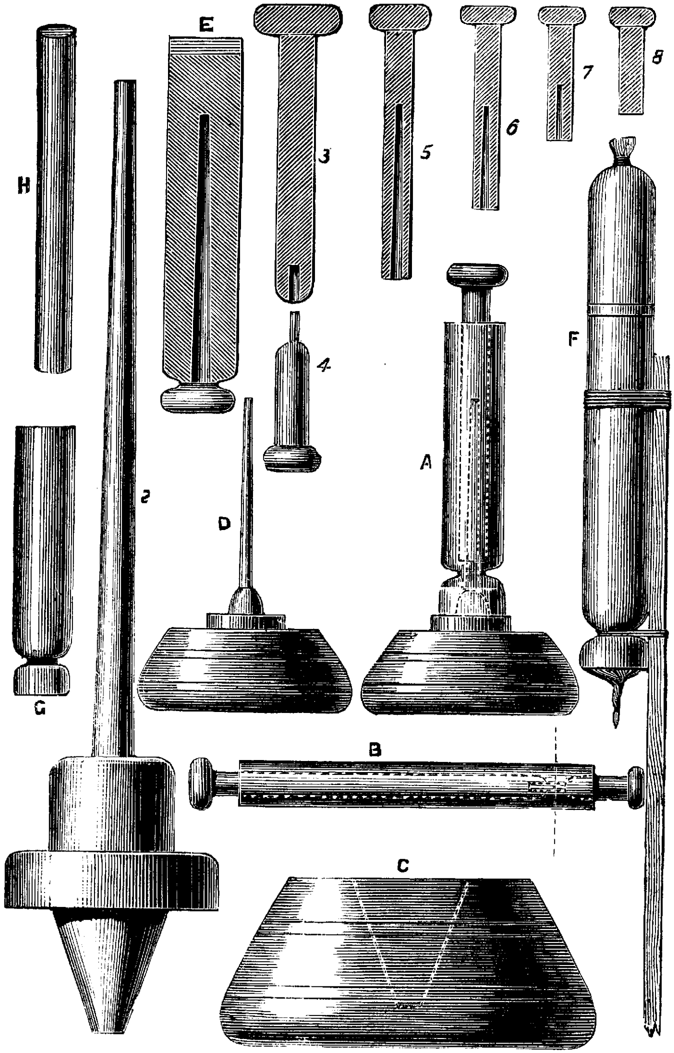

ROCKET MAKING APPARATUS (p. 11).

The Art of Pyrotechny:

BEING

COMPREHENSIVE AND PRACTICAL INSTRUCTIONS

FOR THE

MANUFACTURE OF FIREWORKS,

SPECIALLY DESIGNED FOR THE

USE OF AMATEURS.

By W. H. BROWNE, Ph.D., M.A., L.R.C.P., &c.

(Author of "Gun Cotton and other Explosive Compounds," "The Chemistry of Warfare," &c., &c.)

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PREFACE.

THE author's object in the present work is to give a lucid description of the various processes (chemical and mechanical) employed in the art of pyrotechny; such descriptions being illustrated with drawings and diagrams, designed by the author expressly for this manual, to simplify the work and render the task an easy one for the pupil and amateur; and he can most faithfully promise his readers that if they accurately and carefully carry out the instructions, they will be amply repaid for their labour and expense by the production of work fit for any exhibition that the most critical spectator might wish to witness.

Since the first appearance of his papers in *The Bazaar* newspaper, the author has been induced to make considerable alterations and arrangements, so as to simplify the manipulation in the hands of the amateur, and improve the pieces under construction.

The author most cordially thanks the readers of his former papers for the kind indulgence he has received at their hands for errors committed in publishing the series in their crude form, and he trusts that the additions and alterations here made will be received in the same spirit as that shown to him on his first appearance before them as a pyrotechnic author.

Several of the old formulæ have been re-written, and new ones added to the store, so as to give the best possible results with a minimum cost, this object being kept in view throughout the entire work.

Should this little work serve to amuse the old hand, as well as to give help and instruction to the amateur, the author will not consider his task to have been unsuccessful.

INTRODUCTION.

THE art of firework making dates from a very early period. The Chinese practised it, making offerings of this description to their gods and for the overthrow of evil spirits, several centuries before the birth of Christ. The Hindoos also made use of fiery projectiles for offensive purposes long before the birth of our modern Congreve rocket. Pyrotechny was first practised in Europe by the Florentines in the thirteenth century, and soon spread to France, Germany, Italy, and England. Modern chemistry has done much to improve this beautiful art, and, no doubt, as scientific research extends we shall have more valuable additions given to our store, and the art of pyrotechny will become an established science of no mean order.

The Greeks spread terror throughout the land by the introduction of that terrible (or rather diabolic) liquid Greek fire, the composition of which has given rise to so much dispute amongst learned men, both of the present and past generation, and one of the latest pamphlets published on pyrotechny speaks of this compound as consisting of " saltpetre, sulphur, and possibly petroleum or pitch," but all I can say upon this subject is that Greek fire cannot be made with these materials at all; the nearest imitation of this liquid that I can produce (at all resembling that spoken of by the ancient authors) is by dissolving phosphorus in carbon disulphide (CS^2). I most strongly urge upon my readers not to attempt to experiment with this fluid, its danger cannot be too highly overrated, or its use condemned; the only object I have in speaking of this compound, is to give an idea of its probable composition compared with its impossible one.

