall be ⅞ of an inch. This is for a gauge, with which to measure the external diameter of the case. Write upon it, ⅞ space.

Procure some 60 lb., 70 lb. or 84 lb. imperial brown paper; the size of a sheet will be 29 in. by 22½. Cut a sheet into four equal parts, each 14½ by 11¼; paste the four pieces on one side, and lay them on one another, with the pasted face upward, putting the fourth piece with the pasted side downward, upon the pasted side of the third piece. Turn them over; take off the now top piece, and lay it flat on the near edge of a table, pasted side upward. Take the former, Fig. 7, and paste the tube all over. Lay it along the edge of the paper, bend the paper over with the fingers of both hands, and roll it tightly up, until the external diameter of the case about fits the guage, Fig. 8. If the paper should be too long, of course a piece must be cut off; if it should not be long enough, more must be added, taking care to bind in the second piece with three or four inches of the first piece; for if the whole of the first piece be rolled up before beginning the second, the latter, when dry, will probably slip off and spoil the case. The case having been rolled up, take the handle of the former in the left hand, lay the case flat on the near side of the table, take the rolling board, Fig. 6, in the right hand, press the front part of it on the case, and drive it forward five or six times, like a jack plane, letting the handle of the former slip round in the left hand. This will tighten the case, and render it, when dry, as hard as a book cover.

The former must always be pasted before rolling a case, to prevent its sticking. It should, likewise, be wiped clean with a damp sponge before being laid aside. Brass tubes keep clean a much longer time if lacquered. To lacquer them, clean them with very fine glass paper; make them hot by the fire, till you can just bear them on the back of the hand; then, with a camel's hair pencil, wash them over with thin lac solution. The cases may be either 14½ or 11¼ in. long; but 11¼ is the best, for when the cases are too long, the fuse, as it approaches the bottom, is apt, if slow, to smoke; if fierce, to set the top of the case in a flame. If the learner decides upon 11¼ in., the former and rammer may each be two or three inches shorter.

After the first case has been rolled up to fit the gauge, it may be unrolled and the paper measured. Future pieces of the same quire of paper can then be cut of the right size at once, so that the case will fit the gauge without further trouble.

A large slab of slate is convenient for rolling upon, but a smoothly planed board will answer every purpose.

When a number of cases are finished hitch a piece of flax two or three times round each of them, and hang them up to dry in a place free from draught, that they may not warp.

Flax is sold in balls; the thick yellow is the best. It is named indifferently, flax or hemp. It is much used by shoemakers and is sold at the leather shops. Two or three thicknesses of this, waxed, or drawn through the hand with a little paste, is very convenient for passing round the necks of small choked cases, tying cases on wheels, etc.

To Make a Roman Candle Star.—Take the former, Fig. 1, which, as said before, is 1⅛ in. long; have a cylindrical piece of turned wood, box, beech or mahogany, Fig. 2, about 2 in. long, and of a diameter to just fit easily into Fig. 1. At a point, *a*, at the distance of about ⅝ of an inch from the end, *d*, with a bradawl or very small gimlet or nosebit, make a hole and drive in a piece of brass wire, to project just so much as to prevent the tube slipping over it. A piece of a brass rivet, such as used by shoemakers, is convenient for the purpose. The part with the head on is best; a quarter of an inch length will be sufficient, filed or cut off with the nippers. It is evident that upon inserting Fig. 2 into the tube, Fig. 1, a vacant space of ⅝ of an inch will be left at the bottom. Fig. 3 is a piece of turned wood, or better still, of turned brass, exactly like Fig. 2, without the side pin, *a*. Now, to pump a star, insert Fig. 2 in Fig. 1; press the tube into damped composition, turn it round and withdraw it. Rest the tube on a flat surface, insert Fig. 3 and give it two or three taps with a small mallet, like Fig. 26. A convenient size for the mallet is 1⅛ in. square, 3 in. long, with a turned handle. The mallet is best made of beech or mahogany. The slight malleting consolidates the star and prevents it from getting broken in charging; it will compress it to about nine-sixteenths of an inch in height. Push it out and set it by to dry.

Stars are best made in summer, and dried in the sunshine; when dry they should be put into clean pickle bottles furnished with tight fitting bungs. A piece of wash leather passed over the bottom of the bung, gathered up round the sides, and tied at the top like a choke, makes a good stopper. Shot shaken up in bottles, with water, soon cleans them.

To Damp Stars.—Stars containing nitrate of strontium must be damped either with lac solution or wax solution; anything containing water destroys the color. Niter stars may be damped with gum water, dextrine solution or thin starch. Most other stars with either of the solutions. Crimsons and greens will mix with boiled linseed oil, but they cannot then be matched, as oil renders meal powder almost inflammable. With all stars, not a drop more of the solution should be used than is sufficient to make the composition bind; and it is advisable not to damp more than half an ounce at a time; this is particularly the case in using the lac solution, as it dries rapidly; and if a large quantity of composition is damped and gets dry and has to be damped over and over again, it becomes clogged with the shellac and the color is deteriorated. If it should get dry, and require a second damping, it is best to use pure alcohol only the second time.

Before mixing compositions, every article should be as fine as wheaten flour and perfectly dry. Nitrate of strontium, if purchased in the lump, should be set over the fire in a pipkin; it will soon begin to boil in its water of crystallization; it must be kept stirred with a piece of wood till the water is evaporated and a fine dry powder left. A pound of crystals will yield about eleven ounces of dry powder, which should be immediately bottled. Even then, if used in damp weather, it is best dried again and mixed with the other ingredients while warm. This second drying may be in a six inch circular frying pan.

Articles, separately, may be reduced to powder with the pestle in a mortar. See that it is wiped clean every time, as there is danger of ignition with chlorates and sulphides. When the articles are to be mixed, they may be put into the mortar and stirred together with a small sash tool. A ⅜ in. is a convenient size. The mixture must then be put into a sieve and shaken in the usual way; or it may be brushed through with the sash tool. Return it to the sieve and brush and shake through again. As it lies in a heap, level or smooth it with the blade of a table knife, or any straight edge: if thoroughly mixed, it will present a uniform color; if it appears darker in one part than in another, it must be sifted again. A sieve with a top and receiver is very desirable, as nearly all mixtures are either black or poisonous; the dust from star mixtures is very injurious to the lungs. If a top and receiver cannot be readily purchased, both may easily be constructed out of a sheet of millboard, fastened with a bradawl and waxed yellow flax, and neatly covered with paper.

Mixtures may be damped on a Dutch tile, a marble slab, or a slate without a frame. They may be stirred about with a dessert knife, pressed flat, and chopped, or minced, as it were, and again pressed flat.

To Make Lac Solution.—Put half an ounce of flake shellac into a tin pot, and pour upon it ¼ of a pt. or 5 oz. of methylated spirit; or preferably, a like quantity of wood naphtha. Let it stand for about a day, stirring it occasionally till dissolved. Then half fill a basin with boiling water, set the tin containing the lac in it and leave it till it boils and curdles. If the water does not remain hot long enough to make it boil, set it in a second basin of boiling water. As soon as it has curdled remove it, and when cold pour it into a vial and cork it. Spirit must never be boiled over a fire nor near one, as the vapor might inflame. Keep the pot, therefor, while in the hot water, at a distance from a fire or flame of a lamp or candle.

To Make Wax Solution.—Put into a vial ⅛ an oz. of white (bleached beeswax), pour upon it 5 oz. of mineral naphtha (coal or gas tar naphtha); keep it tightly corked.

To Make Stearine Solution.—Dissolve a piece of composite candle in mineral naphtha in the same way. Mineral naphtha must not be used near a candle or fire, as it gives off an inflammable vapor at less than 100° Fahrenheit.

To Make Gum Solution.—There is no better way of preparing this than simply to put cold water upon gum arabic, and let it stand till dissolved. If for sticking purposes, as much water as will just cover the gum will be sufficient; but, for making quick match, 1 oz. or 1¼ oz. of gum to a pint of water. If required in a hurry, put the gum into cold water, in a pipkin or tin saucepan, set it on the fire, make it boil, and keep stirring till dissolved. When cold, bottle and cork it.

To Make Dextrine Solution.—Take ½ an oz. of dextrine and 5 oz. or a ¼ pt. of cold water, put the dextrine into a cup or basin, add a little of the water, and mix it well with a teaspoon, rubbing it till all is dissolved; then add the remainder of the water, stir well together a second time, pour it into a vial and cork for use. Dextrine, wetted to the consistency of honey, may be used instead of thick gum arabic water for pasting. For this purpose it is advisable to keep either in a wide mouthed bottle, and to set the bottle in a gallipot containing a little water; the brush, a camel's hair pencil, or very small sash tool with one-third of the bristles cut away on each side, to render it flat, can then be kept in the water when not in use; this will prevent it, on the one hand, from becoming dry and hard; and, on the other, from getting clogged and swollen. It can be squeezed between the thumb and fingers when wanted for use. The flat gum brushes now sold, bound with tin, are not pleasant to use, as the tin oxidizes and turns of a disagreeable brown color. If there is a difficulty in obtaining a graduated water measure, one sufficiently correct for pyrotechnic purposes may be made with a vial. Paste a narrow strip of paper up the outside of the vial, weigh 4 oz. of water in a cup in the scales; pour it into the vial, mark the height, and divide it into four equal parts for ounces; of course, it can be graduated into half and quarter ounces, and increased, if large enough, to five or more ounces. A gallon of distilled water weighs exactly ten pounds. Consequently a pint of pure water weighs a pound and a quarter. This is also near enough for spirit, though, of course, spirit is a trifle lighter. Doctors' vials are often marked with ounce divisions.

To Make Paste.—Paste is most economically made in a zinc pot, which may be 4 in. deep and 3½ in. diameter. Any zinc worker will make one to order. Put into it 2 oz. wheaten flour, add a little cold water, rub the two together with a spoon till smooth and free from lumps; pour in more water till the pot is full within about an inch, set the pot in half a saucepanful of water, put it on the fire; make the water boil, and keep it and the paste boiling for four or five minutes, stirring the paste the while. Remove it from the fire, and set it by to cool. The paste is to remain in the zinc pot, in which it will keep good for a length of time and beautifully white.

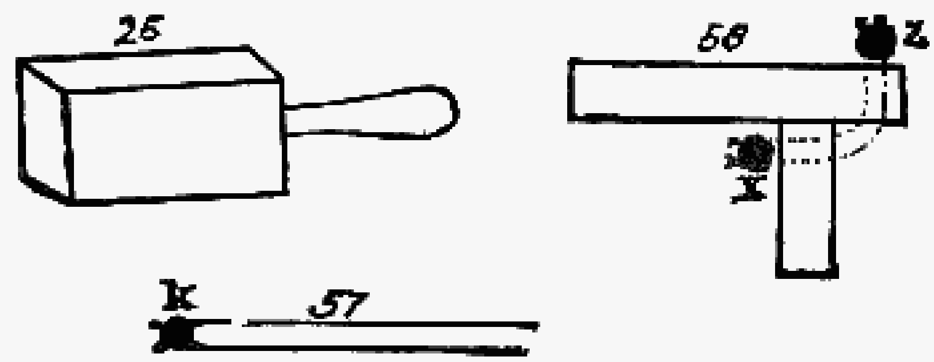
Some recommend alum in paste; but it is best avoided, especially in cases intended to receive colored fires. Alum is a double salt, a sulphate of alumina and potassa; it has an acid reaction; and, coming in contact with chlorate of potash and sulphur, may cause spontaneous combustion. A drop of sulphuric acid instantly ignites stars containing them. At theaters the clown sometimes fires a cannon with what appears to be a red hot poker, but which in reality is only a piece of wood painted red. A mixture is made of chlorate of potash and sulphur or sugar, a glass bead is filled with sulphuric acid, and the hole stopped up with wax. This is laid in the mixture, and when it is struck with the poker, the liquor escapes and inflames the potash and sulphur. Sulphate of copper is a particularly dangerous salt, and must never be used, as it is almost certain to cause spontaneous combustion. Chertier, to whom pyrotechny otherwise owes so much, introduced an empirical preparation, by dissolving sulphate of copper in water, together with chlorate of potash, drying it, and wetting it with ammonia; but this, however dried, when again wetted, turns litmus paper red. Practicus has named it Chertier's copper. Its use is not recommended.

Two paste brushes will be sufficient for an amateur, sash tools, one about an inch diameter, the other smaller for light purposes. Let them stand in the paste. If they get dry, the bristles fall out. For convenience, one may be kept in the paste and one in water.

Dry clay, powdered and sifted as fine as possible, is used for plugging or stopping up the bottoms of cases. Amateurs have discontinued its use, and employ plaster of Paris in preference. Directions will be given for each, so that the learner can adopt which he pleases; but plaster is infinitely preferable. It is an American improvement.

Roman Candle Scoops.—No species of fireworks require greater care in their construction than Roman candles. In the first place the stars must be fierce, that they may light thoroughly; next, they must not be driven out with too great velocity. For this purpose the blowing powder must be carefully adjusted. The stars also must be of so easy a fit that when put into the case they may fall to the proper depth of their own accord. If they require pushing, they are too tight, and will probably be blown out blind. When made as directed they will necessarily be of an easy fit, as they will be of the inner diameter of the brass tube, while the bore of the case is equal to its external diameter.

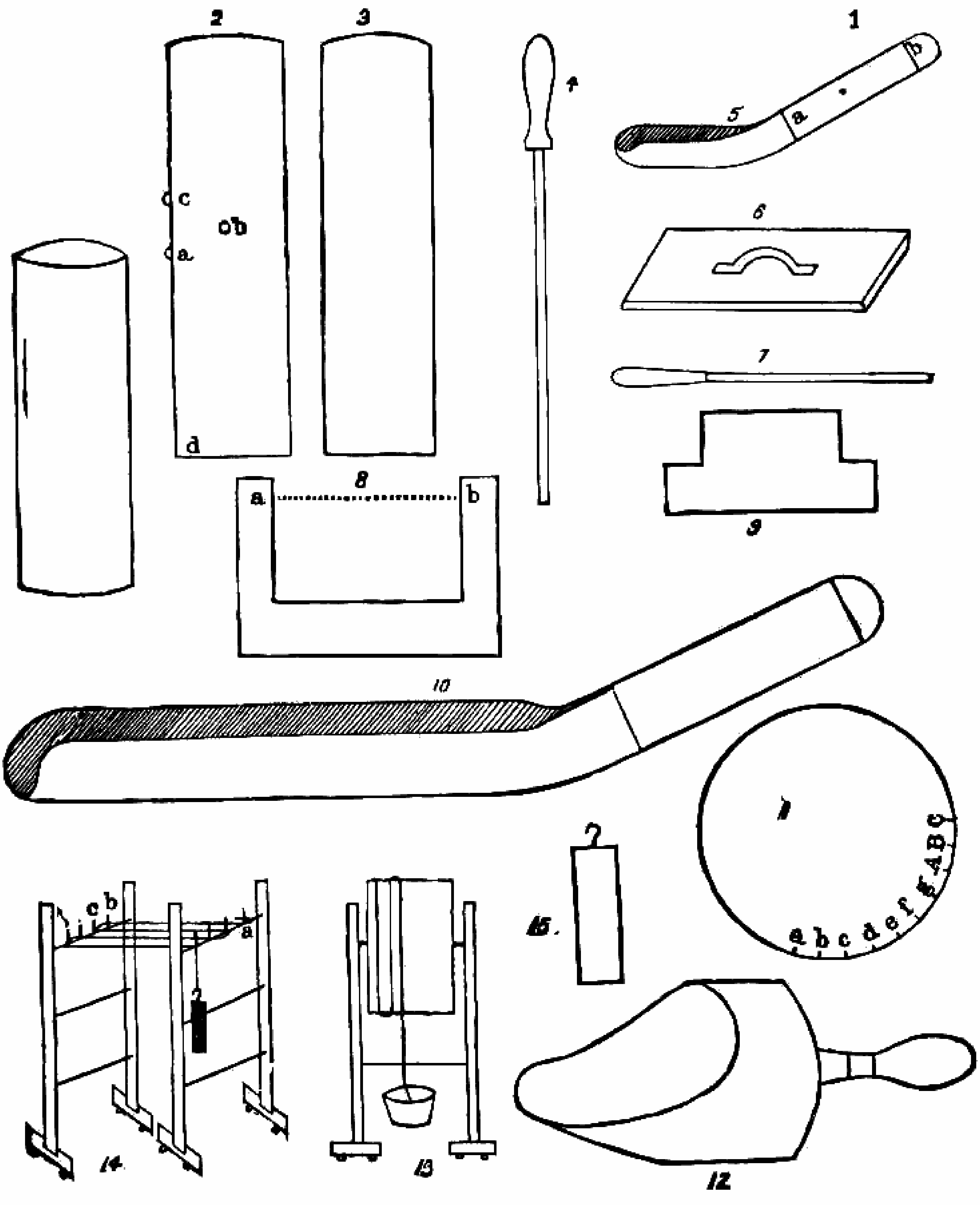
To regulate the blowing powder, prepare a number of little scoops, like Fig. 5, which is about the right size for the bottom star. They are formed of pieces of tin, zinc, or copper. Cut a long strip of tin ½ in. broad; cut this across into 7 pieces of the following lengths: 1⅝, 1¾, 1⅞, 2, 2⅛, 2¼, and 4 in. Round off the corners. Take a piece of brass wire, or stair rod about ¼ in. in diameter, and with the wooden mallet before mentioned, Fig. 26, bend each of the pieces round the rod into a half cylinder or gutter. Take up the smallest and hold ⅝ in.



of the end of the stair rod in the end of the semi-cylinder to keep it open; put the other part, from *a* to *b*, Fig. 5, in a vise and pinch it up; it will assume the form represented; the bowl part will be ⅝ in. long and the handle 1 in. long. Make the bowl of the next scoop ¾ in. long, the next ⅞ in.. and so on; the handle will always be 1 in. long. The last, for the top star, will have a bowl of 3 in. The smallest scoop ought to hold as much grain powder as will weigh about one twelfth of the star; but to have the scoops accurate, it will be necessary to charge a Roman candle, fire it, and observe whether the stars go a uniform height. For measuring the interval fuse, or fuse between the top of one star and the bottom of the next, a large scoop of the size of Fig. 10 will be required. The tin may be 1 in. broad, and the bowl part 2½ in. long, bent round the rammer, Fig. 4. To adjust it, take a Roman candle case, fit on the foot, Fig. 9, which is a piece of wood or brass turned with a tenon to fit tight at the bottom of the case. Fill the scoop and strike it level with a straight edge; empty it into the case, rest the foot on a flat surface; insert the rammer, Fig. 4, and jolt it up and down a dozen times or more, lift it about ½ in. at a time; put in another scoopful and jolt it in like manner. If the two scoopfuls thus compressed fill 1 in. of the case, the scoop will be correct. If more or less, the scoop must be shortened or lengthened accordingly.

A piece of writing paper may be pasted and wound twice round the handle of each scoop, as from *a* to *b*, Fig. 4. One dot can be put upon the scoop for the first or bottom star; two dots for the second scoop, etc., or any memorandum can be written upon them for future guidance. Should they get soiled, they may be cleaned with a soaped damp piece of sponge.

Gunpowder for fireworks is used in two forms, meal powder and grain powder. Meal powder is a fine black dust and is employed in all cases of mixing. Grain powder is of three kinds, F, FF, and FFF—fine, double fine and treble fine. FFF is best for crackers, simply because it runs rapidly down the pipes; for driving stars, shells, etc., F will be sufficient but FFF may be employed; FF need not be purchased. If in any place there should be a difficulty in obtaining meal powder, F grain


1
a
b
5
2
c
b
a
d
3
4
6
7
8
a
b
9
10
11
A B C
a b c d e f g
12
13
14
c b
a
15.

powder may be crushed in a leather bag by laying the bag on a hard surface and beating it with a hammer. The leather should be of the same kind as shoes are made of.