With respect to works of pyrotechny I have little to say, the simplest and best that has been published of late years is one printed by Wm. Underwood, Eden-quay, Dublin, in 1850, now out of print. The French press gave to the world "Chertier sur les Feux d'Artifice," and the Germans produced Martin Websky's "Lustfeuerwerkerei," which I believe to be the best work published on the subject.

We cannot remain ignorant of the fact, that,from want of good information, amateur pyrotechnists have abandoned in despair their frantic efforts to produce even bad imitations of pyrotechnic displays, and have, naturally, condemned works useless to assist them, leading them into grave errors, often ending in accidents injurious to the operator and his friends. I must here speak of the danger in the manufacture of fireworks. It is true that a number of the preparations, under certain conditions, are highly explosive, and that serious accidents have taken place by which many persons have lost their lives; but, when we take into consideration the gross ignorance, want of chemical knowledge, and reckless manner in which these explosive compounds are handled, we can only feel astonished that "Firework explosions" do not appear more frequently in the daily papers, and, if space would permit, I could give scores of instances in which I have seen such wanton carelessness used in the production of fireworks, not far short of amounting to suicidal mania, and their manufacturers fit subjects for a lunatic asylum. There is nothing easier than to make the practice of pyrotechny dangerous, but, at the same time, it is not only possible, but very easy, to manufacture fireworks without danger to the operator or yet risk to his habitation; and I shall again speak on this subject in different parts of this treatise and so render my instructions easier to comprehend.

The work will treat of the manufacture and scientific construction of the following works in pyrotechny:

"Rockets, of various sizes, with brilliant, coloured, and tailed stars, and gold rain, asteroid, magnesium, detonating, peacock's plume, and comet rockets," and the tools required in their construction; "Roman candles, brilliant and coloured;" "Gerbs and jets of Chinese brilliant and sparkling fires;" "Coloured (or peacock) gerbs;" "Wheel cases and small wheels;" "Colour cases for wheels, &c.;" "Comets and Flying Pigeons;" "Bengal Lights and Coloured Fires;" "Lances, coloured for devices, &c.;" "Saxons or Chinese Flyers, plain and brilliant;" "Mines of Stars, Serpents, and Crackers, and the various description of mortars employed;" "Tourbillons, plain and brilliant;" "Bomb Shells, and the mortars employed in firing them;" "Set Pieces of Various Designs, consisting of Brilliant Suns, Prince of Wales Plumes, Bouquets of Chinese and Brilliant Fire, Rainbow Wheels, Horizontal and Vertical Wheels;" &c., &c.

The first task I have to perform in commencing this subject is to describe the tools, &c., required in the weighing and mixing of the compositions and the manufacture of the rockets after the proper incorporation of the ingredients required in their construction.

I shall make use of two kinds of weights, the troy for weighing the composition for the cases, and the apothecaries' standard for the coloured stars and fires. It will be seen farther on why I have adopted this plan in preference to other methods. A set of troy weights, from 4 ounces down to a quarter of a quarter of an ounce, will be required, and a pair of scales with copper bowls, the same kind as small shopkeepers use to weigh tea in. These can be purchased at any ironmonger's at a trifling cost. Also a set of apothecaries' scales and weights, with brass pans. These will be found extremely useful in the household, or for trying small experiments. The weights consist of two drachms down to half a grain, so that small quantities of the chemicals for trying the strength of compositions or the colours of the stars can be weighed very accurately

The cost of such scales and weights, with oak box complete, will be about three or four shillings.

Sieves with receivers and covers, with brass or copper wire gauze, for mixing and sifting the composition will also be required; one, the mixer, with twenty meshes to the inch; the other, the sifter, with forty meshes to the inch; or to do the thing more economically, a fine hair sieve for the coarser one and a muslin one for the finer can be used. A very good plan, and one that saves a great deal of trouble and expense, is to have a zinc or brass drum made and a hoop to slide over the drum, by which a piece of muslin, of any texture suitable to the requirements can be stretched; this answers very well, and can be very easily replaced when worn out, this should have a receiver and cover. Fig. 1, B

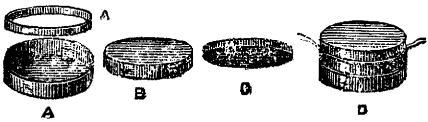


Fig. 1.

C A A sieve with hoop, cover and receiver. These, with the necessary scoops for weighing the compositions, can be purchased at any of the turnery or coopers' shops, but any handy carpenter or turner would soon be able to make one or two from these directions. Some tins (common biscuit tins or boxes will answer very well) for containing nitre, charcoal No.'s 1, 2, and 3, sulphur, and powdered clay, will be required; the other materials must be kept in well corked or stoppered bottles; I always use stoppered bottles for all my preparations; but let me give this piece of advice—if bottles with glass stoppers are used *for star or coloured fire composition, containing sulphur and potassium chlorate, do not let any of the ingredients get ground between the stopper and the neck of the bottle when the former is replaced, as several accidents have arisen from this careless trick,* but with ordinary care this will never arise, only have your bottles quite dry.