To Charge Roman Candle Cases.—Pour some F grain powder into a wooden bowl or platter, represented by Fig. 11. Round the edge lay the little blowing powder scoops side by side, beginning with the smallest at *a*, the next at *b*, and so on to *g*. Put some Roman candle fuse into a large tin scoop, made to stand on a flat bottom, like Fig. 12, the same in shape as used by tea dealers; and, on the right hand of it lay the charging fuse scoop, Fig. 10. If the Roman candle is to contain different colored stars, set seven in a row in the order desired. When the cases are intended to be fired in threes or fours, the stars in one may be all blue, in another crimson, in another green, in another white. Fit the foot, Fig. 9, in the bottom of the case, put in a scoopful of clay, insert the rammer, Fig. 4, and jolt it till the clay is well composed. The clay should fill half an inch. This being done, invert it, and shake out any little dust that may remain. Put in the little scoopful, *a*, of F grain powder, then lay the scoop at A. Now put in a star. As previously stated, it ought to fall of its own accord; but make sure that it has reached the blowing powder by putting in the rammer. Having ascertained this, put in a scoop of fuse, Fig. 10; lay the scoop on the right of Fig. 12; insert the rammer and jolt it; put in another scoop of fuse, Fig. 10; lay the scoop on the right of Fig. 12; insert the rammer and jolt it as before. Then proceed with the scoop, *b*, of grain powder and lay it at B, and so on, till the case is filled. The fuse on the top star is best driven in with a short solid rammer and mallet, as it is difficult to jolt the long rammer in so small a space. The last eighth of an inch, near the mouth of the case, should be fine meal powder, as it binds better than the Roman candle fuse, and also blows off the leader pipe.

The blowing powder scoops, having been laid at A, B, etc., all that is required is to turn the bowl or platter a little round to the left and they will come in rotation ready for the next case. Also, by putting the scoop, Fig. 10, alternately to the left and right of the scoop, Fig. 12, it will always be known whether the proper quantity of fuse has been put in.

Colored stars, from their fierceness, have a tendency to burn in the cases. This defect may be remedied by putting upon each star a small coopful of starting fire, No. 1, before putting in the interval fuse as much as will fill round the sides of the star. This composition is somewhat fiercer than would suit for the regular fuse; so catches the blowing powder sooner.

A Roman candle is well charged when the stars isochronize, or come out at equal intervals of time; they should also, theoretically, ascend to equal heights; but with colored stars this cannot be perfectly insured, as some shrink more than others in drying, and of course fit more loosely; some are heavier, some fiercer than others.

The interval fuse must always be driven in at twice, never at once. Each star, with its blowing powder and fuse, occupies about an inch and a half; perhaps a trifle more.

Instead of driving in clay at the bottom, plaster of Paris may be used, and then the foot, Fig. 9, will not be required. Have some plaster of Paris in a wide-mouthed bottle; a glass of cold water with a salt spoon in it; and a number of pieces of paper about four inches square. Put a small quantity of the plaster on one of the pieces of paper; indent the middle with the finger; put to it a little water and work it up with a dessert knife. Just as it gets to the consistency of mortar and is about to set, mould it with the fingers to the shape of a cork; push it in to the end of the case; rest the case on a flat surface; insert the rammer and give it two or three slight jolts; turn it round a few times and withdraw it. If the plaster sticks to the end of the rammer, it shows either that you have used the plaster too wet or have not turned the rammer round a sufficient number of times.

No more plaster must be mixed at a time than will suffice for one case. When plaster has once set it cannot be mixed up a second time; therefore take a fresh piece of paper and let the knife be cleaned every time. It is advisable to have two dessert knives, then one can be used to scrape the other. As much plaster should be used as will fill the case up about half an inch. They must be set by to dry; their not requiring the use of the foot will be found a great convenience.

Roman candles are usually made from three-eighths to six-eighths, but five-eighths is a very satisfactory size. If a Roman candle is intended to be fired singly, twist a piece of touch paper round the mouth. If the cases are intended to be fired in threes, fours, etc., to form a bouquet, or to be placed round a mine, jack-in-the-box, or devil-among-the-tailors, omit the touchpaper and envelop the case in double crown, made to project an inch beyond the mouth, to receive the leader or quick-match.

A steel pen inserted, nib backward, in the end of a small paper tube, rolled round the end of a pen holder, makes a neat little scoop. It may be fastened in with a little plaster of Paris. A scoop may also be made with a quill.

Composition for Roman Candles.—1. Niter, 18 parts; sulphur, 6 parts; fine charcoal, 7 parts; meal powder, 4 parts.

2. Niter, 16 parts; meal powder, 8 parts; fine charcoal, 8 parts; sulphur, 6 parts.

3. Niter, 16 parts; meal powder, 11 parts; sulphur, 6 parts; antimony, 4 parts. The next thing is to fill the case. Before filling it introduce a little clay to the bottom of the case, thus forming a better and firmer bottom. This being done properly, put in a little coarse pow-

der, and over this a small piece of paper to prevent the composition mixing with the powder; then ram down as much composition as will fill the case one-sixth of its height; over this put a small piece of paper covering about two thirds of the diameter, then a little corn powder, and upon that a ball, observing that the ball is rather smaller than the diameter of the case. Over this first ball more of the composition must be put and rammed lightly down to prevent breaking the ball, till the case is one third full; then a piece of paper, a little powder, and then another ball as before, till the case is filled with balls and composition, taking care to place composition above the highest ball. When the case is thus filled, cap it with touch paper by pasting it round the orifice, and a little priming of powder being added, the work is complete.—*Pyrotechnist's Treasury.*

Saxon.

Number	1	2	3
Sulphur	1	3	5
Niter	1	4	9
Meal powder	2	5	15

Shell Fuse.

Number	1
Meal powder	4
Niter	2
Sulphur	1

Signal Fireworks.—The following proportions are given in an English patent by E. H. Lamarre, of Paris, for colored lights for signals:

White Light.—One hundred parts potassium chlorate, 10 parts antimony sulphide, 15 parts boiled linseed oil.

Red Light.—Fifty parts potassium chlorate, 50 parts strontium nitrate, 5 parts wood charcoal, with as much linseed oil as is required to knead the mass together.

Green Light.—Fifty parts potassium chlorate, 50 parts barium nitrate; 5 parts wood charcoal and linseed oil, as above. The use of linseed oil is claimed as a specialty in substitution for oil of turpentine or resin.—*Science Record*, 1874.

To Make Slow Match.—Dissolve 1 drm. nitrate of lead in ½ oz. boiling water. Cut a sheet of blotting paper in six equal parts, and wet them on both sides, with a sash tool, with the solution. When dry, paste a piece all over, and upon it smoothly press another piece; upon this, pasted, put a third piece; and so on, till all the six form a stiff board. Lay them under a heavy weight; and, when dry, with a sharp knife and straight edge, cut the whole into strips a quarter of an inch broad. Four inches will burn about a quarter of an hour. Narrow tape, boiled in the solution, makes excellent slow match.

Squibs, Compositions for.—1. Meal powder, 20 parts; niter, 8 parts; sulphur, 4 parts; E. charcoal, 4 parts.

2. Meal powder, 16 parts; E. charcoal, 2 parts.

3. Meal powder, 24 parts; niter, 4 parts; E. charcoal, 4 parts; sulphur, 1 part.

4. Meal powder, 16 parts; niter, 6 parts; sulphur, 4 parts; E. charcoal, 3 parts. Weigh out all the ingredients, mix them thoroughly, and pass the composition through a sieve at least three times. The composition cannot be over-mixed.

Slow Fires, to be Heaped upon a Tile in Shape of a Cone, and Lit at Top.

Colors.	Scarlet.			Green.			Purple.		Yellow.		Crimson.	
Nitrate of strontium	16	24	108	—	—	—	108	72	20	—	40	36
Nitrate of barytes	—	—	—	16	16	16	—	—	—	10	—	—
Oxalate of soda	—	—	—	—	—	—	—	—	3	5	—	—
Sulphure of copper	—	3	30	—	—	—	24	3	—	—	—	—
Chlorate of barytes	—	—	—	—	—	12	—	—	—	—	—	—
Chlorate of potash	1	3	12	1	1	—	9	4	2	2	5	4
Charcoal, fine	1	—	—	1	—	—	—	—	—	—	2	—
Calomel	—	6	24	—	5	9	24	18	—	—	—	—
Sulphur, washed	4	8	39	4	2	7	39	24	4	1	13	12
Shellac	—	1	2	—	2	1	2	3	2	6	—	1
Vegetable black	—	—	1	—	—	—	1	2	—	—	—	1
Sulphide of antimony	—	—	—	—	—	—	—	—	—	—	4	4

In order to get the powder into a conical heap, press it into a wineglass, or lay a tile upon the top, and invert.

Squib and Serpent.

Number	1	2	3
Sulphur	1	—	—
Charcoal	1	1	—
Niter	2	—	—
Meal powder	8	8	4
Steel filings	—	—	1

Stars, Crimson. — 1. Chlorate of potash, 24 parts; nitrate of strontia, 32 parts; calomel, 12 parts; sulphur, 6 parts; shellac in fine powder, 8 parts; sulphide of copper, 2 parts; fine charcoal, 2 parts.

2. Chlorate of potash, 12 parts; nitrate of strontia, 20 parts; sulphur, 11 parts; charcoal, 2 parts; antimony, 2 parts; mastic, 1 part.

3. Nitrate of strontia, 72 parts; sulphur, 20 parts; gunpowder, 6 parts; coal dust, 2 parts.

Rose Colored Stars.—Chlorate of potash, 20 parts; carbonate of strontia, 8 parts; calomel, 10 parts; shellac, 2 parts; sulphur, 3 parts; fine charcoal, 1 part. The advantage of this composition is that it is not at all liable to suffer from damp in winter. The carbonate of strontia is a salt not absorbent of moisture like the nitrate, and is, moreover, always to be had in a state of fine powder.

Green Stars.—1. Chlorate of potash, 20 parts; nitrate of baryta, 40 parts; calomel, 10 parts; sulphur, 8 parts; shellac, 3 parts; fine charcoal, 1 part; fused sulphide of copper, 1 part.

2. Nitrate of baryta, 40 parts; realgar, 2 parts; sulphur, 8 parts; lampblack, 1 part.

3. Chlorate of potash, 28 parts; nitrate of baryta, 12 parts; sulphur, 15 parts; mastic, 1 part.

Pale Rose Colored Stars.—Nitrate of strontia, 8 parts; chlorate of potash, 4 parts; sulphur, 3 parts; sulphuret of antimony, 2 parts. Take especial care that the nitrate of strontia used in this formula is very dry.

Pale Green Stars.—Nitrate of baryta, 16 parts; chlorate of potash, 8 parts; sulphur, 6 parts; antimony, 3 parts.

Yellow Stars.—1. Chlorate of potash, 20 parts; bicarbonate of soda, 10 parts; sulphur, 5 parts; mastic, 1 part.

2. Chlorate of potash, 30 parts; dried soda, 12 parts; sulphur, 8 parts.

Golden Yellow Stars.—Chlorate of potash, 20 parts; nitrate of baryta, 30 parts; oxalate of soda, 15 parts; sulphur, 8 parts; shellac, 4 parts. If it is thought advisable to give the stars made from this formula a tailed appearance, add one part of fine charcoal. The composition is to be moistened with the shellac solution. The stars form a beautiful contrast with those of an intense blue.

Blue Stars.—1. Chlorate of potash, 8 parts; sulphide of copper, 6 parts; Chertier's copper, 5 parts; sulphur, 4 parts.

2. Chlorate of potash, 12 parts; Chertier's copper, 6 parts; sulphur, 4 parts; calomel, 1 part.

3. Chlorate of potash, 16 parts; Chertier's copper, 12 parts; calomel, 8 parts; stearine, 2 parts; sulphur, 2 parts; shellac, 1 part. This gives a most intense blue.

4. Chlorate of potash, 20 parts; carbonate of copper, 14 parts; sulphur, 12 parts; mastic, 1 part.

5. Niter, 12 parts; sulphide of antimony, 2 parts; sulphur, 4 parts; lampblack, 2 parts. All these compositions should be moistened with gum water, and in No. 3 the stearine employed must be in fine powder.

Violet Stars.—Chlorate of potash, 9 parts; nitrate of strontia, 4 parts; sulphur, 6 parts; carbonate of copper, 1 part; calomel, 1 part; mastic, 1 part.

White Stars.—Saltpeter, 9 parts; sulphur, 3 parts; antimony, 2 parts.

No. 1. *Mauve and Lilac Stars and Lances.*

Number	1	2	3	4	5	6	7	8	9	10
Chlorate of potash	28	17	60	40	25	24	24	25	12	6
Calomel	12	—	—	—	10	12	12	—	—	2
Shellac	4	—	—	—	5	5	5	—	—	1

No. 3. *Purple and Violet Stars and Lances.*

Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Chlorate of potash	42	28	48	16	6	16	3	6	26	30	96	24	20	32	37
Nitrate of strontium	42	14	48	—	4	—	—	1	—	—	24	—	—	—	—
Sulphur, washed	13	—	28	2	1	6	1	3	—	3	—	2	6	12	9
Calomel	12	14	28	7	2	6	2	2	20	8	48	8	8	12	13
Sulphide of copper	4	1	40	8	1	—	3	—	8	12	1	—	—	—	—
Shellac	4	5	1	—	1	—	—	—	—	4	—	1	1	2	8
Vegetable black	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Black oxide of copper	—	—	—	—	—	4	4	1	—	—	—	—	—	1	1
Carbonate of strontium	—	—	—	—	—	—	—	—	4	12	—	—	—	—	—
Loaf sugar	—	—	—	—	—	—	—	—	14	—	42	—	—	—	—
Oxychloride of copper	—	—	—	—	—	—	—	—	—	—	—	4	5	8	9
Stearine	—	—	—	—	—	—	—	—	—	—	—	2	2	—	1

Nitrate of strontium..	4	4	25	14	—	4	—	16	16	1
Sulphide of copper....	2	7	20	—	5	2	2	—	—	1
Stearine..............	1	—	—	—	1	—	1	—	—	—
Sulphur, washed.......	—	7	35	16	—	—	—	12	2	—
Chloride of lead.......	—	1	—	2	—	—	—	—	—	—
Nitrate of lead........	—	—	—	—	10	—	12	1	—	—
Oxychloride of copper.	—	—	8	12	—	—	—	6	—	—
Salammoniac...........	—	—	1	—	—	—	—	—	—	—
Vegetable black......	—	—	—	1	—	—	—	1	1	—
Niter................	—	—	—	2	—	—	—	2	1	—
Carb'nate of strontium	—	—	—	—	5	—	4	—	—	—
Orpiment or realgar...	—	—	—	—	—	—	1	—	1	—

The following refers to table No. 6, page 18 :

If powdered nitrate of barytes and shellac, crushed by being hammered in a bag, are mixed together and melted in a pipkin over the fire, the mixture, when cold, may be reduced to a powder in an iron mortar with patience. Take No. 6. Weigh out 21 parts nitrate of barytes, and 2 parts coarsely powdered lac; melt them together; when cold, powder them, and add the other substances in proper proportion. Shellac may be melted with nitrate of strontian, in the same way.

No. 2. *Sugar Blues for Stars and Lances.*

Number............	1	2	3	4	5	6	7	8	9	10
Chlorate of potash....	8	36	40	40	36	9	44	40	6	2
Calomel..............	4	18	24	24	12	3	12	—	5	1
Loaf sugar	3	12	9	12	4	1	12	9	4	—
Sulphuret of copper.	5	22	22	12	4	3	12	22	—	—
Stearine..............	—	1	2	1	3	1	1	2	—	—
Oxychloride of copper	—	—	—	3	4	2	5	—	—	—
Salammoniac	—	—	—	—	—	—	—	6	—	—
Copper filings	—	—	—	—	—	—	—	—	1	—
Black oxide of copper	—	—	—	—	—	—	—	—	—	—

No substance combines better with salts of copper than sugar. Sugar, put into the bowl of a tobacco pipe and placed in the fire, burns fiercely, and is converted into caramel. This poured on to a plate, slightly smeared with butter to prevent it sticking, hardens on cooling; and is used for coloring brandy, vinegar, gravy, porter, coffee, etc. Stearine must be scraped very fine from a Stearine candle. Sugar blues are to be damped with pure water only, as the sugar itself, when wetted, is sufficiently cohesive. Use an exceedingly small quantity of water, and rub it up thoroughly in the mortar; the longer it is rubbed, the better it combines.

The following refers to table No. 10, page 19 :

It is impossible to powder shellac sufficiently fine by hand; and, twenty years ago, powdered shellac could not be procured. About that time the drug grinders, finding a demand for it, submitted it to the action of the stamping mills (mechanical pestle and mortar), and now it can be obtained at most shops.

Chertier mixed flake shellac with salt; melted the two together; powdered the mixture; and washed out the salt. Such process is needless now. It is useless, unless as fine as wheaten flour.

No. 4. *Steel Stars for Rockets and Shells.*

Number.	1	2	3	4	5
Nitrate of lead..	8	24	28	—	—
Chlorate of potash	3	5	6	5	4
Charcoal.........	2	6	6	1	—
Steel filings......	2	6	6	3	4
Niter............	—	4	3	—	—
Shellac, fine......	—	—	1	—	—
Sulphur, washed	—	—	—	1	1

Rub up the mixture thoroughly in a mortar with just enough boiled oil to make it cohere, and pump it into Roman candle stars; the oil will preserve the steel from rusting. For Roman candles or Italian streamers they will be ready at any time; for rockets and shells they may be matched and enveloped, like figure 32, a day or two previously. They form beautiful stars. Or they may be charged in cases, and primed with chlorate meal powder. Or they may be damped with lac solution.

No. 5. *Pearl Streamer.*

Number..........	1	2	3	4	5
Niter............	12	26	2	—	—
Charcoal	5	11	1	—	—
Zinc filings......	14	28	4	10	15
Meal powder. ...	—	—	1	8	12
Vegetable black.	—	—	—	1	1

Instead of filings, zinc may be obtained in a fine powder, by pouring it, melted, into a hot iron mortar, and hammering it with the pestle directly it begins to solidify. Sift it through a fine sieve. Protect the hands with cloth gloves while using the pestle. Damp the composition with gum water for Roman candle stars. Broken bits of the stars may be put into colored gerbes.

No. 6. *Green or Emerald Stars and Lances.*

Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Chlorate of potash	16	8	132	32	144	8	3	1	—	16	6	12	16	3	48	22	24	108	24	16	2	13
Nitrate of barytes	16	8	108	54	160	21	2	—	—	8	7	5	8	3	42	22	32	108	32	48	10	32
Chlorate of barytes	—	—	—	—	—	3	2	2	4	8	3	4	4	—	—	—	—	—	—	—	—	—
Sulphur, washed	5	4	6	6	4	7	1	1	1	5	—	—	1	—	—	—	10	18	8	12	2	8
Charcoal, fine	1	1	—	—	—	1	—	—	—	1	—	1	—	—	—	—	—	—	—	1	1	2
Sulphide of antimony	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	—
Calomel	—	—	48	27	100	—	—	—	—	—	5	2	2	2	—	10	—	48	—	8	—	—
Shellac	—	—	24	12	12	2	—	—	—	—	—	3	4	—	7	1	—	24	—	5	—	—
Vegetable black	—	—	1	1	1	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—
Loaf sugar	—	—	—	—	—	—	—	—	—	—	5	—	—	2	7	14	—	—	—	—	—	—
Sal ammoniac	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5	—	—	—	—	—	—	—
Orpiment, or Realgar	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3	—	3	—	—	—
Sulphide of copper	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—

No. 7. *Deep and Pale Yellow Stars and Lances.*

Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Chlorate of potash	8	4	12	16	12	16	4	4	16	8	8	16	16	4	8	6	20	5	6
Oxalate of soda	3	2	8	4	4	4	3	1	4	4	4	5	—	1	—	4	15	—	3
Bicarbonate of soda	—	—	—	—	—	—	—	—	—	—	—	—	3	—	3	—	—	1	—
Nitrate of strontium	—	—	—	—	—	—	20	—	—	—	16	—	4	—	—	—	—	—	—
Carbonate of strontium	—	—	—	3	2	8	—	—	—	—	—	—	—	—	—	—	—	—	—
Nitrate of barytes	—	—	—	—	—	—	—	—	4	10	—	—	3	—	—	7	30	—	—
Sulphur, washed	—	—	—	4	4	4	—	1	2	—	61	5	—	—	—	3	8	1	2
Shellac	2	1	3	—	1	1	5	—	2	3	1	—	4	1	—	1	4	—	1
Stearine	—	—	—	—	—	1	—	—	1	—	—	—	—	—	—	—	—	—	—
Charcoal, fine	—	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—	1	—	—
Orpiment, or realgar	—	—	—	1	1	1	—	—	—	—	—	—	—	—	1	—	—	1	—
Loaf sugar	—	—	—	—	—	—	—	—	—	—	—	—	—	1	3	—	—	—	—

No. 8. *White or Bright Stars and Lances.*

Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Meal powder	8	3	2	1	1	1	1	1	3	—	—	—	—	—	—
Sulphur	4	6	4	2	8	2	2	1	11	5	7	—	8	2	1
Niter	8	14	14	5	10	6	9	4	48	24	34	18	—	—	—
Sulphide of antimony	1	—	1	—	3	—	2	1	10	5	6	3	1	1	2
Sulphide of arsenic, realgar	—	—	—	1	—	1	—	—	—	3	5	—	—	—	—
Minium, or red lead	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—
Nitrate of lead	—	—	—	—	—	—	—	—	—	—	—	3	16	3	12
Chlorate of potash	—	—	—	—	—	—	—	—	—	—	—	28	16	4	3
Shellac	—	—	—	—	—	—	—	—	—	—	—	5	—	—	1