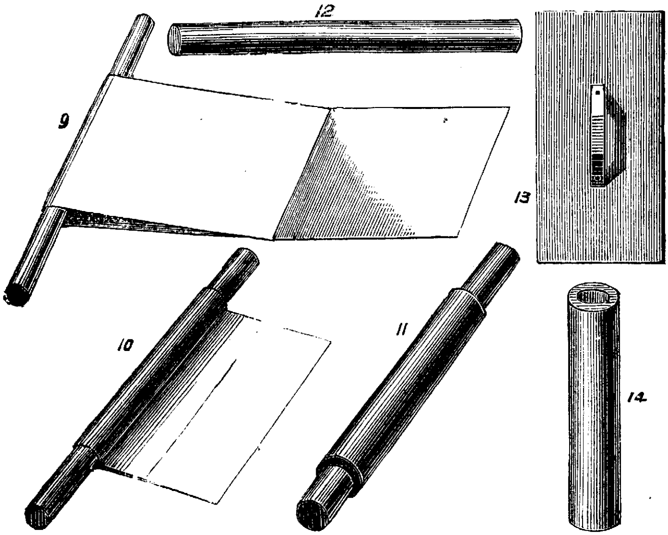
Never use a pestle and mortar, as by accident there may be traces of potassium chlorate and sulphur in the compound to be ground, and the result will be detonation. These accidents have occurred, I am sorry to say, but can easily be avoided. The golden rule should be *never powder or grind anything, purchase all the materials in fine powder* (*except charcoal Nos.* 2 *and* 3) *ready for use*; it is the cheapest and best, and will save much trouble and anxiety, remembering at the same time that the finer the materials are, the easier they are to incorporate and the better the result.

CHAPTER I.

ROCKETS.

In the construction of these, it must be remembered that patience and perseverance will be required to produce this king of fireworks, that we must not be daunted by any triffling failure that may occur; only find out the cause and never let it take place again.

Now comes the question of tools. These can easily be made by a good wood turner and machinist from the illustrations given.



The rockets I make are of six sizes, See following table:

Size of Rockets.

No. 1.	... $\frac{3}{8}$in. bore	... $\frac{1}{2}$oz. size		No. 4.	... $\frac{3}{4}$in. ,,	... $\frac{1}{4}$lb. size
No. 2.	... $\frac{1}{2}$in. ,,	... 1oz. ,,		No. 5.	... 1in. ,,	... $\frac{1}{2}$lb.
No. 3.	... $\frac{5}{8}$in.	... 2oz. ,,		No. 9.	... $1\frac{1}{4}$in. ,,	... 1lb.

The cases for rockets are rolled round a former, made of the proper size, from a piece of straight brass tubing, of a diameter proper for each description.

The	½oz.	former	should	measure	8in.	long and	⅜in.	in diameter.
,,	1oz.	,,	,,	,,	12in.	,,	½in.	,,
,,	2oz.	,,	,,	,,	18in.	,,	⅝in.	,,
,,	¼lb.	,,	,,	,,	14in.	,,	¾in.	,,
,,	½lb.	,,	,,	,,	16in.	,,	1in.	,,
,,	1lb.	,,	,,	,,	18in.	,,	1¼in.	,,

My directions will apply more intimately to the 2oz. and ¼lb. rockets; though I have given the six sizes that the amateur may choose just such size of rocket as suits his requirements and pocket.

The 2oz. rocket is the first that I shall describe as it is much simpler in construction than the larger description.

The Two-Ounce Rocket.—The diameter of this rocket will be found (on referring to the table) to be exactly ⅝in. diameter inside, or bore as it is termed. The tools that will be required for the construction of this piece of pyrotechny are rather numerous (*see* frontispiece). The rocket mould is the most essential tool; Fig. 2 is a full-sized drawing of the nipple and spindle for a two-ounce rocket. Fig. C, the wooden block for nipple and spindle completes the mould. See D, mould with block, complete. A, mould with case on spindle with drift inside the case, ready for filling with composition; Figs. 3 and 4 choking piece; Figs. 5, 6, and 7, hollow drifts; Fig. 8, solid drift. E, rocket case filled with composition, removed from the spindle; F, finished rocket with cap and part of stick, showing how they are tied to this appendage; B, choking piece inside case, ready for choking; dotted line showing the position of the string for this operation; G, finished rocket case; H, brass former for rolling cases.

The first step towards the production of the rocket will be making the case; do not be in a hurry about this part of the operation, the success or failure depends in a great measure on the good or bad workmanship of the case, and the quality of the paper and paste. The paste should not be too thin, but just sufficiently so to work well with the brush; let it be made in small quantities, so as to have it new and sweet. The paper that I use is the 70lb. imperial brown, the size of the sheet is about 29½in. by 22¾in.; this can be purchased at Messrs. Bolton and Co., 146, Holborn-bars, London, E.C., at 1s. 6d. per quire. Having the imperial brown paper ready, cut strips 4¾in. wide, and the whole length of the half-sheet, *i.e.*, 22¾in. long, or so; then take one of these strips and paste it well all over on its upper side. It is best to paste half a dozen sheets before the cases are begun to be rolled, then having spread some paste on the brass former to prevent it sticking to the paper, take one of the pasted strips of paper and place it flat on the table, pasted side uppermost, and lay the brass former across it about two-thirds from the end, and fold the paper over the former, and commence to roll the case as straight and as tight as possible. (See illustrations, from 9 to 12.) After all the paper has been rolled round the former, take the rolling board (Fig. 13), and roll the former and case well, in one direction only, that will be in the same direction in which the paper was first rolled round the tube. This operation presses out any superfluous paste, and makes the folds of the paper lie close together.

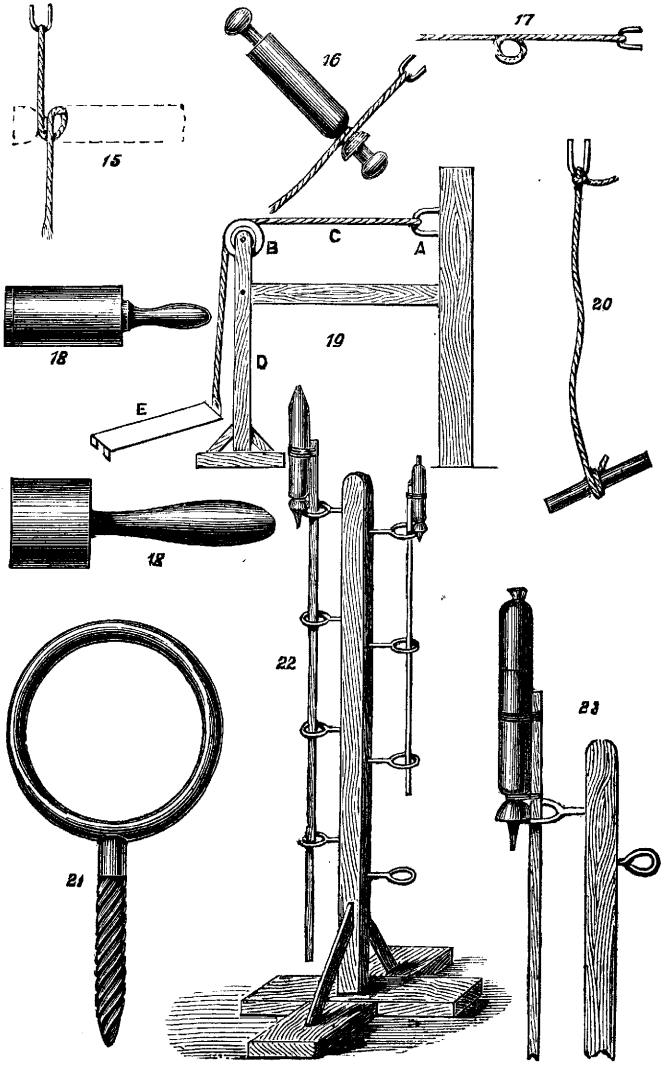
The case is now ready for the operation called choking, which is forming the mouth and neck of the rocket. There are two methods of performing this operation. One by the aid of the treadle machine (Fig. 19), and the other by the cord and stick or loop (Fig. 20); the former plan is adopted, I believe, by nearly all professional pyrotechnists, and when we come to consider the trifling cost of constructing such an apparatus, compared with its advantages, we can no longer hesitate about which course to adopt.

A thick wooden plug must be driven into the wall (Fig. 19) about four feet from the ground, to form a firm foundation for a strong wrought-iron staple A, to which is attached a piece of well spun cord about one-eighth or three-sixteenths of an inch in diameter (ordinary whipthong cord answers very well indeed for small cases, such as the ½oz., 1oz., and 2oz. size, but for the larger cases the cord must be of the dimensions given above), the other end must be attached to the treadle. The cord should then be passed round the case, about half an inch from the end, the choking piece having been previously introduced into the case, and by making pressure with the foot on the treadle E, the part will become contracted (Fig. 16) sufficiently to form the mouth and neck of the rocket. By rubbing the cord well with Castile soap the operation will be materially assisted, and by giving the case a gentle rolling motion backwards and forwards, making pressure on the treadle at the same time, the neck will be more uniformly contracted, and the case much less liable to be injured. This operation requires a certain amount of practice, but the task can soon be very easily and rapidly performed. It will be seen by referring to the illustration that the construction of the choking machine is very simple, and can be made very easily by a carpenter or joiner for a few shillings, so that I should strongly advise my readers to adopt this plan in preference to all others. The other method is by the cord and stick or cord and loop, one end being fastened to a staple in the wall, and the other end attached to a stick or loop; the stick being placed between the operator's legs, or the loop round his body, and by simply leaning backwards sufficient tension is given to the cord to choke the case in the manner described above. This plan answers very well indeed for the smaller cases of ½oz. or 1oz. capacity.