No. 9. *Blue Stars and Lances without Sugar.*

Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Chlorate of potash	5	40	18	40	6	8	48	40	24	16	30	24	8	22	40	6	16	24	2	5	40	40	36
Calomel	4	20	8	28	2	2	12	12	6	8	10	8	1	6	20	3	1	8	—	—	—	—	12
Sulphide of copper	4	20	10	28	—	2	—	—	—	—	—	—	3	6	25	5	—	—	—	1	20	22	—
Shellac	1	5	—	—	—	—	2	2	1	—	—	1	—	—	5	—	—	1	—	—	6	—	6
Oxychloride of copper	—	2	—	—	—	—	8	—	6	5	10	4	1	2	—	—	2	—	1	1	—	—	9
Dextrine	—	—	5	10	—	—	—	9	—	—	..	—	—	..	2	2	—	—	—	—	—	—	—
Sulphur	—	—	—	..	3	4	4	1	1	2	3	2	3	5	—	—	4	2	1	2	5	5	9
Stearine	—	—	—	3	—	—	1	—	2	2	3	1	—	—	—	—	—	—	—	—	—	3	1
Black oxide of copper	—	—	—	—	1	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Copper filings	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5	—	—	—	—	—
Sal ammoniac	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	6	6	—

No. 10. *Crimson and Scarlet Stars and Lances.*

Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Chlorate of potash	16	8	16	16	24	16	24	16	8	16	25	4	32	6	16	28	32	26	96	8	24	8	2	13
Nitrate of strontium	16	16	32	32	—	16	20	24	5	6	30	7	48	5	—	—	42	10	72	12	18	12	8	32
Sulphur, washed	5	6	9	12	6	5	10	—	1	—	10	1	6	—	—	—	13	5	24	2	—	2	2	8
Charcoal, fine	1	1	1	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	2
Shellac	—	1	4	2	2	—	—	7	1	4	3	1	12	1	—	—	4	3	21	4	5	3	—	—
Calomel	—	—	7	—	6	1	—	14	2	2	9	2	12	5	—	12	12	10	42	—	—	4	—	—
Sulphide of copper	—	—	3	1	—	—	—	1	1	1	3	1	—	1	—	—	4	1	4	1	5	—	—	—
Realgar, or orpiment	—	—	—	—	—	1	5	1	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—
Vegetable black	—	—	—	—	—	—	—	—	—	—	1	—	1	—	—	—	1	—	—	—	—	1	—	—
Loaf sugar	—	—	—	—	—	—	—	—	—	—	—	—	—	—	7	12	—	—	—	—	—	—	—	—
Carbonate of strontian	—	—	—	—	10	—	—	—	—	—	—	—	—	—	11	5	—	—	—	—	—	—	—	—

No. 11. *Tailed, Streamer, or Comet Stars, for Rockets, Shells and Roman Candles.*

Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Vegetable black	1	3	3	6	—	—	—	—	3	1	—	—	—	—
Charcoal	2	8	2	3	1	3	6	12	2	4	1	1	3	—
Sulphur	5	24	2	—	2	4	1	2	2	12	3	3	8	—
Nitter	5	24	9	—	—	—	10	20	9	12	4	4	4	—
Meal powder	8	30	6	16	—	20	5	7	6	8	3	3	12	2
Oxalate of soda	—	—	—	—	4	12	—	—	—	—	—	—	—	—
Sulphide of antimony	—	—	—	—	—	—	—	—	4	—	—	—	—	—
Chlorate of potash	—		—	—	8	16	—	—	—	—	—	—	—	—
Asphaltum, Egyptian	—	—	—	—	—	—	—	—	—	—	1	—	—	—
Burgundy pitch	—	—	—	—	—	—	—	—	—	—	—	1	—	—
Coke grains, fine	—	—	—	—	—	—	—	—	—	—	—	—	4	1

Tourbillion.

Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Sulphur	1	3	3	7	3	4	4	4	2	4	1	7	4	1
Niter	4	5	16	10	8	32	17	17	4	8	8	20	14	4
Charcoal	2	3	8	4	3	6	4	5	—	—	—	—	3	2
Meal powder	1	4	8	24	16	32	—	—	4	9	10	[illegible]	13	1
Steel filings	—	—	—	8	6	5	—	—	—	—	—	—	2	1
Cast iron borings	—	—	—	—	—	8	6	8	8	4	7	14	5	--

Oiled Tailed Stars for Rockets and Shells.

Number	1	2	3
Charcoal	9	6	2
Sulphur	9	5	2
Niter	32	18	9
Meal powder	24	12	5
Sulphide of antimony	16	9	4

To 1 oz. add 24 drops of boiled linseed oil; rub them thoroughly together in a mortar; then spread out the mixture for a few days to dry. When dry, mix with starch, dextrine solution, or gum water, and chop into ⅜ or ⅛ in. cubical blocks. They will keep for years, and improve by age. In order that a star may tail, it must rapidly burn through and leave a cinder, or scoria; from this, as it falls, minute portions become detached, and trail behind.

Magnesium Colors for Stars and Asteroids.

Colors.	Crimson.	Scarlet.	Green.	Blue.	Yellow.	White.
Nitrate of strontium	8	6	—	—	—	—
Chloride of barytes	—	—	12	—	—	—
Oxychloride of Copper	—	—	—	2	—	—
Oxalate of soda	—	—	—	—	2	—
Sulphide of antimony	—	—	—	—	—	1
Chlorate of potash	2	4	—	5	4	—
Niter	—	—	—	—	—	12
Sulphur	2	2	1	2	—	4
Charcoal	1	—	—	—	—	—
Shellac	—	2	3	1	1	—
Calomel	—	4	—	2	—	—
Magnesium filings	2	3	2	2	1	2

A few magnesium filings may be added to any color.

Star Lights, Composition for.—Fine dry niter, 20 parts; sulphur, 6 parts; lampblack, 3⅛ parts.

Starting Fire.

Number	1	2	3
Charcoal	1	3	2
Meal powder	8	16	12
Sulphur	—	4	2
Niter	—	6	3

Streamers.—Streamers or quick matches, used for communicating fire quickly from one tube to another in display pieces, are composed of the following composition packed in slender continuous paper tubes:

Niter	2	oz.
Sulphur	1	oz.
Mealed powder	16	oz.
Charcoal	4	oz.

To Make Touch Paper.—Dissolve ⅛ oz. of niter in ⅛ pt. of hot water. Procure some 12 lb. double crown blue, cut each sheet into four equal parts, fifteen by ten. Lay them smooth upon each other, and, with a sash tool dipped into the niter solution, wash them over on one side, and hang them up to dry.

Wasp Light.

Number	1
Nitre	14
Sulphur	5
Meal powder	3
Realgar	1

Wheel and Fixed Cases.

Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Meal powder	8	24	8	36	4	18	8	12	42	4	16	10	13	16	20	40	38
Sulphur	1	1	—	1	—	—	1	1	3	—	—	—	1	—	1	4	1
Charcoal	1	4	1	4	1	—	—	—	—	—	—	—	—	—	—	3	2
Niter	2	3	—	—	2	2	1	3	8	—	1	—	1	—	—	24	4
Steel filings	—	—	—	—	—	5	3	3	5	1	5	—	—	—	—	6	—
Vegetable black	—	—	—	—	—	—	—	—	—	—	—	1	2	—	—	1	—
Realgar	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	1	—
Litharge	—	—	—	—	—	—	—	—	—	—	—	—	—	3	3	2	—

Case Colors for Wheels, Compositions for—1. White.—Niter, 10 oz.; sulphur, 3 oz.; regulus antimony, 2 oz.; realgar, 1 oz.; red lead, ⅛ oz.; shellac, ½ oz.

2. Golden Yellow.—Potassium chlorate, 8 oz.; barium nitrate, 2 oz.; shellac, 2 oz.; sodium oxalate, 1½ oz.; stearine, ½ oz.

3. Orange.—Potassium chlorate, 8 oz.; strontium chlorate, 1 oz.; barium nitrate, 2 oz.; shellac, 2 oz.; sodium oxalate, 1½ oz

4. Mauve.—Potassium chlorate, 12 oz.; mercurous chloride, 4 oz.; strontium nitrate, 2 oz.; copper subsulphate, 2 oz.; shellac, 2 oz.; stearine, ½ oz.

5. Rich Crimson.—Potassium chlorate, 9 oz.; strontium nitrate, 5 oz.; shellac, 2 oz.; mercurous chloride, 1½ oz.; copper sulphide (fused), 1 oz.; lampblack, ¼ oz.

6. Red.—Potassium chlorate, 8 oz.; strontium nitrate, 5 oz.; shellac, 2 oz.; mercurous chloride,

1 oz.

7. **Brilliant Green.**—Potassium chlorate, 10 oz.; barium nitrate, 5 oz.; shellac, 2 oz.; mercurous chloride, 2 oz.; pure sulphur, 1 oz.; copper sulphide, ¾ oz.; fine charcoal, ½ oz.

8. **Rich Emerald Green.**—Potassium chlorate, 12 oz.; barium nitrate, 9 oz.; barium chlorate, 5 oz.; shellac, 4 oz.; mercurous chloride, 2 oz.; copper powder, 1 oz.; pure sulphur, 1 oz.

9. **Bright Blue.**—Potassium chlorate, 7 oz.; mercurous chloride, 4 oz.; Chertier's copper, 4 oz.; dextrine, 1½ oz.; stearine, ½ oz.

10. **Bright Blue.**—Potassium chlorate, 8 oz.; Chertier's copper, 7 oz.; mercurous chloride, 3 oz.; shellac, 1 oz.; stearine, 1 oz.

11. **Rich Blue.**—Potassium chlorate, 8 oz.; copper subchloride, 2 oz.; shellac, ½ oz.; mercurous chloride, 3 oz.; stearine, 1 oz.

All the ingredients must be perfectly dry and fine enough to pass through a forty mesh sieve. They should be thoroughly well mixed and the compositions should be kept in stoppered bottles ready for use.

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Pyrotechny. This is the art of making fireworks. The three principal materials employed in this art are charcoal, saltpetre, and sulphur, combined with filings of iron, steel, copper or zinc, or with resin, camphor, lycopodium and other substances, to impart color, or to modify the effect and duration of the combustion. Gunpowder is used, either in grain, half crushed, or meal (finely ground), as circumstances may require. Iron filings give red and bright spots. Copper filings give a greenish tint to flame; those of zinc, a fine blue color; sulphuret of antimony gives a less greenish blue than the zinc, but with much smoke; amber, resin and common salt afford a yellow fire. Lycopodium burns with a rose color and a magnificent flame, &c.

2049. The Leading Fireworks. The leading simple fireworks are rockets, Roman candles, flowerpots or gerbs, mines, and their adaptations or varieties; quick fires of different kinds and colors in cases, such as golden rain, spur fire, &c.; slow fires in cases and pots, as blue lights, Bengal lights, &c. These form the fundamental principles of all pyrotechnic display. The endless variety of their combinations in the shape of vertical and horizontal wheels and "set pieces," requires considerable fertility of invention and mechanical ingenuity, combined with a thorough practical knowledge of the nature of firework compositions, and the appropriate means of displaying them to the best advantage. The weights used in the following receipts are avoirdupois.

2050. To Make Plain Rockets. The cases are made of stout cartridge paper, rolled on a rod whose thickness is equal to the desired diameter of the bore. The rod is slightly tapering, to allow of its easier withdrawal after the case is rolled and pasted. The narrower end of the case is choked; that is, a neck is made in it, similar to the neck of a phial. (*See No.* 2053.) The composition (*see No.* 2054) is next rammed tightly into the case (*see No.* 2052), which is supported by a closely fitting mould during this operation, finishing with a small charge of gunpowder to explode when the rocket goes out. The top of the case is then stopped with clay and a conical cap fastened on, to decrease the resistance of the air in its upward flight; and the bottom or choked end of the case is furnished with priming and touch-paper. The whole is secured to the end of a willow stick, to direct its course through the air.

2051. To Make Display Rockets. Rockets whose discharge ends in display, are furnished with an extra case, called the pot, about ¼ the length of the rocket; its inside diameter is the same as the outside diameter of the rocket case, over which it is glued firmly, and takes the place of the conical cap. The *garniture*, consisting of stars, serpents, &c., as the case may be (*see No.* 2055), is inserted in the pot and connected with the charge in the rocket case by a quick match. (*See No.* 2060.) The whole is finished with the clay and cap, the same as the head of a simple rocket.

2052. To Charge Rocket Cases. In charging rocket cases, in order to increase the rapidity of its discharge a wire is sometimes inserted through the centre of the charge, the rammer being constructed with a small bore through its length, to receive this wire when ramming the charge. This wire is withdrawn when the charge is complete, and the space it has left is filled with a quick match (*see No.* 2060), which thus sets fire to the entire charge at once. This central space is called the soul of the rocket, and the adoption of this arrangement is necessary for large rockets, especially those having heavy pots.

2053. To Choke Firework Cases. A short cylindrical piece of wood, of the same diameter as the thin end of the rod used for rolling a case, is furnished with a wire, the thickness of which must be the same as the desired bore of the choke. The end of the

rod has a hole bored in it to receive this wire loosely. A is the rod on which the case is to be rolled; C the cap of the same diameter as the end of the rod, having the wire inserted firmly in its axis. The rod is bored, as the dotted lines at B denote, to receive the wire. The outside dotted lines indicate a case on the rod, choked at N. This is effected by stretching a piece of strong cord, a single turn of which is passed round the case at N, compressing it firmly and leaving a bore of the same size as the wire between the rod and the cap. In rolling a case to be choked, the paper should be used in pieces, each piece wide enough to make about 3 thicknesses when rolled over the rod, and the choking done after each piece is rolled. When finished, the rod is withdrawn from the mouth of the case, and the cap and wire from the other end.

2054. Composition for Rockets. For 2 ounce rockets:—Mix 54½ parts nitre (saltpetre), 18 parts sulphur, and 27½ of charcoal, all in fine powder. Sift through lawn. For 4 ounce rockets:—64 parts nitre, 16 parts sulphur, and 20 parts charcoal. For 8 ounce to 1 pound rockets:—62⅝ parts nitre, 15⅝ parts sulphur, and 21⅞ parts charcoal. For rockets ¾ inch in diameter:—16 parts nitre, 4 parts sulphur, and 7 parts charcoal. For rockets 1½ inches in diameter use 1 part more nitre, and for still larger rockets, another additional part nitre. By using 1 part less charcoal, and adding respectively 3, 4, and 5 parts fine steel filings, the above are converted into *brilliant fires;* or, by using coarse iron filings, and still less charcoal, they become *Chinese fire.*

2055. Chinese Fire for Sky Rockets. If ¾ inch or under, nitre, 16 parts; charcoal, 4 parts; sulphur, 8 parts; cast-iron borings, 4 parts. Mix. Or: If over 1 inch and under 2 inches bore, nitre 16 parts; charcoal, 4 parts; sulphur, 4 parts; iron borings, 5 parts. Mix.

2056. Golden Rain. Mealed powder, 4 ounces; saltpetre, 1 pound; sulphur, 4 ounces; brass filings, 1 ounce; sawdust, 2½ ounces; glass powder, 6 drachms.

2057. Silver Rain. Mealed powder, 2 ounces; saltpetre, 4 ounces; sulphur, 1 ounce; steel dust, ¾ ounce.

2058. Trailed Stars for Rockets and Roman Candles. Saltpetre, 4 ounces; sulphur, 6 ounces; sulphate of antimony, 2 ounces; resin, 4 ounces. With sparks. Mealed powder, 1 ounce; saltpetre, 1 ounce; camphor, 2 ounces. Other receipts for stars suitable for rocket garniture will be found under the head of "Colored Fires." (*See No.* 2065, *&c.*)

2059. To Prepare Touch Paper. Soak unglazed paper in a solution of nitre in vinegar or water. The stronger the solution, the faster will it burn. A good plan is to dip it in a weak solution, dry it, try it, and if it burns too slowly, make the solution stronger and dip it again to make it burn faster.

2060. To Make Quick Match. Quick match is made by immersing lamp-wick in a solution of saltpetre with meal powder, winding it on a frame, and afterwards dusting with meal powder. To 28 ounces cotton, take saltpetre, 1 pound; alcohol, 2 quarts; water, 3 quarts; solution of isinglass (1 ounce to the pint), 3 gallons; mealed powder, 10 pounds.

2061. Inextinguishable Match. Take 4 parts dry nitre, 2 gunpowder, 2 charcoal, and 1 sulphur, and mix them; then ram the compound into paper cases 9 inches in length and of the thickness of a common quill. When this composition is inflamed, rain will not extinguish it; the burning end of the match must be cut off to stay the fire.

2062. To Make Roman Candles. The cases for Roman candles are not choked, but well secured at the bottom with clay. A small charge of gunpowder is first introduced, then a star, followed by a charge of composition (*see No.* 2063); these are gently rammed down, and the same routine of gunpowder, star, and composition, is repeated until the case is full. Lastly, prime and close with touch paper. The stars are flat cylinders of a paste composition, cut to fit the bore of the case, and having a hole bored in their centre to allow the fire to pass through to the charge behind them. The stars which are nearest to the mouth of the case should fit a little tightly, and gradually a little more loosely as they are further from the mouth. The charges of powder behind them should also decrease by degrees as their position is further from the mouth of the case. It is also advisable to put a loose wad of one thickness of paper, with a hole in the centre, between each star and the gunpowder behind it.

2063. Composition for Roman Candles. Mix ½ pound meal-powder, 2½ pounds saltpetre, and ½ pound each sulphur and glass dust.

2064. Colored Stars may be made by using any of the receipts for colored fires, with a solution of isinglass, ½ ounce; camphor, ½ ounce; and alcohol, ¾ ounce. Make into cylindrical cakes of the requisite size, punch a hole in the centre of each, roll in gunpowder, and dry in the sun.

2065. Colored Fires. Great care is necessary in the preparation of these combustibles. The ingredients should be *separately* reduced to powder and sifted; then put into well-corked, wide-mouthed bottles until the time for mixing them for use. Colored fires deteriorate rapidly by keeping, and are nearly all dangerously inflammable; they should, therefore, be mixed as soon as possible - before using them. The ingredients should be pure and perfectly dry; uniformly powdered, but not so fine as to be dusty. Nitrate of strontia, alum, carbonate of soda, and other crystals, should be gently heated in an iron pan until they lose their water of crystallization and crumble into dry powder. (*See Drying, No.* 3842.) Chlorate of potassa must be *very cautiously* handled, as it explodes by moderate friction. The requisite quantity of each ingredient should be weighed and placed on a clean sheet of white paper, and mixed lightly with a bone knife; they may then be more thoroughly mixed by sifting through a fine wire seive.

2066. Colored Fires for Illuminations. **Pack the compounds lightly into small cups or pans.**

2067. Colored Fires for Stars, &c. **The compounds may be put into small pill-boxes, with a little priming and a quick match (*see No.* 2060) attached to each. If kept, they should be put where no damage can happen in case of their catching fire.**

2068. To Make Colored Fires. The following receipts for the preparation of these effective aids in pyrotechnic and dramatic display, are among the very best that are known. These fires have in some theatres been assisted, if not superseded, by the calcium light; color being communicated by passing the rays of light through colored glass. The unpleasant smell of colored fires is avoided, and the effects can be prolonged at pleasure, instead of lasting merely a few moments.

2069. Blue Fire. Mix 2 parts realgar (red arsenic), 3 parts charcoal, 5 parts chlorate of potassa, 13 parts sulphur, and 77 parts nitrate of baryta.

2070. Bird's Blue Fire. 1 part charcoal, 1 part orpiment (yellow sulphuret of arsenic), 16 parts black sulphuret of antimony, 48 parts nitre, and 64 parts sulphur.

2071. Bengal, or Blue Signal Light, used at Sea. 1 part tersulphide of antimony, 2 parts sulphur, and 6 parts dry nitre. (*See No.* 2065.)

2072. Bengal Lights. Braunschweizer recommends the following mixtures as not producing injurious fumes: For red lights: 9 parts nitrate of strontia, 3 parts shellac, 1½ parts chlorate of potassa. For green: 9 parts nitrate of baryta, 3 parts of shellac, 1½ parts chlorate of potassa. For blue: 8 parts ammoniacal sulphate of copper, 6 parts chlorate of potassa, 1 part of shellac.