The aperture at the mouth of the case should be only just sufficient to admit the choking piece, it being formed of the right size when driven down over your spindle.

After the operation of choking has been performed, the choked part (or neck of the case) should be tied with some stout string to prevent its becoming enlarged beyond its proper size, *and while still damp from the paste*, take the case and drive it firmly down over the spindle with the longest drift. This renders the neck of the rocket case much harder when dry, and less liable to injury in the after-part of the performance.

Do not be in too great a hurry about drying the cases. Good cases can easily be spoilt by pushing this part of the process too rapidly, the longer they are in drying (up to a certain point) the better, only keep them away from the fire. The best place for them is a shelf or out-of-the-way place in a kitchen or warm room. If the rocket cases are well made and



ROCKET MAKING APPARATUS.

dried, they should be almost as hard as wood and as light as ordinary pine or white wood. This applies to all-sized cases for rockets, and those that do not come up to this standard should be rejected as useless, and condemned to the waste-paper basket.

The next step is the weighing and mixing of the composition; I do not think that the strength of the composition for any of these rockets need be altered. I may say without hesitation that I have experimented upon a great number of formulæ, first varying one ingredient and then the other, but with very little satisfaction to myself. My aim has been to construct a rocket with a rich tail of fire, unbroken throughout its whole course, majestic in flight, and with ample power to carry sufficient stars or other decorations to end its career nobly and worthy of its artist. The following formula is the one that I use for my two-ounce rockets, and I do not think that anything will be gained by altering it; it gives a rich tail of fire, graceful ascent, and good elevation.

Composition for 2oz. Rockets.

Nitre, 8oz.; sulphur, 1½oz.; meal powder, 2oz.; fine charcoal, 3oz.; charcoal, No. 2, 1oz.

I have one or two important things to mention with respect to mixing the composition. First, weigh out the proper quantity of coarse or No. 2 charcoal, as it is called, and place it on one side out of the way. Next weigh the nitre, sulphur, meal powder, and fine charcoal, and put them into the fine hair, muslin, or wire sieve, and rub them well through on to a large sheet of strong brown paper. After all of it has passed through, pass it through the coarse sieve, the one with forty meshes to the inch, called the mixer, two or three times, *then examine it closely to see that all the ingredients are well incorporated.* This being satisfactory, add the No. 2, or coarse charcoal and mix thoroughly. Do not be afraid of overdoing this part of the process, for a great deal depends on these directions being properly carried out.

The composition being in a proper condition for use, the next important step is the filling of the case. Take the 2oz. case, which must be perfectly dry and hard, and drive it down over the spindle with the longest of the hollow drifts (*vide* Fig. 5), then commence to fill the case with the composition, using a small scoopful at a time, and giving about ten or twelve blows of the mallet (Fig. 8) after the addition of each batch of the composition. The 2oz. mallet should measure in the head 5in. long and 2½in. diameter, and its handle about 6in. long, this will be found a most convenient size; it can be turned out of either ash or beech. Do not use too much composition at a time, the less that is used the firmer and more solid will be the finished rocket, and the less likely will the case be to come to grief in the performance. I use a small copper scoop about 1½in. long and ½in. deep, and just sufficiently wide to go into my cases, and I find that this filled about half or three-quarters with the composition is quite sufficient at a time during the filling of the case. One most important point is to have a firm and solid foundation for the rocket mould during the operation; a stone, or thick wooden block is the best.

When the case is filled about half way (this fact can easily be ascertained by measuring the height of the drift inside the case and then making a mark on the outside), take the second sized drift (Fig. 6) and go on filling the case up to the top of the spindle, two sizes only of the hollow drifts for the 2oz. rockets or the smaller cases will be required, but the larger ones require the three sizes given in the page of illustrations. As soon as the composition is about a quarter of an inch above the top of the spindle commence to use the solid drift; *be careful not to use this drift before the top of the spindle is well protected*, or either the mould will be injured or the drift will be split, accidents very annoying to those at a distance from the workmanship or materials for repair. Add the composition as directed before, and use the mallet freely for all the composition above the spindle, which should be driven hard and solid to the top of the mouth of the case; the proper quantity of solid composition to use above the spindle for a 2oz. rocket is from $\frac{5}{8}$in. to $\frac{3}{4}$in. If a case of the size given in my paper be used, and the mould of the same proportion, it will not be necessary to make any measure of the composition above the spindle, but simply to fill the case full up to the mouth. The rocket is now complete, so far as the ascending power is concerned, but I think it best at this stage of the proceedings to give full directions about the filling of the $\frac{1}{4}$lb. rocket, before I commence with the subject of rocket signals, decorations, &c. The construction of this size is the type of all rockets, having clay tops or plugs, to withstand the extra pressure exerted in raising them to their proper elevation, and (remembering the great law in mechanics, "what we gain in power we lose in speed"), we shall find that the flight of the $\frac{1}{4}$lb. or 1lb. rocket is comparatively slow, when compared with those of smaller size, but the height and majestic beauty of their ascent amply repays us for the labour and expense required in their production.