2073. Blue Fire for Stage Effect. 15 parts of sulphur, 15 parts sulphate of potassa, 15 parts ammonio-sulphate of copper, 27 parts nitre, and 28 parts chlorate of potassa. The blue is made darker or lighter by increasing or diminishing the potassa and copper ingredients. This is Marchand's preparation.

2074. Marsh's Blue Fire. Mix 7 parts sulphate of copper, 24 sulphur, and 69 parts chlorate of potassa.

2075. Marsh's Crimson Fire for Pots. Mix 17 parts chlorate of potassa, 23 willow charcoal, 90 parts sulphur, and 270 parts nitrate of strontia.

2076. Marsh's Crimson Fire for Stars and Boxes. Mix 17 parts charcoal, 22 parts sulphuret of antimony, 69 chlorate of potassa, 72 parts sulphur, and 220 parts nitrate of strontia.

2077. Marchand's Purple Crimson Fire. Mix 16 parts sulphur, 23 parts dry chalk, 61 parts chlorate of potassa.

2078. Green Fire for Ghost Scenes. Equal parts charcoal and nitrate of baryta.

2079. Brilliant Green Fire. A magnificent green fire can be prepared by mixing 8 parts chlorate of thallium, 2 parts calomel, and 1 part resin.

2080. Green Fire. Take 2 parts metallic arsenic, 3 parts charcoal, 5 parts chlorate of potassa, 13 parts sulphur, 77 parts nitrate of baryta. This is a beautiful fire, particularly when burnt before a reflector of glass or metal.

2081. Marchand's Green Fire. Mix 10 parts boracic acid, 17 sulphur, and 73 parts chlorate of potassa.

2082. Green Fire for Theatrical Tableaux. Take 18 parts chlorate of potassa, 22 parts sulphur, 60 parts nitrate of baryta.

2083. Light Green Fire. Mix 16 parts sulphur, 24 carbonate of baryta, 60 parts chlorate of potassa.

2084. Green Fire for Pots or Stars. Take 7 parts charcoal, 7 sulphuret of arsenic, 42 parts sulphur, 93 parts chlorate of potassa, 250 parts nitrate of baryta.

2085. Lilac Fire for Pans. Take 6 parts black oxide of copper, 20 dry chalk, 25 parts sulphur, 49 parts chlorate of potassa.

2086. Lilac Fire for Stars. Take 3 parts black oxide of copper, 22 parts dried chalk, 25 parts sulphur, 50 chlorate of potassa.

2087. Red Fire. Mix 16 parts sulphur, 23 parts carbonate of strontia, 61 parts chlorate of potassa.

2088. Red Fire for Stage Effect. Mix 20 parts chlorate of potassa, 24 sulphur, 56 parts nitrate of strontia.

2089. Orange Red Fire. Take 14 parts sulphur, 34 chalk, 52 parts chlorate of potassa.

2090. Purple Red Fire. Sulphur, 16 parts, 23 parts chalk, 61 parts chlorate of potassa.

2091. Purple Fire. Take 1 part each of lampblack, red arsenic, and nitre; 2 parts sulphur, 5 parts chlorate of potassa, and 16 parts fused nitrate of strontia.

2092. Pink Fire for the Stage. Mix 1 part charcoal, 20 chalk, 20 parts sulphur, 27 parts chlorate of potassa, 32 parts nitre.

2093. Rose Colored Fire. Take 16 parts sulphur, 23 dried chloride of calcium, 61 parts chlorate of potassa.

2094. Pale Violet Fire. Take 14 parts sulphur, 16 parts alum, 16 carbonate of potassa, 54 parts chlorate of potassa.

2095. Dark Violet Fire. Take 12 parts alum, 12 parts carbonate of potassa, 16 parts sulphur, 60 parts chlorate of potassa.

2096. White Fire for Theatres. Take 2 parts charcoal, 22 sulphur, 76 parts nitre.

2097. White Fire for Pans or Stars. Take 60 parts nitre, 20 parts sulphur, 10 black antimony, 4 parts powdered camphor, 6 parts meal powder.

2098. Marsh's White Fire for Pans. Take 25 parts gunpowder, 36 zinc filings, 46 parts sulphur, 93 parts nitre.

2099. Yellow Fire. Take 16 parts sulphur, 23 parts dried (*See No.* 2065) carbonate of soda, 61 chlorate of potassa.

2100. Marsh's Yellow Fire. Mix 12 parts charcoal, 149 parts dry (*see No.* 2065) nitrate of soda, 39 parts sulphur.

2101. Fire-eating Ghosts. Pour some strong warm spirits into a flat dish, sprinkle some salt into it, and set it on fire on a table in a perfectly dark room, taking care to protect the table from injury. Persons standing round the table will appear of a deathly pallor, and by eating raisins dipped in the burning spirit, will appear to eat fire. Shutting the mouth quickly on the burning raisins, extinguishes them instantly.

2102. Port Fire. The port fire used for cannon is composed of 3 parts nitre, 9 sulphur, and 1 gunpowder, well mixed and rammed into cases. These are also useful for igniting fireworks.

2103. Signal Lights. Such lights are generally composed of sulphur and nitre, with a small quantity of metallic sulphuret. Mix 600 grains nitre, 2 sulphur, and 100 yellow sulphuret of arsenic, and ram it into a conical paper case. When touched with a red-hot iron it deflagrates rapidly with a brilliant white light. The sulphuret of antimony may be substituted for that of arsenic.

2104. Indian White Fire Signal. Dry (*see No.* 2065) nitre, 24 parts; sulphur, 7 parts; powdered charcoal, 1; or instead of the charcoal, 2 parts red sulphuret of arsenic. Mix them intimately in an iron vessel, and ram the mixture into thick paper cylinders of about 3 inches in length by 1 in diameter. These are kept in a dry place, and when one is required to be used, it is set on end, and a piece of red-hot charcoal placed upon it.

2105. Iron Sand for Fireworks. Used to give corruscations in fireworks, is far better than iron or steel-filings. It is made by beating cast steel or iron into small pieces on an anvil. These are sifted into 4 sizes, the smallest for the smallest pieces, and vice versa. The corruscations produced by these are exceedingly brilliant. The sand should be kept in a dry place in a well-closed bottle, as any rust damages it. Fireworks containing it should not be made very long before using.

2106. Open Fires. The following article and receipts for open fires are by Professor Ferrum, and we quote them from the "American Druggists' Circular":

Among the many receipts for open fires, but few deserve to be recommended, and these have been selected. The white and red fires only show a clear, distinct color. The green is generally pale, and shows off only when burnt after a red. A pure blue is very difficult to obtain. The following should be observed as general rules: The ingredients for the fires are dried singly at a slightly elevated temperature, finely powdered, and preserved in well-stoppered bottles, until required for use The mixing of the ingredients is best performed on a sheet of paper by means of a card, and should be done very carefully so as to ensure a complete mixture. Sifting is in most cases admissible, while triturating in a mortar is above all to be avoided. After mixing, the powder is piled in small heaps in open vessels, for which purpose small flower-pots or flower-pot dishes are well adapted. On top of these several piles, some gunpowder is placed to facilitate the lighting. The vessels should be arranged in such a manner that the flame may illuminate the intended object without being seen by the spectators. The distribution of the material into a greater or less number of dishes is governed by circumstances. A great number of small flames from a certain quantity of mixture generally give a more intense, but so much shorter-lived light than the same quantity distributed in larger portions; beyond a certain limit, however, even that intensity is not materially heightened by a few more lights. If the fire is to continue for some time, it must further be considered that large quantities of the mixture form a correspondingly greater amount of slags, which greatly mar the effect. It is therefore, best in such cases to burn off a number of small charges successively.

2107. White Fire. The following mixture we recommend as the very best for white lights, being unsurpassed in brilliancy and power by any other:

Saltpetre, 18 parts; sulphur, 10 parts; black sulphuret of antimony, 3 parts; burnt lime, 4 parts. The sulphur is used in the form of flowers previously dried; the lime is not to be slacked, but must be finely powdered; it must be fresh, and be powdered immediately before use. All other mixtures for white fires have either a bluish tinge or contain deleterious ingredients, which render them at least unsuitable for indoor use. Of the latter class we will mention only one: Saltpetre, 12 parts; sulphur, 4 parts; sulphite of tin, 1 part. Two other mixtures deserve mention, though not equal to the last:

I. Saltpetre, 48 parts; sulphur, 13¼ parts; sulphide of sodium, 7¼ parts; and

II. Saltpetre, 64 parts; sulphur, 21 parts: gunpowder, 15 parts.

2108. Blue Fire. The only mixture to be relied on, though the light is not purely blue, but bluish white, is the following: Saltpetre, 12 parts; sulphur, 4 parts; black sulphuret of antimony, 1 part.

2109. Red Fire. The following mixture is the best in use; its composition may be altered by various admixtures:

I. Nitrate of strontia, 13 parts; sulphur, 1 part; powder dust, 1 part. The latter ingredient is prepared from fine gunpowder, rubbed up carefully in a mortar and then sifted through a hair sieve. Another receipt is:

II. Nitrate of strontia, 24 parts; chlorate of potassa, 16 parts; stearine, 4 parts; powdered charcoal, 1 part. In using chlorate of potassa the precautions given in No. 2124 must be strictly observed, and all pounding and rubbing avoided.

III. Nitrate of strontia, 20 parts; chlorate of potassa, 4 parts; sulphur, 5 parts; black sulphuret of antimony, 2 parts; powdered charcoal, 1 part. Gives a very strong light.

The nitrate of strontia for these fires, as the ingredients for all others, must be well, but carefully dried. *(See No. 2065.)*

2110. Yellow Fire. This color, which is very little used, is produced by the following mixture: Nitrate of soda, 48 parts; sulphur, 16 parts; black sulphuret of antimony, 4 parts; powdered charcoal, 1 part.

2111. Green Fires. The coloring ingredients for these lights are the salts of baryta. The color is generally not very deep.

I. Nitrate of baryta, 45 parts; sulphur, 10 parts; chlorate of potassa, 20 parts; calomel, 2 parts; lampblack, 1 part.

II. Nitrate of baryta, 60 parts; chlorate of potassa, 18 parts; sulphur, 22 parts.

III. Chlorate of baryta, 3 parts; sulphur, 1 part.

IV. Chlorate of baryta, 24 parts; stearin, 3 parts; sugar of milk, 1 part.

V. Chlorate of baryta, 3 parts; sugar of milk, 1 part.

2112. Colored Lights. We derive the receipts for these from the same source as the open fires. (*See No.* 2106.) Colored lights are formed by filling cylinders of thin writing paper of about an inch in diameter with the mixtures. The length of the cylinder determines the duration of the light. The mixtures may be moistened and pounded into the cylinder with a wooden rod; after drying, they will then be hard enough to allow of the removal of the paper, and may be further strengthened by being dipped in or painted over with mucilage of gum-arabic. The cylinders, when finished, are tied to the upper end of sticks fastened in the ground in a vertical position. The mixtures vary essentially from those used for colored fires.

2113. White Lights. Saltpetre, 4 parts; sulphur, 1 part; black sulphuret of antimony, 1 part.

2114. Yellow Lights. I. Black sulphuret of antimony, 2 parts; chlorate of potassa, 4 parts; sulphur, 2 parts; oxalate of soda, 1 part.

II. Saltpetre, 140 parts; sulphur, 45 parts; oxalate of soda, 30 parts; lampblack, 1 part.

2115. Green Lights. I. Chlorate of baryta, 2 parts; nitrate of baryta, 3 parts; sulphur, 1 part.

II. Chlorate of potassa, 20 parts; nitrate of baryta, 21 parts; sulphur, 11 parts.

2116. Red Lights. Nitrate of strontia, 25 parts; chlorate of potassa. 15 parts; sulphur, 13 parts; black sulphuret of antimony, 4 parts; mastich, 1 part.

2117. Pink Lights. Chlorate of potassa, 12 parts; saltpetre, 5 parts; sugar of milk, 4 parts; lycopodium, 1 part; oxalate of strontia, 1 part.

2118. Blue Lights. Chlorate of potassa, 3 parts; sulphur, 1 part; ammoniated copper, 1 part.

2119. Colored Lights without Sulphur—For Indoor Illuminations. These are used for the purpose of lighting up tableaux vivants, and for private theatricals.

2120. White Light. Chlorate of potassa, 12 parts; saltpetre, 4 parts; sugar of milk, 4 parts; lycopodium, 1 part; carbonate of baryta, 1 part.

2121. Yellow Light. Chlorate of potassa, 6 parts (or nitrate of baryta 10 parts); saltpetre, 6 parts; oxalate of soda, 5 parts; powdered shellac, 3 parts.

2122. Green Light. Only after yellow or red lights. Chlorate of potassa, 2 parts; nitrate of baryta, 1 part; sugar of milk, 1 part.

2123. Red Light. Nitrate of strontia, 12 parts; chlorate of potassa, 8 parts; sugar of milk, 1 part; stearine, 2 parts.

2124. Caution in the Use of Chlorate of Potassa. This substance should never be kept in admixture with any inflammable matter, especially sulphur or phosphorus, as they explode with terrific violence by the most trivial causes, and not unfrequently spontaneously. All pounding and rubbing must be avoided.

2125. Paper for Producing Flashes of Colored Light. Soak unsized paper for ten minutes in a mixture of 4 parts, by measure, oil of vitriol, and 5 parts strong fuming nitric acid; wash out thoroughly in warm distilled water, and dry it thoroughly at a gentle heat. The paper thus prepared is similar in its properties to gun cotton, and a small pellet of it, lighted at one point at a flame, and then thrown into the air, will produce a brilliant flash, and leave no perceptible ash. The color is given by saturating the gun-paper in the one of the solutions given below and then drying it.

A solution of chlorate of strontium makes the flash a bright crimson. Chlorate of barium, green. Nitrate of potassium, violet. Chlorate of copper, blue. Any one of the foregoing chlorates may be prepared by mixing a warm solution of the corresponding chloride with an equivalent quantity of a warm solution of chlorate of potassa; the precipitate formed will be chloride of potassium, and the clear liquid, poured off, will be the desired chlorate, to be used for saturating the gun-paper.

2126. Japanese Matches. Lampblack, 5 parts; sulphur, 11 parts; gunpowder, from 26 to 30 parts, this last proportion varying with the quality of the powder. Grind very fine, and make the material into a paste with alcohol; form it into dice, with a knife or spatula, about ¼ inch square; let them dry rather gradually on a warm mantel-piece, not too near a fire. When dry, fix one of the little squares in a small cleft made at the end of a stalk of broom-corn. Light the material at a candle, hold the stem downward, and await the result. After the first blazing off, a ball of molten lava will form, from which the curious corruscations will soon appear.

2127. Japanese Firework Mixture. Finely pulverized nitrate of potassa, 70 parts; washed flowers of sulphur, 30 parts; powdered lycopodium, 12 parts; best and very light lampblack, 8 parts. From 1½ to 2 grains of this powder are sufficient for use packed in strips of suitable paper.

2128. Colored Flames. The flame of alcohol may be colored by mixing certain salts with the spirit. A green color is given by muriate of copper, or boracic acid. Red, by nitrate of strontian, nitrate of iron, or nitrate of lime. Yellow, by nitrate of soda, &c.

2129. Greek Fire. True Greek fire is simply a solid, highly combustible composition, consisting of sulphur and phosphorus dissolved in the bisulphide of carbon, to which occasionally some mineral oil is added, with the view of increasing its incendiary powers. When the liquid is thrown on any surface exposed to the air the solvent evaporates, leaving a film of the phosphorus or sulphide of phosphorus, which then inflames spontaneously. The proper mode of extinguishing such a fire is to throw damp sand, ashes, sawdust, lime, or any powder, wet sacking or carpeting, in short, any material which will exclude the air from the fire. No attempt should be made to remove the covering for some time after the flame has been extinguished. The place should afterward be thoroughly washed by a powerful jet of water forced upon it.

Explosives. This is a general term for all substances which explode with violence. Some of these, as gunpowder, gun-cotton, &c., explode by being brought into contact with fire. Others, to which the term of *Fulminates* is applied, explode with violence by slight heat, friction, or concussion.

2131. Fulminating Antimony. Grind well together 100 parts of dried tartar emetic, and 3 parts of lampblack, or charcoal powder; then take a crucible capable of holding 3 ounces of water, and having ground its edge smooth, and rubbed the inside with powdered charcoal, ¾ fill it with the above mixture, cover it with a layer of charcoal powder, and lute on the cover. Expose it for 3 hours to a strong heat in a reverberatory furnace, and, when taken out, let it stand to cool for 6 or 7 hours before removing its contents, to prevent an explosion. The crucible being now opened, the contents must be hastily transferred, without breaking, to a wide-mouthed stoppered phial, when, after some time, it will crumble down into a powder of itself. Or: Triturate together, very carefully, 100 parts antimony, 75 parts carburetted (roasted to blackness) cream of tartar, and 12 parts lampblack; preserve it in phials. When the above processes are properly conducted, the resulting powders fulminate violently on contact with water. It is to the presence of the very inflammable metal potassium that they owe this property. Another compound, made with 60 parts of carburetted cream of tartar, 120 bismuth, and 1 of nitre, treated as above, contains an alloy very rich in potassium. A piece the size of a pea introduced into a mass of gunpowder explodes it on being thrown into water.

2132. Fulminating Gold. Dissolve gold in aqua regia (made by dissolving 4 ounces sal ammoniac in 12 or 16 ounces nitric acid), and precipitate with a solution of carbonate of potassa. Fulminating gold should be made in very small quantities at a time, to avoid risk, as without great care it explodes with extreme violence. This is caused by the slightest friction or sudden increase of heat. Its fulminating property may be destroyed by boiling it in pearlash lye, or oil of vitriol; and by heating the powder after washing it in water, pure gold will be obtained.

2133. Fulminating Silver. Digest oxide of silver (recently precipitated, and dried by pressure between bibulous paper) in concentrated liquor of ammonia for 12 or 15 hours, pour off the liquid, and cautiously dry the black powder in the air. The decanted ammonia, when gently heated, yields, on cooling, small crystals, which possess a still more formidable power of detonation, and will scarcely bear touching, even while under the liquid. This compound is exploded by the slightest friction or percussion, and should therefore be only made in very small quantities at a time, and handled with great caution. Its explosive powers are tremendous; in fact, it can hardly be handled with safety, even in the moist state. Many frightful accidents have happened from the spontaneous explosion of this substance. At most 1 or 2 grains can be exploded with safety at one time.

2134. Fulminating Mercury. Dissolve by a gentle heat 100 parts, by weight, of mercury in 100 parts nitric acid of specific gravity 1.4; and when the solution has acquired a temperature of 130° Fahr., slowly pour it through a glass funnel tube into 830 parts alcohol of specific gravity .830. As soon as the effervescence is over and white fumes cease to rise, filter it through double paper, wash with cold water, and dry by steam (not hotter than 212°) or hot water. This is the formula of Dr. Ure, and said to be the cheapest and safest. If parts by measure be adopted, the above proportions will be, for 100 parts, by measure, of mercury, 740 parts nitric acid, and 830 parts alcohol.

2135. Fulminating Copper. Digest copper, in powder or filings, with fulminate of mercury or of silver, and a little water. It forms soluble green crystals that explode with a green flame.

2136. Fulminating Powder. Powder *separately* 3 parts nitre, 2 parts dry (*see No.* 2065) carbonate of potash, and 1 flowers of sulphur; mix them together carefully. If 20 grains of this compound are slowly heated on a shovel over the fire, it melts and becomes brown, exploding with a loud report.

2137. New Explosive Compound. B. G. Amend has observed that glycerine mixed with crystallized permanganate of potassa in a mortar spontaneously deflagrates.

2138. Priming for Percussion Caps. To make this compound 100 grains of fulminating mercury are triturated with a wooden muller on marble, with 30 grains of water and 60 grains of gunpowder. This is sufficient for 400 caps. Dr. Ure recommends a solution of gum mastich in turpentine as a medium for attaching the fulminate to the cap.

2139. Percussion Pellets. Mix equal parts of the chlorate of potassa and sulphuret of antimony with liquid gum, so as to form a paste. When dry it may be formed into pellets, and used as percussion powder for guns. This composition, placed on the ends of splints dipped in sulphur, produces friction matches. This mixture may also be employed for percussion caps, only without the gum; the two substances, mixed together dry, are forced into the caps, and a drop of varnish deposited on the inside surface of each. A mixture of the fulminate of mercury, chlorate of potassa, and sulphur, however, is more commonly used for lining percussion caps.

2140. To Make Gunpowder. Pulverize separately, 76 parts nitrate of potassa, 11 sulphur, and 13 freshly burned charcoal, and mix them with a little water, so as to form a cake when rolled out on a board. This is then dried on a clean sheet of paper placed in a warm situation, and afterwards crumbled into grains. It will form unglazed gunpowder. The pulverized ingredients, thoroughly mixed, without the addition of any water, constitute what is called *meal powder;* this may also be made by pulverizing grained gunpowder very cautiously in a mortar, or with a muller. (*See Porphyrization, No.* 25.)

2141. To Prepare Gun-Cotton. The simplest way consists in immersing, for a few seconds, well-carded cotton in a mixture of equal parts, by volume, of oil of vitriol of specific gravity 1.845, and nitric acid of specific gravity of 1.500. The cotton, when well saturated, is to be removed and squeezed to repel the excess of acid, and then well washed in clean cold water, until the water no longer reddens litmus paper. It is then dried at a heat not exceeding 212°. A lower temperature is still safer. The cotton thus prepared explodes well, but does not dissolve easily in ether. Under *Collodion* will be found other preparations of Gun-Cotton.

2142. Nitro-glycerine. This is an oily, colorless liquid, with a specific gravity of 1.60. It has no smell, but a taste which at first is sweet, but soon becomes pungent, like pepper; is soluble in ether and methylic alcohol, but not in water, but the presence of water diminishes the risk of explosion. It begins to evaporate at 365° Fahr. It has been found that pure nitro-glycerine, dropped upon a thoroughly red hot iron, assumes a spheroidal state and flashes off into vapor in the same way as gunpowder; but if the iron is not red hot, only hot enough to cause the nitro-glycerine to boil suddenly, a frightful explosion takes place. The explosion of a single drop in this manner will cause serious damage. This dangerous compound requires most careful handling, a slight shock sometimes exploding it.

2143. To Prepare Nitro-glycerine. Mix 100 parts fuming nitric acid at 50° Baumé with 200 parts sulphuric acid; when cool, add 38 parts glycerine slowly, allowing it to trickle down the sides of the vessel. The glycerine will remain on the surface for hours without mixing. Stir the glycerine and acids with a glass rod for 10 seconds, pour it into 20 times its volume of water, and the nitro-glycerine will be instantly precipitated to the extent of 76 parts, or double the amount of glycerine employed. It must be repeatedly washed with water, and then saturated with bicarbonate of soda or lime.

2144. Blasting Powders. Neither fresh nor salt water has any injurious effect on blasting powders; they need only to be dried to regain their explosive character. Their emitting but little smoke renders them useful in underground operations, and their explosive force is eight times that of gunpowder. They explode with extreme facility, either by contact with a strong acid, a slight elevation of temperature, or the slightest friction. In preparing them, therefore, excessive precaution is necessary, especially in mixing the ingredients. A straw, slightly wetted with oil of vitriol, applied to a small heap of the powder, will cause instantaneous explosion.

2145. To Make Blasting Powder. Reduce *separately* to powder, 2 parts chlorate of potassa and 1 part red sulphuret of arsenic; mix very lightly together. Or:—Powder separately, 5 parts chlorate of potassa, 2 parts red sulphuret of arsenic, and 1 part ferrocyanide of potassium (prussiate of potassa); mix carefully. Or:—Mix carefully, as before, after having separately reduced to powder, equal parts chlorate of potassa and ferrocyanide of potassium.

2146. Parlor or Congreve Matches. Dissolve 16 parts gum-arabic in the least possible quantity of water, and mix with it 9 parts phosphorus in powder (*see No.* 4338); then add 14 parts nitre (saltpetre), and 16 parts of either vermilion (red sulphuret of mercury), or binoxide (black oxide) of manganese, and form the whole into a paste. Dip the matches into this paste, and then let them dry. When quite dry they are to be dipped into a very dilute copal or lac varnish, and again dried; by this means they are less likely to suffer from damp weather.

2147. Cheap Parlor Matches. A cheaper paste for dipping may be made by soaking 6 parts glue for 24 hours in a little water, and liquefied by rubbing in a heated mortar; 4 parts phosphorus are next added at a heat not exceeding 150° Fahr.; then add 10 parts finely powdered saltpetre; and lastly 5 parts red lead and 2 parts smalts are mixed in, the whole being formed into a uniform paste. The matches are dipped, dried, varnished, and dried again, as before.

2148. To Make Matches Without Sulphur. To obviate the use of sulphur for igniting the wood of the match, the ends of the matches are first slightly charred by rubbing them against a red hot iron plate, and then dipped into as much white wax, melted in a suitable vessel, as will cover the bottom about ⅛ inch in depth. Or they may be dipped into camphorated spirit. Or into a solution of 1 ounce Venice turpentine and ¼ ounce camphor, in ¼ pint oil of turpentine, with a little gum-benzoin and cascarilla by way of perfume. After any of the above preparations the matches are ready for dipping in the phosphorus paste.

2149. Substitute for Lucifer Matches. The dangers arising from the universal adoption of the common lucifer match have induced chemists to seek a substitute for it. M. Peltzer has recently proposed a compound which is obtained in the shape of a violet powder, by mixing together equal volumes of solutions of sulphate of copper, one of which is supersaturated with ammonia, and the other with hyposulphite of soda. A mixture of chlorate of potash and the above powder will catch fire by percussion or rubbing; it burns like gunpowder, and leaves a black residue. M. Viederbold proposes a mixture of hyposulphite of lead, or baryta, or chlorate of potash, for matches without phosphorus. The only inconvenience of this compound is that it attracts moisture too easily.

2150. Mixtures for Matches. For sulphur dips: Phosphorus, 3 parts; glue, 6 parts; sand, 1 part; incorporated below 100° Fahr., with 10 parts of water. Or, phosphorus, 5 parts; fine sand, 4 parts; red ochre, 1 part (or, ultramarine), ½ part; gum-arabic, 5 parts, in 6 pints of water (or, 4 parts of glue in 9 parts of water). For stearine dips: Phosphorus, 3 parts; brown oxide of lead, 2 parts; turpentine, ½ part, softened in 3 parts water. Instead of the brown oxide, 2 parts of red lead stirred up with ½ part of nitric acid may be used.

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FIREWORKS.

Bengal Lights. Besides the combustible and coloring components, the fireworks known under this name contain substances which, by yielding oxygen, aid combustion. The principal ingredients used for this purpose are charcoal, lampblack, sulphur, stearine, linseed oil, colophony, sugar, etc. For coloring the lights the following substances are made use of: Sulphide of antimony, arsenical sulphides, nitrate of barium, nitrate of strontium, sulphate of potassium, carbonate of sodium, cupric oxide, boracic acid, chlorate of potassium, saltpetre, etc. In preparing colored lights the greatest attention should be paid to the absolute purity of the ingredients used, and that they are powdered as finely as possible and very intimately mixed with a spatula after pulverization. Every mixture containing chlorate of potassium must be treated and handled with the utmost care and caution, as such mixtures are liable to spontaneous ignition and even to explosion. For preparing a very fine powder of it, it is best to allow a supersaturated hot solution of chlorate of potassium to become cold, with constant stirring, when the salt will be separated in the form of a very fine crystallized flour, which should be dried without exposing it to direct heat. To secure uniformity the ready mixtures should be sifted. It is advisable to use dry materials only in manufacturing them, not to prepare large quantities at one time, and to store the mixtures in a dry place in hermetically closed vessels.

Colored lights are best used by pressing the mixture into cases (cartridges) of paper twice as long as wide and igniting it by means of a quick match.

Quick Matches are made of 4 parts of saltpetre, 2 of gunpowder, 2 of charcoal, and 1 of sulphur. Quick matches made of this composition never miss fire and are not extinguished by rain or wind.

White Fire. This excellent light, on account of its brilliant whiteness, is especially adapted for night signalling and also for festive occasions. It is produced by mixing 24 parts of saltpetre, 7 of flowers of sulphur, and 2 of realgar.

In mixing the saltpetre with the flowers of sulphur sulphurous vapors are developed which form moist lumps in the mass. To secure a good ignition and quick combustion of the mass it is necessary to dry it thoroughly in an iron pan with gentle heat, as, if this precaution is neglected, it frequently misses fire or ignites and then goes out. The mixture is cheaper than gunpowder, as less labor is required in preparing it and very little danger incurred.

Mohr's White Fire, which is very effective and scarcely ever misses fire, is composed of 24 parts of saltpetre, 7 of sulphur, and 1 of fine charcoal. The charcoal increases the inflammability of the mixture and shortens the length of time during which the light burns, but adds to its intensity. It is not permissible to use a larger amount of charcoal than that given, as the composition would then approach that of gunpowder.

White Fire for Theatres, etc. I. Forty-eight parts of saltpetre, 13.25 of sulphur, 7.25 of sulphide of antimony.

II. Twelve parts of saltpetre, 4 of sulphur, 1 of sulphide of sodium.

III. Sixteen parts of saltpetre, 12 of mealed powder, 12 of cast-iron filings, 8 of powdered charcoal.

IV. One part of charcoal, 3 of sulphur, 7 of saltpetre, 1 of chlorate of potassium, 4 of sulphide of antimony.

V. Thirty-two parts of saltpetre, 12 of sulphur, 8 of sulphide of sodium, 1 of gunpowder.

VI. One hundred to 133 parts of pulverized antimony, 48 to 206 of pulverized sulphur, 375 to 500 of saltpetre.

VII. Sixty-four parts of pulverized saltpetre, 21 of pulverized sulphur, 15 of gunpowder.

VIII. One hundred parts of potassium carbonate, 10 of sulphide of antimony, 15 of boiled linseed oil.

IX. Eleven parts of chlorate of potassium, 4 of nitrate of potassium, 1 of stearine, 1 of carbonate of barium, 5 of milk sugar.

X. Forty-five parts of sulphide of antimony, 15 of washed flowers of sulphur, 96 of saltpetre, 15 of stearine.

The stearine is either grated or cut in shavings and then rubbed with some pulverized saltpetre into as fine a powder as possible. The other powdered ingredients are then mixed with it and the mixture passed through a fine sieve.

XI. Eighteen parts of saltpetre, 3 of sulphide of antimony, 10 of sulphur, 4 of burned lime (unslaked).

Greenish-white Fire. I. Two parts of sulphur, 1 of oxide of zinc, 2 of sulphide of antimony, 1 of powdered charcoal.

II. Fifty parts of saltpetre, 25 of sulphur, 5 of sulphide of antimony, and 0.5 of alum.

Bluish-white Fire. *Uhden* has made experiments in regard to the availability of sulphide of cadmium for pyrotechnic purposes. In the following mixture the sulphide of cadmium burns with a brilliant white flame surrounded with a magnificent blue border: Mix 20 parts of saltpetre, 4 of sulphide of cadmium, 5 of sulphur, and 1 of pulverized charcoal. This mixture may be used for fire-balls.

Red Fire. I. Forty parts of nitrate of strontium, 15 of sulphur, 5 of chlorate of potassium, and 2 of charcoal.

II. Fifty parts of chlorate of potassium, 50 of nitrate of strontium, 5 of charcoal, and a sufficient quantity of linseed oil to knead the mass together.

Red Fire according to Braunschweiger. Nine parts of nitrate of strontium, 3 of shellac, 1.5 of chlorate of potassium. The shellac need only be coarsely powdered. The above 3 mixtures for red fire possess the advantage of not emitting injurious vapors, and can therefore be used in rooms, etc.

Holtz's Red Fire, which was so much used in Berlin during the festivities in celebration of the victories in the French war, contains no chlorate of potassium, but is simply composed of 1 part of shellac and 4 of nitrate of strontium. The absence of chlorate of potassium makes it possible to store such mixtures without any danger, though the light produced is less intense and brilliant in color. The mixture is not very inflammable, burns better if slightly moistened, develops but little smoke, and, as it burns very slowly, is without doubt the cheapest material for red lights. A very small addition of chlorate of potassium improves the color of the flame very much.

Receipts for other Red-fire Mixtures. I. Fifty-six parts of nitrate of strontium, 24 of sulphur, 20 of chlorate of potassium.

II. Twenty-three parts of carbonate of strontium, 16 of sulphur, 61 of chlorate of potassium.

III. Mix 40 parts of pulverized nitrate of strontium, 6 of pulverized chlorate of potassium, 13 of washed flowers of sulphur, and 2 of pulverized charcoal.

Instead of the rather expensive precipitated chalk, salts of strontia, carbonate of calcium, and the native sulphate of strontium (coelestine), may be used for preparing red fire according to the following receipts:

I. Mix carefully 3 parts of powdered coelestine, 2 of sulphur, and 5 of chlorate of potassium.

II. Three parts of precipitated chalk, 2 of sulphur, 6 to 8 of chlorate of potassium.

III. Twelve hundred and fifty parts of sulphate of strontium, 375 of purified sulphur, 166 of chlorate of potassium, and 133 of antimony.

IV. Seven hundred and fifty parts of carbonate of strontium, 500 of purified sulphur, 1750 of chlorate of potassium.

V. Rub fine and mix 195 parts of nitrate of strontium, 45 of chlorate of potassium, 45 of washed flowers of sulphur, 7.5 of powdered charcoal, and 22.5 of stearine.

VI. Eleven parts of chlorate of potassium, 4 of nitrate of potassium, 5 of milk sugar, 1 of earth-moss seed, 1 of oxalate of strontium.

Purple Fire. Powder and mix 61 parts of chlorate of potassium, 16 of sulphur, 23 of chalk.

Rose-red Light. I. Rub fine and mix 61 parts of chlorate of potassium, 16 of sulphur, 23 of chloride of potassium.

II. Pulverize and mix 20 parts of sulphur, 32 of saltpetre, 27 of chlorate of potassium, 20 of chalk, 1 of charcoal.

Red-orange Fire. Pulverize and mix 52 parts of chlorate of potassium, 14 of sulphur, 34 of chalk.

Dark-violet Fire. Rub fine and mix 60 parts of chlorate of potassium, 16 of sulphur, 12 of carbonate of potassium, and 12 of alum.

Pale-violet Fire. Rub fine and mix 54 parts of chlorate of potassium, 14 of sulphur, 16 of carbonate of potassium, and 16 of alum.

Blue Fire. I. Eighteen parts of chlorate of potassium, 24 of saltpetre, 14 of sulphur, 6 of cupric oxide.

II. Four parts of mealed gunpowder, 3 of sulphur, 3 of powdered zinc, 2 of saltpetre.

III. The following mixture gives a loudly detonating compound: Two parts of saltpetre, 1 of sulphur, 2 of carbonate of potassium, 6 of common salt.

IV. Mix 27 parts of pulverized saltpetre, 28 of triturated chlorate of potassium, 15 of pulverized sulphur, 15 of pulverized sulphate of potassium, and

15 of powdered cupro-ammonium sulphate.

The dark-blue color will gain intensity by adding potassium sulphate to the mixture.

V. Seventeen hundred and fifty parts of chlorate of potassium, 500 of sulphur, 575 of carbonate of copper, and 375 of burned alum.

VI. Twenty-one parts of chlorate of potassium, 23 of copper precipitated with chlorate of potassium, 12 of sulphate of copper, 12 of calomel, 4 of milk sugar, and 3 of stearine.

Dark-blue Fire. Mix 60 parts of chlorate of potassium, 16 of sulphur, 12 of carbonate of copper, and 12 of alum.

Pale-blue Fire. I. Mix 61 parts of powdered chlorate of potassium, 16 of pulverized sulphur, and 25 of strongly heated and pulverized alum.

II. Mix 61 parts of powdered saltpetre, 17½ of pulverized sulphur, 20 of powdered anhydrous soda, and 1½ of pulverized charcoal.

Blue Fire with a Bluish-green Flame. Rub fine and mix 12 parts of nitrate of barium, 5 of chlorate of potassium, and 4 of sulphur.

Green Fire. I. Rub fine and mix 433 parts of purified sulphur, 2250 of nitrate of barium, 166 of chlorate of potassium, 66 of arsenic, and 100 of charcoal.

II. Fifty parts of chlorate of potassium, 50 of nitrate of barium, 5 of charcoal, and a sufficient quantity of linseed oil to knead the mass.

Green Fire according to Braunschweiger. Three parts of shellac, 9 of nitrate of barium, 1½ of chlorate of potassium.

Other Receipts for Green Fire. I. Sixteen parts of nitrate of barium, 4 of sulphur, and 16 of chlorate of potassium.

II. Forty-five parts of nitrate of barium, 10 of sulphur, 20 of chlorate of potassium, 2 of calomel, 1 of lampblack.

III. Mix very carefully 12 parts of nitrate of barium dry as dust, 4 of sulphur, and 6 of chlorate of potassium.

IV. Powder and mix 6 parts of nitrate of barium, 1 of sulphur, 2 of chlorate of potassium, and ½ of charcoal.

Pale-green Fire. I. Rub fine and mix 60 parts of chlorate of potassium, 16 of sulphur, and 24 of carbonate of barium.

II. Sixty parts of nitrate of barium, 14 of washed flowers of sulphur, and 40 of chlorate of potassium.

III. Thirty-eight parts of nitrate of barium, 10 of chlorate of potassium, and 8 of charcoal.

IV. Six parts of nitrate of barium, 1 of sulphur, 2 of chlorate of potassium, and ½ of charcoal.

Dark-green Fire. One hundred and twenty parts of nitrate of potassium, 60 of washed flowers of sulphur, 45 of chlorate of potassium, 37½ of anhydrous carbonate of sodium, 2 of pulverized charcoal, and 22.5 of stearine.

Yellow Fire. I. Mix carefully 48 parts of sodium nitrate, 16 of sulphur, 4 of sulphide of antimony, and 1 of charcoal.

II. Rub as fine as possible and mix 20 parts of sodium nitrate, 3 of sulphur, and 1 of sodium sulphide.

III. Two thousand parts of chlorate of potassium, 500 of purified sulphur, and 750 of sodium carbonate.

IV. Fifteen hundred and sixty-six parts of saltpetre, 625 of sodium carbonate, and 400 of gunpowder.

V. Six parts of chlorate of potassium, 6 of potassium nitrate, 5 of sodium oxalate, and 3 of shellac.

VI. Sixty-one parts of chlorate of

potassium, 16 of sulphur, and 23 of anhydrous soda.

VII. One hundred and twenty parts of potassium nitrate, 30 of flowers of sulphur, 45 of chlorate of potassium, 37½ of anhydrous sodium carbonate, 2 of charcoal powder, 22½ of stearine.

VIII. Sixty-one parts of saltpetre, 17½ of sulphur, 20 of soda, and 1½ of charcoal.

Other Colored Fireworks.

White Stars. Mix 32 parts of pulverized saltpetre, 12 of pulverized sulphur, 8 of powdered sodium sulphide, and 1 of gunpowder.

Red Stars. Rub fine and mix 40 parts of nitrate of strontium, 10 of chlorate of potassium, 13 of sulphur, 2 of charcoal, 5 of sodium sulphide.

Green Stars. Thirty parts of chlorate of barium, 10 of flowers of sulphur, and 1 of mastic.

Blue Stars. Rub fine and mix 20 parts of chlorate of potassium, 11 of sulphur, 14 of cupric oxide, and 1 of mastic.

Bluish-green Stars. I. Rub fine and mix 24 parts of nitrate of barium, 56 of chlorate of potassium, 30 of sulphur, and 1 of mastic.

II. Twenty parts of nitrate of barium, 18 of chlorate of potassium, 10 of sulphur, 1 of mastic, and 3 of sodium sulphide.

Yellowish-green Stars. I. Rub fine and mix 60 parts of chloride of barium, 30 of nitrate of barium, 20 of sulphur, and 1 of mastic.

II. Twenty parts of chlorate of potassium, 5 of sulphur, 1 of mastic, and 1 of carbonate of barium.

Yellow Stars. Rub fine and mix 16 parts of sodium nitrate, 5 of sulphur, 2 of sodium sulphide, and 1 of charcoal.

White Candles. Powder and mix 4 parts of saltpetre, 1 of sulphur, and 1 of sodium sulphide.

Red Candles. Rub fine and mix 26 parts of nitrate of strontium, 15 of chlorate of potassium, 12 of flowers of sulphur, 2 of charcoal, 2 of sodium sulphide, and 1 of mastic.

Green Candles. Mix 20 parts of chlorate of barium, 30 of nitrate of barium, and 10 of sulphur.

Blue Candles. Rub fine and mix 18 parts of chlorate of potassium, 6 of saltpetre, 10 of sulphur, and 6 of cupric oxide.

Bluish-green Candles. Rub fine and mix 20 parts of chloride of barium, 30 to 42 of nitrate of barium, 40 of chlorate of potassium, 10 to 22 of sulphur and of sodium sulphide.

Yellow Candles. Rub fine and mix 80 parts of sodium nitrate, 7 of sulphur, 3 of sodium sulphide, and 2 of mastic.