The $\frac{1}{4}$lb. Rocket.—This is exactly $\frac{3}{4}$in. bore, or internal diameter. The same kind of paper as for the 2oz. rocket, viz., the 70lb. brown imperial, will be required in making these cases. In addition to this, some two-sheet imperial pasteboard will be wanted. This is a kind of thin millboard, made from two sheets of brown paper pasted and rolled together; it can be obtained from Messrs. Bolton and Co., at 2s. the dozen sheets. The same firm will supply any chemicals that may be wanted.

The tools required for the $\frac{1}{4}$lb. rocket are of the same description and number as those given for the 2oz. rocket; but of course will differ in size. First there are the block, nipple, and spindle. The nipple should measure $\frac{3}{4}$in. in length, and the same in diameter; spindle 4in. long, diameter at the base, close to the nipple, $\frac{5}{16}$in., and at the point $\frac{5}{32}$in., gradually tapering from base to apex. Next there are four drifts, three hollow and one solid, and the choking and setting down piece. The first hollow drift should measure 6in. long, and be pierced 4in. to receive the spindle; the second 4in. long and pierced 2in.; third $1\frac{1}{2}$in. long and pierced just sufficiently large to fit the brass stud (Fig. 28); fourth, the solid drift, 2in. long. This measurement does not include the head. The hollow drifts should fit well in the case, but not too tightly, the solid one for the composition above the spindle, and the pierced one for the brass stud should fit as tightly as it is possible for them to be used. The $\frac{1}{4}$lb. mallet should measure in the head $5\frac{1}{4}$in. long and $2\frac{3}{4}$in. diameter, and the handle about 6in. long. The brass former is simply a perfectly straight piece of brass tubing $\frac{3}{4}$in. in diameter. All the various sized formers should be made from brass tubing, quite true, or the case cannot be rolled perfectly level.

I make all my $\frac{1}{4}$lb. rocket cases $6\frac{1}{2}$in. long; this is a little longer than the generality of this sized case, but with the composition I shall give it will not be wisdom to make use of a much shorter one, as the quantity of solid composition and the powdered clay will occupy all the room there is left above the top of your spindle. The case is composed of a strip of 70lb. brown paper $22\frac{1}{2}$in. long, and $6\frac{1}{2}$in. wide, and also a piece of imperial board $9\frac{1}{2}$in. long, and $6\frac{1}{2}$in. wide. The brown paper and board must be well pasted all over on their upper side, the brass former is then placed on the pasted surface of the paper in the position given. (*Vide* illustrations for rolling 2oz. cases, Figs. 9 to 14.) After the paper and former are in position, make one turn of the paper round the brass tube, then in the crease made by the paper in front of the former, place the end of the board pasted side uppermost and commence to roll the paper and board smoothly and evenly to the end; when all the paper, &c., is rolled quite tight round the tube, take the rolling board and roll the case well, so that all folds of the paper lie in close contact with each other; the case can then be slipped off and placed on one side ready for choking; this operation being performed in exactly the same manner as that described for the 2oz. case.

After they are quite dry, they may be filled with the composition:

Composition for $\frac{1}{4}$lb. Rockets.

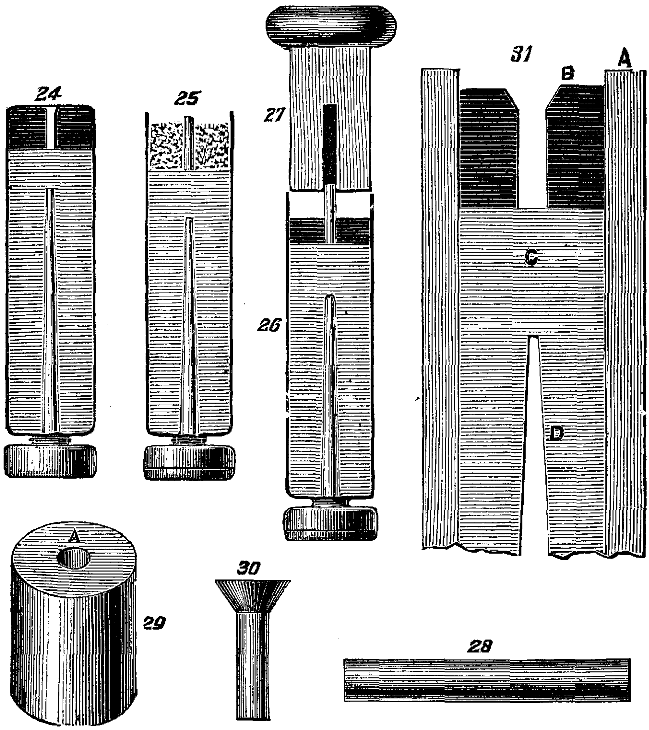
1.	2.	3. Fine fire.
Nitre, 8oz.	Nitre, 8oz.	Nitre, 8oz.
Sulphur, $1\frac{1}{2}$oz.	Sulphur, $1\frac{1}{2}$oz.	Sulphur, 2oz.
Meal powder, 2oz.	Meal powder, $2\frac{1}{2}$oz.	Meal powder, $2\frac{1}{2}$oz.
Fine charcoal, $2\frac{1}{2}$oz.	Fine charcoal, 2oz.	No. 1 fine charcoal, 4oz.
No. 2 charcoal, $1\frac{1}{2}$oz.	No. 2 charcoal, 2oz.	

These quantities will be found quite sufficient to make at once. I have given three formulæ for composition for the $\frac{1}{4}$lb. rockets. No. 1 is not quite so strong as those given at Nos. 2 and 3, but all will answer very well in the strength of case given. The latter are very rapid in combustion, and require great care in being rammed in small quanties hard and solid in the cases, and the clay at the top of the solid composition should not be less than $\frac{3}{4}$in. thick, and well compressed. I should advise the amateur to begin with the composition given at No. 1; it works very well indeed, and will give great satisfaction if all the directions are properly carried out. Nos. 2 and 3 require a great amount of care in filling the cases, and in nicely balancing the rocket; after that operation is complete, unless all the little items are accurately fulfilled, it will be found that the rocket when fired will either explode (*à la* maroon), or rush off in a direction not at all intended. Formulæ 2 and 3 are my own, and, when nicely prepared, cannot be surpassed; their rich, sparkling tails of fire and great elevation place them on an equality with a great number of $\frac{1}{2}$lb. rockets that I have seen fired by various first-class amateurs and professionals, but, at the same time, I strongly advise my readers not to attempt to make use of these compositions until they are well practised in the performance of that given at No. 1, and the use of tools has become familiar to them.

Having made choice of the composition, and prepared it ready for use, according to the directions already given for the smaller rockets, the case may be filled in the manner described before, only giving an extra number of blows with the mallet after adding each batch of composition. These should be about fourteen to sixteen in number for all the composition round the spindle, and from sixteen to twenty for that above the spindle and the powdered clay. I now suppose, for brevity's sake, that the case is filled with composition to the top of the spindle; the next question will be—What is the proper quantity of solid composition that should be above the spindle? If we use too much the rocket, on reaching its proper elevation, turns and begins to descend again before it fires the stars, &c. On the other hand, if we use too little, the stars are fired before it reaches its proper elevation, and gives an idea that it is in a great hurry to get through its performance, and its motto "Short and sweet." The proper quantity of solid composition required depends upon—first, the strength of the composition with which the rocket is filled; secondly, on the weight of stars it has to carry, or stick to which it is attached. If the formula given at No. 1 be used, and the case be not overweighted, $\frac{3}{4}$in. to 1in. of solid composition will be found quite sufficient for all ordinary purposes; but, if formulæ 2 and 3 are used, 1in. to $1\frac{1}{4}$in. will not be found too great a quantity.

When the case is filled with the solid composition above the spindle, some powdered clay will be required; this may be either common potter's clay, pipe clay, fire clay, or ordinary red brick clay. It matters very little which of these is used, providing it is quite dry and in fine powder; the latter is what I always use. It can be easily obtained at any of the brick yards, ready dried; when it only requires crushing with the mallet to be ready for use.

We now come to a very important part of our work, viz., heading the composition with the powdered clay. The old method was to drive a batch of powdered clay forcibly down over the solid composition, sufficient to withstand the pressure from the combustion during its flight, the necessary communication between the body of the rocket and the head containing the stars, &c., being made by simply boring a hole through the solid clay with a bradawl or gimlet down into the top of the composition; this operation was very much easier to describe than to accomplish, and required a great amount of care and skill—essentials not always found in amateur pyrotechnists. If this bore were not quite down on to the composition, the stars did not fire when the rocket reached its proper height, and if the boring operation were carried a little too far (an accident not at all unlikely to take place), the stars fired before the rocket reached its proper elevation, and the rocket still continued its flight passing through the cluster of burning stars. Another great objection to this plan was the danger of boring through clay (often containing particles of coarse silica) down on to explosive substances, an operation to be strongly condemned; also, the cracking of the clay during the boring, was sometimes to such an extent as to weaken the head and cause it to be blown out of the case before the rocket could leave the stand. My simple plan of operation is this: I take a piece of brass wire $\frac{3}{16}$in. in diameter, and $1\frac{1}{2}$in. long, this I call the stud (Fig. 28), and place it exactly in the middle of my solid composition and pack it round with



powdered clay with my fingers, pressing it well down so that the brass stud will stand upright without assistance—the clay should reach to the op of the case before commencing to drive it down—I then take the smallest hollow drift (Fig. 27), which should fit very easily over the stud, and pass it over the brass wire, and ram the clay down quite hard, using about sixteen to twenty blows of the mallet; I remove the drift and then add more clay, again driving this down quite solid, until I have the proper quantity, sufficient for each rocket, viz., the $\frac{1}{4}$lb., $\frac{1}{2}$lb., and 1lb. size. The other sizes given do not require this addition.