Japanese Matches. One part of powdered charcoal, 1½ of sulphur, and 3¼ of saltpetre.

According to another receipt they consist of 5 parts of lampblack, 11 of sulphur, and 26 to 30 parts of gunpowder. The mixture is made into a paste with alcohol, formed into small dice, and dried. When dry one of the little squares is fixed into the cleft of a lavender stalk, lighted on a candle, and held stem downward. After the first blazing off, a ball of molten lava will form from which the curious and very beautiful corruscations will soon appear.

Prof. Böttger says about *Japanese matches:* The mixture consists either of 3 parts by weight of lampblack, 8 of flowers of sulphur, and 15 of saltpetre (dry as dust); or 2 parts by weight of finely sifted lime-wood charcoal, 4 of flowers of sulphur, and 7 of saltpetre (dry as dust). The mode of preparing the matches is as follows: Cut the finest commercial tissue paper into strips about 6¼ inches long, 1 inch wide on one end, and running into a point at the other. By rolling these small strips of paper tightly together, commencing at the pointed end, and filling the lower part with from 30 to 45 grains of one of the above mixtures, a close imitation of the genuine Japanese matches will be the result.

Fireworks for Use in Rooms, according to Perron. Mix 12 parts of saltpetre, 15 of flowers of sulphur, and 30 of gunpowder. Then dissolve 2 parts of camphor in 8 of spirit of wine, and 4 of gum Arabic in water. Knead the whole into a dough, and form small cornered pieces from it which are dried. When ignited they give a beautiful light.

Pharaoh's Serpents. This curious chemical toy is prepared as follows: Dissolve mercury, with the aid of heat, in dilute nitric acid, being careful that there shall always be an excess of mercury present. When the action of the acid has ceased, decant the solution, and pour into it a solution of sulpho-cyanide of potassium or ammonium, which may be procured at any druggist's. Use about equal quantities of the two solutions. A precipitate of sulpho-cyanide of mercury falls out, which should be filtered off, washed, and dried. Then take for every pound of this substance 1 ounce of gum tragacanth, which should be soaked in water. When the gum is completely softened it is transferred to a mortar, and the dried precipitate is gradually rubbed up with it into a homogeneous paste, with the addition of a little water. This mass is filled into moulds of conical or other shape, made of silvered paper, and dried. When these are ignited by the application of a match at the conical end they form an enormous volume of ash, which proceeds in great coils from the body of the mass, and which by its serpentine movements, as it is formed, has suggested the name. (W.)

Harmless Substitute for Pharaoh's Serpents. The above-named experiment, though curious and interesting, is not altogether free from danger, because poisonous mercurial fumes are evolved during the combustion of the mass. On this account several substitutes have been suggested. One of these, which is almost as good as the original, and is not poisonous, is prepared in the following manner:

Take

Bichromate of potassium	2 parts.
Saltpetre	1 part.
White sugar	3 parts.

Pulverize each of the ingredients separately, and then mix them thoroughly. Make small paper cones of the desired size, and press the mixture into them. When quite dry they are ready for use. They should be kept away from moisture and light. (W.)

Blasting Compounds, Blasting Powder, Dynamite, Gun-Cotton, Gunpowder, Nitro-glycerine, Fulminates, Etc.

Among the blasting compounds nitro-glycerine and the explosive substances, dynamite, etc., derived from it, occupy the foremost place.

Nitro-glycerine is obtained in the following manner: Fuming nitric acid of 49° to 50° Beaumé is mixed with twice its weight of highly concentrated sulphuric acid in a vessel kept cool by being surrounded with cold water. Ordinary commercial glycerine, free from lime and lead, is evaporated to 30° or 31° Beaumé. When entirely cold, it should be of a syrupy consistency. 7½ pounds of the cold acid mixture are brought into a glass flask or earthen vessel; this is placed in cold water, and 1 pound of glycerine is slowly poured into it; constant stirring being kept up during the addition of the glycerine. Great care must be observed to avoid any heating of the mixture, as the consequence of this would be an oxidation of the glycerine with development of carbonic acid. When the mixture is complete, it is allowed to stand quietly for 5 or 10 minutes, when it is poured into 5 or 6 times its volume of cold water, to which a rotary motion has previously been imparted. The nitroglycerine subsides quickly as a heavy oil, which, by decantation, is brought into a vessel of greater height than width. It is now washed with water, until not a trace of acid reaction is indicated by blue litmus paper, when it is put in flasks ready for use. It is a yellow or brown oil, heavier than water, and practically insoluble in it, but soluble in alcohol and ether. When impure or acid, it decomposes spontaneously in a short time, with development of gas, and formation of oxalic and glyceric acids.

Mowbray's Process of Manufacturing Nitro-glycerine. This product is preeminent because of its stable character. It freezes at 45° F., is clear as water, and never of an orange color. When detonated it does not produce what is known as glycerine headache and is non-explosive when frozen. These excellent qualities are imparted to it by the care taken in its preparation. The nitrifying acid is made in a well-ventilated building, in which are placed five retorts each of 1½ pounds' capacity and charged with 10½ ounces of sodium nitrate and 13¼ ounces of sulphuric acid. Terra-cotta pipes conduct the vapors from each retort into a row of four earthenware receivers standing upon a trestle raised slightly above the floor. 165 pounds of sulphuric acid are poured into the first two receivers and 110 pounds into the third, while the fourth remains empty. The nitric acid vapors are condensed in the receivers, whereby the mixture of acids required for nitrating is at once obtained. When the distillation, which requires 24 hours, is finished, the acid mixture (about 660 pounds) is drawn off and emptied into a large trough of soapstone. To remove the hyponitric acid, as well as to obtain a homogeneous mixture, *Mowbray* passes a current of air into the trough through an iron pipe, which answers the purpose perfectly. This operation is of great importance, as the presence of hyponitric acid and nitrous acid probably causes the spontaneous decomposition and consequent explosion of this substance. The room in which the nitrating process is carried on is about 103 feet long and contains 116 jars of earthenware in 9 wooden troughs. 18¾ pounds of acid are poured into each of the jars and the troughs are filled with ice water, or with a mixture of ice and salt, to within ½ inch of the edge of the jars containing the acid. Upon a shelf above the troughs are placed glass vessels, one for each jar. Each contains 2¼ pounds of *pure* glycerine (not crude glycerine), which is conveyed drop by drop into the acid mixture by means of a siphon and rubber hose. Beneath the shelf upon which the glycerine vessels stand runs an iron pipe 2½ inches in diameter, through which passes a current of cold and dry air, which is introduced into the jars, while the acid and glycerine intermingle, through glass tubes 16½ inches long and ¼ inch in diameter. 1½ hours are required for the glycerine to run off, and the greatest attention and care are necessary during this time. The three workmen overseeing the mixing process walk constantly up and down with a thermometer in hand, and should they find the temperature rising in one of the jars, or that red vapors are emitted, they stir the mixture with a glass rod. It happens sometimes that the glycerine runs too rapidly, when the flow must be diminished, and in case the engine should cease working must be entirely stopped and the mixture stirred.

When the conversion of glycerine into nitro-glycerine is completed, and no more red vapors escape, the jars are emptied into a vat containing cold water (42.8° F.). The quantity produced amounts at each operation to 495 pounds. In this vat the oil subsides to the bottom, being covered with water about 6 feet deep. It remains here for 15 minutes, when, after the water has been run off, it is drawn off into another vat resembling an old-fashioned churn, but much larger. Here it is washed 5 times—three times with pure water and twice with a solution of soda, a current of air being passed through it at the same time. The water from the washing apparatus is allowed to run into a vat, and from this through two barrels buried in the ground, whence it finds its way to the outside. If any of the oil should have been carried off with the wash-water, it is regained in one of the barrels. The nitro-glycerine is then transported in copper vessels to a magazine about 300 feet distant from the work-room and emptied into crocks each having a capacity of 66 pounds. These are placed on wooden shelves, each holding about 20 crocks, which are immersed in water of about 70° F., reaching to within 6 inches of the edge of the crocks. Here they remain for 72 hours, during which time the impurities that may be contained in the oil rise to the surface in the form of a scum, which is removed with a spoon. The nitro-glycerine is then chemically pure, transparent as water, and strongly refracts light. In this condition it is ready for packing. The tin cans used for this purpose are coated inside with paraffine, and have a capacity of 61½ pounds each. When they are to be filled they are placed in a shallow wooden vat; the oil is first poured into copper cans and then through a rubber funnel into the tin cans. To render any oil which may be spilled harmless the precaution is used to cover the bottom of the vat with a thick layer of plaster of Paris, which quickly absorbs the fluid. When the cans have been filled they are placed in a wooden vat filled with ice water, or ice and salt, until their contents are frozen, and 30 to 40 of them are stored away together in smaller magazines at a distance of about 325 feet from the factory. For transporting the nitro-glycerine the tin cans are packed in open wooden boxes, the bottom of which is covered with several inches of sponge. Around the cans themselves are fastened two gutta-percha tubes crossing each other on the bottom of the can. To thaw the nitro-glycerine each can is provided with a tube about 10 inches long and 1½ inches in diameter, passing through the centre from top to bottom, into which water of from 70 to 90° F. is poured. The cans are closed by a cork covered with a piece of bladder. Sleighs are used in winter for transporting the cans, and in summer wagons covered with a layer of ice and this with a blanket.

R. Böttger recommends the following process as free from risk for preparing small quantities of nitro-glycerine: A few grammes of anhydrous and entirely pure glycerine are poured into a test-glass kept cool by being surrounded with a freezing mixture, and containing 1 part by volume of concentrated sulphuric acid of 1.52 gravity, and 2 parts by volume of stronger sulphuric acid of 1.83 gravity. The mixture is poured as quickly as possible into a larger volume of water. In this the nitro-glycerine, resembling drops of oil, subsides to the bottom; it is then washed and re-washed, first with water, and finally with a weak solution of soda. It is freed from water by means of a few small pieces of chloride of calcium, when a product will be obtained of such purity that it may be kept without risk for an indefinite time and without suffering decomposition.

Dynamite possesses all the properties of nitro-glycerine for blasting purposes, and is less dangerous. Explosion is accomplished by means of a percussion cap in the same manner as with nitro-glycerine. The most common mode of making dynamite is by mixing 75 per cent. of nitro-glycerine with 25 per cent. of powdered sand.

Dynamite, according to *H. Champion* and *H. Pellet*, may be divided into, *a*, dynamite with an inert absorbent (infusorial earth, ashes, tripoli, etc.), and *b*, dynamite with an active absorbent. In the latter variety rosin, finely-powdered coal, or saltpetre are used as absorbents. To this class belong dualin, lithofracteur, etc.

To make the manufacture of dynamite less dangerous, *A. Sobrero* suggests to stir infusorial earth with water into a dough, form it into shapes of suitable size, dry them at 212° F., and finally dip them into nitro-glycerine. Dynamite with 75 per cent. of effective explosive can be prepared in this manner.

Cellulose Dynamite. Franzl has succeeded in producing a nitro-glycerine powder which, while it possesses all the properties of dynamite prepared with infusorial earth, has the advantage of being unaffected by water. He found that certain organic absorbents possessed the property of retaining absorbed nitro-glycerine, even when placed under water, and did not lose their explosive power. The nitrogenized absorbents—wood fibre and gun-cotton—were found to be too dangerous for manufacturing large quantities. But *Franzl* has now succeeded in preparing a wood fibre which absorbs from 70 to 75 per cent. of nitro-glycerine, which retains these proportions unchanged when in contact with water, and which retains also its explosive power after being pressed out and dried.

Norbin & Ohlsson's Patent Dynamite consists of a mixture of ammonium nitrate, with 8 to 10 per cent. of pulverized charcoal or coal, and 10 to 30 per cent. of nitro-glycerine. The compound, which, on account of the hygroscopic property of the ammonium nitrate, must be kept in metallic cases or glass vessels, is exploded by means of a percussion cap.

A. Nobel's Dynamite is a mixture of 69 parts of saltpetre, 7 of paraffine or naphthaline, 7 of coal dust, and 20 of nitro-glycerine. It is claimed that the addition of paraffine or naphthaline renders the mixture less hygroscopic.

Lithofracteur, as manufactured by *Krebs & Co.* of *Deutz*, is composed of 52 parts of nitro-glycerine, 30 of infusorial earth, 12 of coal, 4 of saltpetre, and 2 of sulphur.

Dittmar's Dualin consists of 50 parts of nitro-glycerine, 50 of nitrated sawdust, and 20 of saltpetre.

New Dynamite by Anthoine & Genaud. In this preparation unsized paper takes the place of silica. The paper is not only saturated with nitro-glycerine, but dipped in succession into solutions of saltpetre, potassium chlorate, and potassium picrate.

Carboäzotine. This explosive mixture, patented in France by *de Soulages* and *Cahuc*, is composed of 50 to 64 parts of saltpetre, 13 to 16 of sulphur, 14 to 16 of spent tan, or very fine sawdust, 9 to 18 of lampblack, and 4 to 5 of ferrous sulphate. The mixture is heated with a suitable quantity of water to 230° to 248° F., then allowed to cool, and the solid mass dried and shaped into bricks.

Brise-rocs, an explosive agent patented by *Robaudi*, consists of 40 parts of saltpetre, 20 of soda saltpetre, 15 of sulphur, 1 of rock salt, and 15 of woody substance, spent tan, sawdust, etc.

Pudrolith. Poch's blasting powder, known under this name, consists of 3 parts by weight of spent tan, 5 of sawdust, 3 of soda saltpetre, 3 of barium nitrate, 6 of wood charcoal, 12 of sulphur, and 68 of saltpetre. The barium and sodium salts are dissolved in hot water, the tan and sawdust stirred into the solution, and the mixture is evaporated to dryness. The other ingredients, previously pulverized, are intimately mixed with the powdered residue in a revolving cylinder.

Pyrolith. This blasting powder, patented by *Wattlen*, and used for blasting hard rocks, such as granite, etc., consists of 12.5 parts by weight of sawdust, 67.5 of saltpetre, and 20 of flowers of sulphur.

For blasting softer rocks, such as limestone, coal, etc., *Wattlen* recommends the following composition: 11 parts by weight of sawdust, 50.5 of saltpetre, 16 of soda saltpetre, 1.5 of powdered charcoal, and 20 of flowers of sulphur.

Trets' Blasting Powder, patented in *England*, consists of 52.5 per cent. of Chili soda saltpetre, 20 per cent. of sulphur, and 27.5 per cent. of spent tan.

Frozen Dynamite. Dynamite, when frozen solid, is comparatively valueless, as in thawing for use it becomes injured and sometimes ignites; but by granulating it, as freezing takes place, and keeping it in this condition, it may be transported, handled, or poured and rammed into bore holes with entire safety and convenience. Freezing the dynamite in grains may be readily accomplished by passing it through a coarse sieve after it is manufactured, but just before it congeals, and allowing it to fall loosely and lie undisturbed during its exposure to a freezing temperature. The particles will slightly adhere, but may be readily separated by stirring. Dynamite so frozen will readily explode by the ordinary means, but the cap should have about three times the usual quantity of fulminate.

Augendre's White Powder. This powder may be advantageously used for blasting very hard rock, although it is somewhat expensive. Considerable care and caution are required in ramming it into the drill holes, and for this reason the work should be only intrusted to experienced workmen. By the following process *Augendre's* gunpowder can be produced as a very homogeneous mixture and of great explosive energy. The three ingredients of white gunpowder, potassium ferrocyanide, sugar, and potassium chlorate, are pulverized, each by itself, in a mortar, and then thoroughly dried. Each of the ingredients, when dry, is again pulverized as finely as possible, and passed through a fine hair sieve. The respective quantities of the ingredients are then weighed off, poured upon a sheet of paper, and intimately mixed with the fingers or with a feather. The powder is then placed in a capacious porcelain mortar, moistened with absolute alcohol, and an intimate mixture is produced by continued rubbing with a pestle, the process being entirely free from danger if done in this manner. The powder, which is now in the form of a stiff dough, is spread upon a smooth board and dried in a warm room. The alcohol evaporates quickly, when the thin, dry cakes of powder are crushed between two smooth boards, and the powder passed through a fine sieve. In this manner it is obtained in the form of very fine, intimately mixed dust, possessing excellent explosive properties.

Hafenegger's Gun and Blasting Powder, several varieties of which have been patented in England, resembles *Augendre's* white powder. Their composition is as follows:

I. Nine parts of potassium chlorate, ¼ of sulphur, and ¼ of wood charcoal.

II. Two parts of potassium chlorate, 1 of refined sugar, and 1 of potassium ferrocyanide.

III. Four parts of potassium chlorate, 1 of sulphur or sugar, ¼ of wood charcoal, and 1 of potassium ferrocyanide.

IV. Four parts of potassium chlorate, 4 of sugar, ¼ of wood charcoal, and ¼ of sulphur.

V. One part of potassium chlorate and 1 of sugar.

VI. Eleven parts of potassium chlorate, ¼ of sulphur, and ¼ of wood charcoal.

Dr. Borlinetto's Gunpowder. Mix very intimately 10 parts of Chili saltpetre, 10 of picric acid, and 8½ of potassium bichromate.

Sharp & Smith's Patent Gunpowder consists of 2 parts of saltpetre, 2 of potassium chlorate, 1 of potassium ferrocyanide, 1 of potassium tartrate, and 2 of sulphur.

Spence's Powder for Cannon of Large Calibre. Two parts by weight of finely-pulverized charcoal are boiled with 38 parts by weight of water. The boiling is interrupted after a short time, and, with constant stirring, 20 parts by weight of potassium chlorate, 2 of pulverized coal, and 4 of sodium bicarbonate are added to the mixture of charcoal and water. The mass is again brought to the boiling point, 7 parts by weight of fine sawdust are added, and the boiling continued until the woody mass has formed a magma with the water. When this is done the mass is evaporated in open pans until it is of a consistency to be granulated in the usual manner in the powder-mill.

Non-explosive Powder. When this powder is ignited it does not explode, but burns slowly with a hissing noise. It loosens and raises stones without blasting them. It is cheaper than the ordinary powder, of quite a coarse grain, and contains 3 parts of potassium nitrate to 1 of sodium nitrate. The powder is mixed in the following proportions: 56.22 to 56.23 per cent. of potassium nitrate, 18.33 to 18.39 per cent. of sodium nitrate, 9.68 per cent. of sulphur, and 14.14 to 15.01 per cent. of charcoal.

Green's Blasting Powder consists

principally of barium nitrate, contains but little saltpetre and no sulphur. There is less danger in manufacturing it than gunpowder, but it is not fit for firearms. It possesses the great advantage of not emitting thick smoke or choking gases, and therefore does not interrupt the work in mines; and further, that it takes up less room than gunpowder and is much cheaper. Its effect as compared with gunpowder is as 18 to 11.

Giant Dynamite is a mixture of 18 to 28 parts by weight of pyroxyline, 55 to 44 of nitro-glycerine, 5 to 10 of pyro-paper, 20 to 16 of nitro-starch, 1 to 1 of nitromannite, and 1 to 2 of water-glass The materials, which should be free from acid, are carefully mixed and brought under a cartridge press, in the stamp of which is fastened a needle which makes a hole in the cartridge for the reception of the fuse. The cartridge thus prepared is hermetically closed with collodion, and packed in the same manner as lithofracteur. Shortly before the cartridge is to be used the coating of collodion is broken on those places where the holes are for the reception of the fuse. This consists of soft gun-cotton impregnated with potassium chlorate and plumbic ferrocyanide, and is prevented from dropping through by a knot on one end. It is drawn through the holes and a *Bickford's* fuse fastened to the other end.

Blasting Compound from Potato-Starch. The process is similar to that of manufacturing nitro-glycerine. The potato-starch is shaken with concentrated nitric acid until it is dissolved, and then, with vigorous stirring, poured into sulphuric acid, whereby the preparation is separated in a finely-divided condition. All traces of acid are then removed by washing and rewashing, and treating the preparation with sodium carbonate. The explosive starch flour, when dry, forms a tender white powder. When touched with a glowing piece of wood it is quickly consumed with a yellow flame without leaving a residue. A great advantage of the explosive starch flour is that it explodes only after having been repeatedly struck with a hammer upon an anvil. Its ignition temperature is between 356° and 374° F. In external appearance this explosive agent does not differ from ordinary starch flour. It remains entirely unchanged when boiled in water, but loses the property of being colored blue by iodine. If examined with the microscope the well-known starch globules cannot be detected.

A New Blasting Powder, patented in Germany by *Th. Martinsen*, consists of:

	Parts.		
	I.	II.	III.
Saltpetre	70	64	56
Sulphur	12	12	22
Lampblack	5	3	3
Sawdust or tan	13	21	29
Ferrous sulphate	2	3	5

The ferrous sulphate is completely dissolved in a little water, and the other components are mixed with it at 248° to 266° F. The mixture is cooled off by constantly stirring it and then dried. This powder can be stored, transported, and used without danger, and develops no smoke in the mine. The first mixture is intended for dense rocks, the second for anthracite, and the third for bituminous coal.

To protect blasting agents containing nitro-glycerine and ammonium nitrate from moisture, and to prevent the exudation of the nitro-glycerine, Nobel adds paraffine to them. He recommends the following proportions: 69 per cent. of sodium nitrate, 7 per cent. of paraffine, and 4 per cent. of charcoal.

These ingredients are carefully mixed, and 20 per cent. of nitro-glycerine is added to the mixture. Or, 75 per cent. of ammonium nitrate, 3 per cent. of charcoal, 4 per cent. of paraffine, and 18 per cent. of nitro-glycerine.

Giant Powder. Forty parts of nitro-glycerine are mixed with 60 parts of a dry mixture, consisting of 40 parts of sodium nitrate, 6 of rosin, 6 of sulphur, and 8 of infusorial earth or other analogous absorbent substance. This forms a powerful blasting compound, which will not ignite from contact with flame nor from a blow, but may be readily exploded by the shock given by discharging a cap containing fulminate.

Faure & French's Blasting Compound is a mixture of 1 part of charcoal, 16 of barium nitrate, and 1 of nitro-cellulose stirred into a dough with some water and then formed into disks and dried.

Gun-Cotton. Cotton-wool is immersed in a boiling dilute solution of potassium carbonate, then washed with water and well dried. It is now steeped for a few minutes in a cold mixture of 1 part of concentrated nitric acid and 3 of oil of vitriol, then squeezed, and again placed in a fresh acid mixture and left there for 48 hours. It is then again well squeezed and washed for a long time with running water, and finally steeped in a solution of potassium carbonate.

Gun-cotton thus manufactured will keep without change indefinitely, and may be kept under water for safety's sake, and possesses, after drying, all its original properties.

It is insoluble in water, alcohol, and ether. It takes fire at 300° F., burning away rapidly but without explosion; but when ignited in a confined space, or by percussion, it decomposes with a violent detonation, the energy of which equals that of five times its weight of gunpowder.

New Blasting Compounds.

1. *Peralite* is a coarse-grained powder consisting of 64 per cent. of saltpetre, 30 per cent. of charcoal, and 6 per cent. of sulphide of antimony.

2. *Juline* contains 65 to 75 per cent. of saltpetre, 10 per cent. of sulphur, 10 to 15 per cent. of lignite, 3 to 8 per cent. of sodium picrate, and 2 per cent. of potassium chlorate.

New Blasting Compound from a Combination of Honey and Glycerine. The following proportions by weight are used:

No. I. Fifty parts of combination of honey and glycerine, 12 of potassium chlorate, 16 of potassium nitrate, 17 of prepared sawdust, and 5 of prepared chalk.

No. II. Thirty-eight parts of combination of honey and glycerine, 19 of potassium chlorate, 24 of potassium nitrate, 10 of prepared sawdust, and 9 of prepared chalk.

The combination of honey and glycerine is prepared as follows: Mix 1 part of nitric acid of 1.50 specific gravity and 2 parts of sulphuric acid of 1.84 specific gravity, and let the mixture cool off to 62° F. Eight parts of this mixture are placed in a wooden vessel lined with lead, and to this is added, with slow and constant stirring, 1 part of a mixture of equal parts of honey and glycerine, keeping the temperature of the compound between 59° and 68° F. After stirring for about 5 minutes the combination of honey and glycerine settles on the bottom of the vessel. It is then separated from the supernatant acid and washed first with water and next with a solution of soda to remove the last traces of acid. It is now ready for mixing with the other ingredients, which must have been previously pulverized and intimately mixed. The sawdust flour is prepared by passing ordinary sawdust through a fine sieve and boiling it in a solution of soda until all resinous and coloring substances have been extracted, when it is washed in cold water and dried.

Preparation of Blasting Compounds by directly Nitrating Crude Tar Oils. The crude tar oils are gradually compounded by constant stirring with nitric acid of a high grade. The clear oil standing over the precipitate is poured off into another vessel, nitric acid added to the residue, and the process repeated.

The nitrogenized substances obtained in this manner are washed, dried, and mixed with substances yielding oxygen. The nitrates of alkalies, potassium chlorate, and the strongest nitric acid (1.5 specific gravity) are principally used for the purpose.

Gelatinous Nitro-glycerine. Cotton carefully cleansed and comminuted is boiled in a closed boiler with 5 parts by weight of dextrine and some acetate of ammonium; the resulting jelly, of which as much as 7 per cent. may be dissolved in nitro-glycerine, forms with it a mass from which no nitro-glycerine can escape.

To prepare the blasting compound "*Forcite*" 76 parts of the above gelatinous nitro-glycerine are mixed with 15 parts of saltpetre and 9 of sawdust.

Cartridge Shells of Easily Combustible Substances. The material consists of very loosely woven cotton or silk tissue, which is impregnated with nitro-glycerine, or with a mixture of sulphur and saltpetre. When the tissue is dry, collodion, to which a small quantity of castor oil has been added, is poured over it and it is then smoothed between rollers.

Fulminate of Mercury is used for filling percussion caps. It is prepared on a large scale by dissolving 1 part of mercury in 12 of pure nitric acid of 1.36 specific gravity, and adding 12 of spirit of wine, when a violent reaction takes place, which is kept in check by adding gradually more alcohol. First, the liquid becomes black by the separation of metallic mercury, which, however, soon disappears. When the liquid becomes cool the fulminate of mercury separates as a crystalline powder. It is nearly insoluble in cold water: from a boiling solution it is obtained in white prismatic crystals. When kindled in the open air it burns away like gunpowder, but by percussion it is decomposed with a violent detonation. The explosion of the fulminate is so violent and rapid that it is necessary to moderate it for percussion caps. For this purpose it is mixed with potassium nitrate or chlorate. For gun caps potassium chlorate is generally mixed with the fulminate, and powdered glass is sometimes added to increase the sensibility of the mixture to explosion by percussion. After a little of the composition has been introduced into the cap, it is made to adhere by a drop of solution of shellac in spirit of wine, which renders it also water-proof.

Fulminate of Silver. Ten grains of pure silver are dissolved, at a gentle heat, in 70 drops of concentrated nitric acid of 1.42 specific gravity and 50 drops of water. As soon as the silver is dissolved the heat is removed and 2,000 drops of alcohol are added. If the action does not commence after a short time, a very gentle heat may be applied until effervescence begins, when the fulminate of silver will be deposited in minute needles, and may be further treated as in the case of fulminate of mercury. When dry the fulminate of silver must be handled with the greatest caution, since it is exploded far more easily than the fulminate of mercury. It should be kept in small quantities, wrapped up separately in paper, and placed in a pasteboard box. The violence of its explosion renders it useless for percussion caps, but it is employed in detonating crackers.

Fulminating Platinum is obtained by dissolving binoxide of platinum in diluted sulphuric acid and mixing the solution with an excess of ammonia, when a black precipitate will result which detonates violently at about 400° F.

Fulminating Gold is obtained as a buff-colored precipitate when ammonia is added to a solution of terchloride of gold. It explodes violently when gently heated.

Explosive Agents.

Blasting Cartridges. Dissolve 73 parts of saltpetre and 1 of magnesium sulphate in ⅓ of their weight of boiling water, and compound with 8 parts of ground wood charcoal, 8 of bran, and 10 of sulphur, previously mixed dry. Stir the mass thoroughly, and heat for 2 hours at a temperature of 284° F., and then dry in a drying apparatus for 5 hours at a temperature of 122° F. The dried mass is pressed into cylinders, four of which are generally formed into a cartridge in a paper shell.

Blasting Paper. Coat unsized paper with a hot mixture of 11 drachms of ferrocyanide of potassium dissolved in 3½ pints of water, 11 ounces of basswood charcoal, 1¼ ounces of refined saltpetre, 2½ ounces of potassium chlorate, and 6½ drachms of wheat starch, stirred to a paste with 1⅛ ounces of water; dry and smooth. For use roll strips of the prepared paper into cartridges.

Explosive Combination. An explosive combination consists, according to a French patent, of 80 parts of powdered potassium chlorate, 20 parts of ordinary coal tar, and a porous, absorbent substance, such as pulverized wood-charcoal or silicious earth. Potassium permanganate can be substituted for a portion of the chlorate.

Explosive Substance. This, according to an English patent, consists of 9 parts of potassium chlorate, 2 of carbohydrate (sugar), 1 of flour, and 1 of ferrocyanide of potassium.

Explosive and Pyrotechnic Substances. Ferrocyanide of potassium, saltpetre, and chlorate of potassium are dissolved and mixed with pulverized charcoal. The water is then evaporated, and the substances are combined by the admixture of paraffine or resins. The paraffine is used either melted or dissolved in benzine. The mass is made into any desired shape, and can also be used for coating paper.

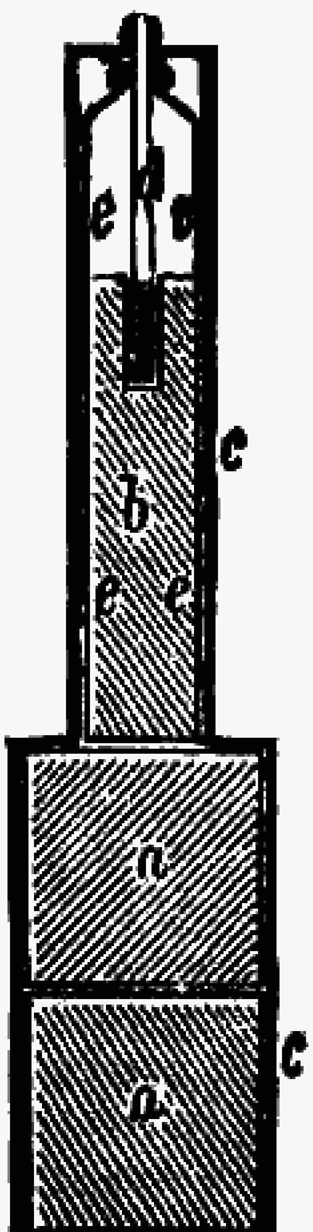

Fig. 60.

Method of Blasting under Water with Compressed Gun-cotton. In the accompanying illustration, Fig. 60, *aa* represent layers of gun-cotton, *b* the cartridge of compressed gun-cotton, and *d* the quick match with the cap. The cartridge is enclosed in the rubber tube *e*, which on the top is fastened water-tight around the quick-match, so that when the cartridge is placed under water the latter can penetrate the gun-cotton only from below. The entire charge is enclosed in the tin case *c*, which is open on top and bottom for the passage of water. The cartridge remains explosible until all the gun-cotton is soaked through by the water entering from below, which with a cartridge about 1 inch in diameter and 4¾ inches long will be the case in exactly 22 hours, which makes the unexpected explosion of a charge missing fire impossible after that time.

New Blasting Powder. Saltpetre, potassium chlorate, and finely-pulverized coal-tar pitch are converted with benzine into a plastic paste, which is made into flat cakes and freed from the benzine by evaporation, and then worked in the same manner as ordinary powder. The grains, which, like those of the ordinary article, are irregular in form, can be made of any desired size. The density, which is 0.9 or somewhat more, corresponds with that of ordinary gunpowder. This new powder possesses considerable hardness, does not lose color, even when wet, and without undergoing a change stands a higher degree of heat than that of melting tin. It is not inflammable by single sparks of short duration. Ignited free, it burns quickly with a white flame; in a closed space it burns, however, very energetically with little smoke and leaving a very small residue. A gun is not in the least affected by its combustion products. The advantages of this powder are: 1. Facility and quickness of manufacture. 2. Safety in its preparation. 3. Absence of all hygroscopic properties (4 ounces placed upon a very sensitive scale in an open window for 4 days of misty weather did not increase in weight). 4. Superior force, 2½ times that of ordinary powder. 5. Very small residue. 6. Scarcely perceptible smoke.

New Method of Preparing Giant Powder. Two mixtures are prepared:

a. 36.06 parts of potassium or sodium bisulphate, 28.60 of potassium nitrate, and 9.20 of glycerine.

b. 50 to 55 parts of some chlorate, and 50 to 45 parts of a substance rich in carbon.

On igniting a mixture of the two, it is claimed mixture *b* evolves sufficient heat to effect the nitrification of the glycerine and explosion of the nitro-glycerine. The material rich in carbon is saturated with concentrated solutions of the bisulphate, nitrate, and chlorate, and dried. The mass is then mixed with the glycerine and made into cartridges.

Preparation of Hyponitric Acid and its Use for Explosive and Illuminating Substances. The following process has been patented in France and Germany: Nitrate of lead is heated in the retort *A* (Fig. 61). The developed gases are first conducted through sulphuric acid, which retains the moisture, and then into the condensers *C* of enamelled cast-iron, which rest in the cooling vessel *E*, whose cooling fluid is kept at zero by the ice machine *G*. While the oxygen escapes for further use through *D*, the hyponitric acid collects in the reservoirs *H* and *J*, the first of which is provided with a test-cock for the examination of the acid. The reservoir *I* contains sulphuric acid. From *J* the hyponitric acid is brought by the pump *O* into the vessel *L*, and from there is drawn into tin cans. The oxide of lead 'in the retorts is reconverted into nitrate by nitric acid.

A mixture of carbon di-sulphide and hyponitric acid is a powerful explosive, which is exploded by fulminate of mercury or gunpowder. It does not explode by a shock alone, nor by heating to 398° F. A mixture of equal parts of hyponitric acid and carbon di-sulphide gives the most powerful explosion.

The mixture burns in the open air with a brilliant white light, which is powerfully actinic.

MATCHES.

Swedish Matches are made in Sweden almost exclusively of white poplar wood, it being the cheapest. Blocks of the length of the match are cut by machinery from the round logs and splintered, the splints kiln-dried and coated with paraffine. The end to be covered with the inflammable compound is dipped in a solution of paraffine in benzine, when they are again dried. They are then dipped into the inflammable compound, which should be of such a consistency that only small drops remain adhering to the stick. The following mixtures are used:

In Nos. I. and II. the paraffine is first rubbed up with the antimony and then incorporated with the compound. The compound ignites easily and transmits the flame quickly to the wood. Matches with compound No. II. ignite well and burn quietly. Matches with No. III. ignite easily on the striking surface and quickly transmit the flame to the wood. Compound No. IV. furnishes matches exactly like those of the *Jönköping* product; they ignite easily on the striking surface, transmit the flame quickly to the wood, burn quietly and without noise.

Striking Surface of Swedish Matches consists of a compound prepared by

	PARTS.			
	I.	II.	III.	IV.
Chlorate of potassium	2000	2000	2000	4000
Plumbic dioxide . .	1150	2150		
Minium	2500	2500	2000	4000
Antimony trisulphide	1250	1250	1300	3000
Chromate of potassium	1318		750	1500
Gum-Arabic	670	670	670	670
Paraffine	250	250		

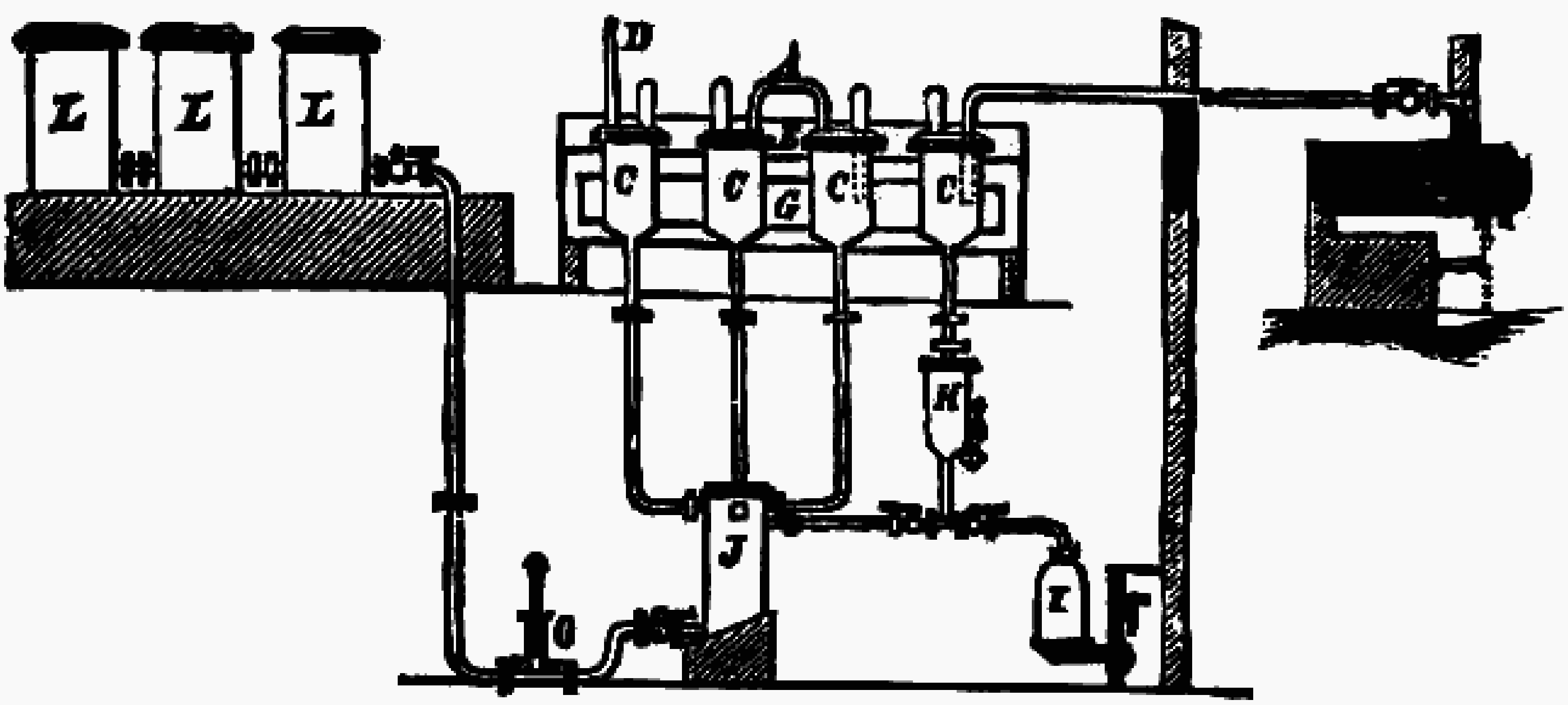

Fig. 61.

mixing 9 parts of amorphous phosphorus, 7 of iron pyrites pulverized and sifted, 3 of pulverized glass, and 1 of glue or gum with the requisite quantity of water.

Matches without Sulphur, which can be ignited by friction on any surface and do not absorb moisture from the air, are prepared by dipping the matches into a hot solution of any kind of fat, and using the following inflammable compound: Seven parts of phosphorus, 7 of gum-Arabic, 40 of lead nitrate, 5 of pulverized glass, and 10 of water.

Inflammable Compounds. H. Schwarz recommends the following mixtures as giving excellent results: I. One part of pulverized sulphur is melted in warm water with 4 of yellow phosphorus. Most of the water is then poured off and the fluid mixture rubbed intimately with 4 parts of dextrine gum. Now compound 45 parts of minium with 1½ equivalent of nitric acid, dry the mixture, pulverize it, and add it gradually to the phosphorus mixture. The matches are saturated with solution of pine rosin in alcohol, and dried at a moderate heat.

II. Mix 1 part of phosphorus, 5 of chalk, 2.8 of anhydrous gypsum, 6 of pulverized glass, and 6 of some agglutinant and coloring matter. This compound requires a rough striking surface, ignites with a slight report, and does not absorb moisture.

Inflammable Compound without Phosphorus. Thirty-six parts of plumbic dioxide, 15 of chlorate of potassium, 9 of manganese dioxide, 8 of flowers of sulphur, 6 each of infusorial earth, pulverized glass or sand and amorphous phosphorus, and 8 of glue.

The compound ignites by friction on any surface.

Parlor Matches. The sticks are first thoroughly dried, then soaked with stearic acid, and finally dipped into an inflammable compound prepared from 3 parts of phosphorus, ½ of gum tragacanth, 3 of water, 2 of fine sand, and 2 of red lead. To perfume the matches they are dipped, after the compound is dry, into a solution of aromatic gum, made of 4 parts of benzoin in 10 of spirit of wine of 40° B.

Colored Parlor Matches. The inflammable compound on the end of the matches may be coated with different colored lacquers to give a variegated appearance when placed in boxes.

The lacquers are prepared in the following manner: Eight parts of pulverized rosin are dissolved in a hot mixture of 200 parts of alcohol and 4 parts of glycerine, and 40 parts of solution of shellac added to the hot solution. The whole is then thoroughly agitated and, while yet warm, compounded with the necessary quantity of coloring matter, and finally allowed to cool.

The green iridescent bronze color, which is in great demand, requires for the above solution of lacquer 80 parts of crystallized fuchsine, or 28 parts of methyl-violet. To produce *violet* an addition of only ½ part of methyl-violet is required; for *blue* ¾ part of aniline blue soluble in water; for *orange* 4 parts of aniline orange; for *blue-green* ½ part of methyl-green. For *yellow-green* 2 parts of blue-green are mixed with 1 of orange; and for *red* 32 parts of coralline with an addition of 2 parts of caustic soda-lye, dissolved in the above lacquer.

Anti-phosphorus Matches. The paste

for the friction surface consists of minium, sand, and amorphous phosphorus rubbed up with a solution of gum-Arabic and applied with a brush; or of 10 parts of amorphous phosphorus, 8 of pyrolusite or antimony trisulphide, and 3 to 6 of glue dissolved in water. To prepare the matches the ends are first dipped into melted sulphur, stearic acid, or wax, and then into a compound of 6 parts of chlorate of potassium and 2 to 3 of trisulphide of antimony mixed with a solution of 1 part of glue in water. It must be remarked here that the mixture of bichromate of potassium and antimony is exceedingly dangerous, as it is easily ignited by a shock or friction.

Matches Inextinguishable by the Wind. Sheets of paper, thin pasteboard, or wood are saturated with a solution of saltpetre in water to which has been added some substance emitting an agreeable odor while burning. When the sheets are dry, a thin layer of a phosphorus compound, as is used in the manufacture of friction matches, and to which some incombustible substance, as pulverized glass, fine sand, etc., has been added, is placed between two of them, leaving a part of one end free for handling. When dry the 2 sheets are pasted together, and this is cut up into strips of suitable shape. These strips are then coated with a varnish to protect them from moisture and to prevent their ignition by friction during transportation, etc.

Matches without Phosphorus. Prepare a paste of 10 parts of dextrine, 75 of pulverized chlorate of potassium, 35 of pulverized plumbic dioxide, and a like quantity of pulverized pyrites with the necessary quantity of water, and dip the end of the splints into the compound.

Matches without Phosphorus, of an excellent quality, and in the manufacture of which there is not the slightest danger, are obtained from the following mixture: 53.8 parts of chlorate of potassium, 10 of gum-Arabic, 3 of gum tragacanth, 6 of pyrolusite, 6 of ferric oxide, 12 of pulverized glass, 5 of bichromate of potassium, 3 of sulphur, 1.2 of chalk, and sufficient water.

Paraffine or sulphur is used for transmitting the flame to the wood. The matches can only be ignited by being struck on a surface composed of the following mixture: Five parts of antimony trisulphide, 3 of amorphous phosphorus, 14 of pyrolusite, and 4 of glue.

Amorces d'Allumettes are matches prepared from 20 parts of phosphorus, 5.5 of gun-cotton, 5 of pulverized wood charcoal, 5 of iron filings, 51.5 of sulphur, and 10 of gum.

Nickle's Process of Preparing an Amorphous Phosphorus from the Ordinary Article. The conversion of ordinary into amorphous phosphorus is accomplished by heating ordinary phosphorus from 446° to 482° F. in a closed iron boiler. After 3 or 4 weeks the phosphorus is found to be converted into a red, brittle mass which is ground by millstones under water, and separated from the ordinary phosphorus either by bisulphide of carbon or caustic soda, in which the latter is soluble. The temperature requires careful regulation, for if it is allowed to rise to 500° F. the amorphous phosphorus quickly resumes the ordinary condition, evolving the heat which it had absorbed during its conversion, and thus converting much of the phosphorus into vapor. This reconversion may be shown by heating a little amorphous phosphorus in a test-tube, when drops of ordinary phosphorus condeuse on the cool part of the tube. Ordinary phosphorus is very poisonous, while amorphous phosphorus appears to be harmless. The vapor of phosphorus produces a very injurious effect upon the persons engaged in the manufacture of matches, resulting in the decay of the lower jaw. This evil may be greatly mitigated by good ventilation or by diffusing turpentine vapor through the air of the work-room, or may be entirely obviated by substituting amorphous phosphorus for the ordinary variety.

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The Techno-Chemical Receipt Book 1896

Henley's Twentieth Century Formulas 1907

Pyrotechnics

FIREWORKS.

The chief chemical process is, of course, oxidation. Oxidation may be produced by the atmosphere, but in many cases this is not enough, and then the pyrotechnist must employ his knowledge of chemistry in selecting oxidizing agents.

The chief of these oxidizing agents are chlorates and nitrates, the effect of which is to promote the continuance of combustion when it is once started. They are specially useful, owing to their solid non-hygroscopic nature. Then ingredients are needed to prevent the too speedy action of the oxidizing agents, to regulate the process of combustion, such as calomel, sand, and sulphate of potash. Thirdly, there are the active ingredients that produce the desired effect, prominent among which are substances that in contact with flame impart some special color to it. Brilliancy and brightness are imparted by steel, zinc, and copper filings. Other substances employed are lampblack with gunpowder, and, for theatre purposes, lycopodium.

Fireworks may be classified under four heads, viz.:

1. Single fireworks.
2. Terrestrial fireworks, which are placed upon the ground and the fire issues direct from the surface.
3. Atmospheric fireworks, which begin their display in the air.
4. Aquatic fireworks, in which oxidation is so intense that they produce a flame under water.

Rockets.—First and foremost among atmospheric fireworks are rockets, made in different sizes, each requiring a slightly different percentage composition. A good formula is

Sulphur............	1 part
Carbon, wood.......	2 parts
Niter..............	4 parts
Meal powder........	1 part

Meal powder is a fine black or brown dust, which acts as a diluent.

Roman Candles.—Roman candles are somewhat after the same principle. An average formula is:

Sulphur............	4 parts
Carbon.............	3 parts
Niter..............	8 parts

CHILDREN'S SAFE FIREWORKS (SPARKLERS):

Coat 12 inch lengths of No. 18 Iron Wire with a compound consisting of:

Powdered sulphur ...	1	ounce
Potassium nitrate ...	5	ounces
Powdered charcoal ..	1½	ounces
Iron filings	2	ounces
Aluminum powder ...	¼	ounce

mixed in shellac to a thick creamy consistency. Dip the wires in the mixture and then insert the base end of wires in holes drilled into a board, until the mixture dries. Repeat this process until each wire is covered with a thick coat.

COLORED FIRES.

The compounds should be ignited in a small pill box resting on a plate. All the ingredients must be dried and powdered separately, and then lightly mixed on a sheet of paper. Always bear in mind that sulphur and chlorate of potassium explode violently if rubbed together.

Smokeless Vari-Colored Fire.—First take barytes or strontium, and bring to a glowing heat in a suitable dish, remove from the fire, and add the shellac. The latter (unpowdered) will melt at once, and can then be intimately mixed with the barytes or strontium by means of a spatula. After cooling, pulverize. One may also add about 2½ per cent of powdered magnesium to increase the effect. Take for instance 4 parts of barytes or strontium and 1 part of shellac.

The following salts, if finely powdered and burned in an iron ladle with a little spirits, will communicate to the flame their peculiar colors.

Potassium nitrate or sodium chlorate, yellow.

Potassium chlorate, violet.
Calcium chloride, orange.
Strontium nitrate, red.
Barium nitrate, apple green.
Copper nitrate, emerald green.
Borax, green.
Lithium chloride, purple.

The colored fires are used largely in the production of various theatrical effects.

Blue Fire.—

I.—	Ter-sulphuret of antimony	1 part
	Sulphur	2 parts
	Nitrate of potassium	6 parts
II.—	Sulphur	15 parts
	Potassium sulphate	15 parts
	Ammonio-cupric sulphate	15 parts
	Potassium nitrate	27 parts
	Potassium chlorate	28 parts
III.—	Chlorate of potash	8 parts
	Calomel	4 parts
	Copper sulphate	5 parts
	Shellac	3 parts
IV.—	Ore pigment	2 parts
	Charcoal	3 parts
	Potassium chloride	5 parts
	Sulphur	13 parts
	Potassium nitrate	77 parts
V.—	Potassium chlorate	10 parts
	Copper chlorate	20 parts
	Alcohol	20 parts
	Water	100 parts
VI.—	Copper chlorate	100 part
	Copper nitrate	50 parts
	Barium chlorate	25 part
	Potassium chlorate	100 parts
	Alcohol	500 parts
	Water	1,000 parts

Green.—

I.—	Barium chlorate	20 parts
	Alcohol	20 parts
	Water	100 parts
II.—	Barium nitrate	10 parts
	Potassium chlorate	10 parts
	Alcohol	20 parts
	Water	100 parts
III.—	Shellac	5 parts
	Barium nitrate	1¼ parts

Pound after cooling, and add

Barium chlorate, 2 to 5 per cent.

Red.—

I.—	Shellac	5 parts
	Strontium nitrate	1 to 1.2 parts

Preparation as in green fire. In damp weather add 2 to 4 per cent of potassium chlorate to the red flame; the latter causes a little more smoke.

II.—	Strontium nitrate	20 parts
	Potassium chlorate	10 parts
	Alcohol	20 parts
	Water	100 parts

Yellow.—

I.—	Sulphur	16 parts
	Dried carbonate of soda	23 parts
	Chlorate of potassium	61 parts
II.—	Sodium chlorate	20 parts
	Potassium oxalate	10 parts
	Alcohol	20 parts
	Water	100 parts

Violet.—

I.—	Strontium chlorate	15 parts
	Copper chlorate	15 parts
	Potassium chlorate	15 parts
	Alcohol	50 parts
	Water	100 parts
II.—	Potassium chlorate	20 parts
	Strontium chlorate	20 parts
	Copper chlorate	10 parts
	Alcohol	50 parts
	Water	100 parts

Lilac.—

Potassium chlorate	20 parts
Copper chlorate...	10 parts
Strontium chloride.	10 parts
Alcohol	50 parts
Water...........	100 parts

Mauve.—

Chlorate of potash .	28 parts
Calomel..........	12 parts
Shellac...........	4 parts
Strontium nitrate..	4 parts
Cupric sulphate ...	2 parts
Fat...............	1 part

Purple.—

Copper sulphide...	8 parts
Calomel..........	7 parts
Sulphur..........	2 parts
Chlorate of potash.	16 parts

White.—

I.—Gunpowder.......	15 parts
Sulphur..........	22 parts
Nitrate of potassium	64 parts
II.—Potassium nitrate...	30 parts
Sulphur...........	10 parts
Antimony sulphide (black)..........	5 parts
Flour.............	3 parts
Powdered camphor.	2 parts
III.—Charcoal..........	1 part
Sulphur...........	11 parts
Potassium sulphide.	38 parts
IV.—Stearine,..........	1 part
Barium carbonate..	1 part
Milk sugar.........	4 parts
Potassium nitrate....	4 parts
Potassium chlorate.	12 parts

As a general rule, a corresponding quantity of shellac may be taken instead of the sulphur for inside fireworks.

The directions for using these solutions are simply to imbibe bibulous papers in them, then carefully dry and roll tightly into rolls of suitable length, according to the length of time they are to burn.

Fuses.—For fuses or igniting papers, the following is used:

Potassium nitrate...	2 parts
Lead acetate.......	40 parts
Water.............	100 parts

Mix and dissolve, and in the solution place unsized paper; raise to nearly a boil and keep at this temperature for 20 minutes. If the paper is to be "slow," it may now be taken out, dried, cut into strips, and rolled. If to be "faster," the heat is to be continued longer, according to the quickness desired. Care must be taken to avoid boiling, which might disintegrate the paper.

In preparing these papers, every precaution against fire should be taken, and their preparation in the shop or house should not be thought of. In making the solutions, etc., where heat is necessary, the water bath should invariably be used.

PYROTECHNIC MAGIC.

[Caution.—When about to place any lighted material in the mouth be sure that the mouth is well coated with saliva, and that you are exhaling *the breath continuously*, with greater or less force, *according to the amount of heat you can bear*.

If the lighted material shows a tendency to burn the mouth, *do not attempt to drag it out quickly*, but simply shut the lips tight, and breathe through the nose, and the fire must go out instantly.

In the Human Gas Trick, where a flame 10 to 15 inches long is blown from the mouth, be careful after lighting the gas, *to continue to exhale the breath.* When you desire the gas to go out, simply shut the lips tight and hold the breath for a few seconds. In this trick, until the gas is well out, any inhalation is likely to be attended with the most serious results.

The several cautions above given may be examined with a lighted match, first removing, after lighting the match, any brimstone or phosphorus from its end.]

To Fire Paper, etc., by Breathing on it.—This secret seems little known to conjurers.

Half fill a half-ounce bottle with carbon disulphide, and drop in 1 or 2 fragments of phosphorus, each the size of a pea, which will quickly dissolve. Shake up the liquid, and pour out a small teaspoonful onto a piece of blotting paper. The carbon disulphide will quickly evaporate, leaving a film of phosphorus on the paper, which will quickly emit fumes and burst into flame. The once-popular term Fenian fire was derived from the supposed use of this liquid by the Fenians for the purpose of setting fire to houses by throwing a bottle down a chimney or through a window, the bottle to break and its contents to speedily set fire to the place.

For the purpose of experiment this liquid should only be prepared in small quantities as above, and any left over should be poured away onto the soil in the open air, so as to obviate the risk of fire. Thin paper may be fired in a similar manner with the acid bulbs and powder already mentioned. The powder should be formed into a paste, laid on the paper, and allowed to dry. Then the acid bulb is pasted over the powder.

Burning Brimstone.—Wrap cotton around two small pieces of brimstone and wet it with gasoline; take between the fingers, squeezing the surplus liquid out, light it with a candle, throw back the head well, and put it on the tongue blazing. Blow fire from mouth, and observe that a freshly blown-out candle may be lighted from the flame, which makes it more effective. After lighting candle chew up brimstone and pretend to swallow.

Blazing Sponge Trick.—Take 2 or 3 small sponges, place them in a ladle; pour just enough oil or gasoline over them to wet them. Be very careful not to have enough oil on them to cause them to drip. Set fire to the sponges and take one of them up with the tongs, and throw the head back and drop the blazing sponge in the mouth, expelling the breath all the time. Now close your mouth quickly; this cuts off the air from the flame and it immediately goes out. Be careful not to drop the sponge on the face or chin. Remove sponge under cover of a handkerchief before placing the second one in the mouth.

Burning Sealing Wax.—Take a stick of common sealing wax in one hand and a candle in the other, melt the wax over the candle, and put on your tongue while blazing. The moisture of the mouth cools it almost instantly. Care should be taken not to get any on the lips, chin, or hands.

Demon Bowls of Fire.—The performer has three 6½-inch brass bowls on a table, and openly pours ordinary clean water (may be drunk) into bowls, until each is about half full. Then by simply passing the hand over bowls they each take fire and produce a flame 12 to 20 inches high.

Each bowl contains about 2 teaspoonfuls of ether, upon which is placed a small piece of the metal potassium, about the size of a pea. If the ether be pure the potassium will not be acted upon. When the water is poured into the bowl the ether and potassium float up, the latter acting vigorously on the water, evolving hydrogen and setting fire thereto, and to the ether as well.

The water may be poured into the bowl and lighted at command. In this case the potassium and ether are kept separated in the bowl, the former in a little cup on one side, and the latter in the body of the bowl. The water is poured in, and on rocking the bowl it is caused to wash into the little cup, the potassium floats up, and the fire is produced.

N. B.—The above tricks are not safe in any but specially made bowls, i. e., bowls with the wide flange round edge to prevent the accidental spilling of any portion of the burning ether.

The Burning Banana.—Place some alcohol in a ladle and set fire to it. Dip a banana in the blazing alcohol and eat it while it is blazing. As soon as it is placed in the mouth the fire goes out.

Sparks from the Finger Tips.—Take a small piece of tin about ½ inch wide and 1½ inches long. Bend this in the shape of a ring. To the center of this piece solder another small piece of tin bent in the shape of a letter U; between the ends of this U place a small piece of wax tape about ½ inch long. Take a piece of small rubber tubing about 2 feet in length and to one end of this attach a hollow rubber ball, which you must partly fill with iron filings. Place the rubber ball containing the iron filings under the arm and pass the rubber tube down through the sleeve of the coat to the palm of the hand; now place the tin ring upon the middle finger, with the wax taper inside of the hand. Light this taper. By pressing the arm down sharply on the rubber ball, the force of the air will drive some of the iron filings through the rubber tube and out through the flame of the burning taper, when they will ignite and cause a beautiful shower of sparks to appear to rain from the finger tips.

To Take Boiling Lead in the Mouth.—The metal used, while not unlike lead in appearance, is not the ordinary metal, but is really an alloy composed of the following substances:

Bismuth............	8 parts
Lead...............	5 parts
Tin................	2 parts

To prepare it, first melt the lead in a crucible, then add the bismuth and finally the tin, and stir well together with a piece of tobacco pipe stem. This "fusible metal" will melt in boiling water, and a teaspoon cast from the alloy will melt if very hot water be poured into it, or if boiling water be stirred with it. If the water be not quite boiling, as is pretty sure to be the case if tea from a teapot is used, in all probability the heat will be insufficient to melt the spoon. But by melting the alloy and adding to it a small quantity of quicksilver a compound will be produced, which, though solid at the ordinary temperature, will melt in water *very much below the boiling point.* Another variety of easily fusible alloy is made by melting together

Bismuth..........	7 to 8 parts
Lead.............	4 parts
Tin..............	2 parts
Cadmium.........	1 to 2 parts

This mixture melts at 158°, that given above at 208° F.

Either one of the several alloys above given will contain considerably less heat than lead, and in consequence be the more suitable for the purposes of a "Fire King."

When a body is melted it is raised to a certain temperature and then gets no hotter, not even if the fire be increased—all the extra heat goes to melt the remainder of the substance.

Second Method.—This is done with a ladle constructed similarly to the tin cup in a previous trick. The lead, genuine in this case, is, apparently, drunk from the ladle, which is then tilted, that it may be seen to be empty. The lead is concealed in the secret interior of the ladle, and a solid piece of lead is in conclusion dropped from the mouth, as congealed metal.

To Eat Burning Coals.—In the first place make a good charcoal fire in the furnace. Just before commencing the act throw in three or four pieces of soft pine. When burnt to a coal one cannot tell the difference between this and charcoal, except by sticking a fork into it. This will not burn in the least, while the genuine charcoal will. You can stick your fork into these coals without any difficulty, but the charcoal is brittle and hard; it breaks before the fork goes into it.

Chain of Fire.—Take a piece of candle wick 8 or 10 inches long, saturated with kerosene oil, squeeze out surplus oil. Take hold of one end with your fire tongs, light by furnace, throw back your head, and lower it into your mouth *while exhaling the breath freely.* When all in, close your lips and remove in handkerchief.

NOTE.—Have a good hold of the end with the tongs, for if it should fall it would probably inflict a serious burn; for this reason also no burning oil must drop from the cotton.

Biting Off Red-Hot Iron.—Take a piece of hoop iron about 2 feet long, place it in a vise and bend it backwards and forwards, about an inch from the end, until it is nearly broken off. Put this in a furnace until it becomes red hot, then take it in your right hand, grasp the broken end in your teeth, being careful not to let it touch your lips or your tongue, make a "face" as though it was terribly hard to bite off, and let the broken end drop from betweer your teeth into a pail of water (which you should always have at hand in case of fire), when the hissing will induce the belief that the portion bitten off is still "red hot"—it may be, for that matter, if the iron be nearly broken off in the first place and if you have good teeth and are not afraid to injure them.

Water Stirred Yellow, Scarlet, and Colorless.—Obtain a glass tube with one end hermetically sealed and drawn into a fine point that will break easily. Into an ale glass put a solution of mercury bichloride (corrosive sublimate, a deadly poison) and into the tube a strong solution of potassium iodide so adjusted in strength that it will redissolve the scarlet precipitate formed by the union of the two liquids. While stirring the solution in the glass the bottom of the tube (apparently a glass rod) is broken and a small portion of its contents allowed to escape, which produces a beautiful scarlet. The balance of the fluid in the tube is retained there by simply keeping the thumb on the open top end. Continue the stirring, allowing the balance of the contents of the tube to escape, and the scarlet fluid again becomes colorless. Before the scarlet appears the liquid is yellow.

To heighten the effect, another ale glass, containing only clean water and a solid glass stirring-rod, may be handed to one of the company, with instructions to do the same as the performer; the result is amusing.