With respect to using the mallet, very little force will be required. The weight of this instrument alone should be almost sufficient to give force enough for what is required.

After the clay operation is completed, the next step will be to remove the brass; but this must be very carefully done. I find the easiest and best plan (and one not likely to injure the foundation of the clay) is to take a pair of small pliers or pincers, and, seizing hold of the end of the stud, gently turn it round, withdrawing it at the same time. If this be properly done, a clean round hole through the centre of the clay (Fig. 31 B.) down on to the top of the composition will be found. All that is to be done now is to pare the top of the hole carefully with the blade of the pocket-knife to give it the cupped or counter-sunk appearance given at Figs. 30 and 31. These are full-sized illustrations, so that there will not be any difficulty in seeing at a glance how far to carry this part of the process. What remains to be done now is to smooth the hole and top of the clay with the finger, shaking out any bits that may have entered this cavity; then remove the rocket from the mould. It is now ready for capping prior to receiving the necessary decorations, such as signals, stars, gold rain, &c.

Before I commence with the subject of the remaining sized rockets, I wish to speak of another method I have for heading large rockets, such as the ½lb. and 1lb. size; this is with the wooden plug, Fig. 29; these are turned out of pine, exactly the bore of the case, so that they will fit in nice and tight. I have them all made of one length, viz., 1¼in. long, but if it be wished to use a shorter plug for the ½lb. rocket, 1in. will answer very well. The plan of operation with these is to glue them in the case, on the top of the solid composition, with strong glue, which must be as hot as possible, or it will set before it is in position. The hole through these plugs should not be less than ¼in. in diameter. The advantage I claim for this improvement (and I speak from a great many years' experience) is the one of lightness combined with strength, over the old method with the clay tops. This is a great consideration in large rockets, especially those of 1lb. and upwards, and others that have to carry a great number of stars, or a still greater advantage in the Asteroid rocket, 1lb. size, which carries three changing stars, with their necessary appendages.

Fig. 31 is a full-sized sketch of the upper part of a rocket of the ¼lb. size, showing the hole through the clay, &c. Fig. 24, rocket complete, with clay top and finished hole; 25, rocket showing the stud surrounded with loose clay; 26, ditto with clay partly driven down; 27, small hollow drift; 28, brass stud; 29, wooden plug; 30, full sized section of hole through the clay tops for ¼lb. rockets; 31, full-sized sketch of upper part of ¼lb. rocket, showing clay, hole, and solid composition, with the upper part of spindle.

Having now given a description of the construction of the 2oz. and ¼lb. rockets, two distinct types of this specimen of pyrotechny, I think it will be best to retrace a little and begin with the ½oz. (or ⅜in. bore) rocket, and continuing the series throughout until I have given full and comprehensive instructions for the manufacture of all the sizes mentioned in my table that I have left undescribed.

The asteroid rocket will be fully described and illustrated later on as the manipulation and dexterity required in the construction of this piece is such that I am afraid to trust my favourite "in 'prentice hands" until my readers have become perfectly master of the rudiments of the art, and thoroughly competent to undertake the large and complicated rockets.

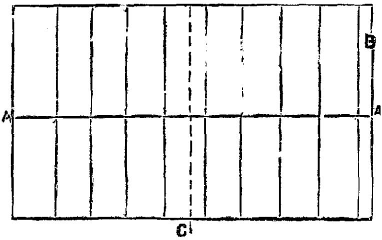


FIG. 32.

The ½oz. rocket will next claim our attention. On referring to the table given, it will be seen that it is exactly ⅜in. in diameter (or bore), and that the length of the case is about 2⅜in., or a little more. These are very easy to make, and should be the first rocket cases on which the amateur should try his skill. The rockets themselves are not at all difficult to construct, and when properly prepared are very pleasing in the performance, and give great satisfaction. In fact, a flight of these rockets during the performance of a set piece is by no means a bad finale to an exhibition of any sort, more especially one in which Roman candles are used in combination. The cases for these small rockets can be made either from cartridge paper or any other coloured or white paper that has substance enough. The paper that I use is called 35lb. brown bag cap paper, and can be obtained from Messrs Bolton and Co., of Holborn Bars, E.C., at 9d. per quire. This paper I also use for my 1oz. cases, and I find it answer most admirably. Eighteen strips of paper can be cut from one of these sheets; each strip will measure 2½in. wide and about 9¾in. long, one of these being sufficient for a ½oz. case. I have given a diagram showing how the paper can be cut to the best advantage. Fig. 32. Sheet of 35lb. brown paper opened to its full size; C dotted line, showing the crease caused by the natural fold of the paper. It should be folded down the middle of the long direction of the sheet, A A, and cut; the halves can then be divided into nine strips. A small portion of the paper, B, will be wasted. The cases may be made a little longer, when the whole sheet must be divided into eighteen equal parts; but my rule in making all rocket cases is to arrive at the exact strength of case suitable for each size, and not to let them carry one grain more paper than is actually necessary. Do not overweight them; but if this be done at all, let it be with stars, not with paper or wood; but by far the best plan is to be on the safe side, and rather give the rocket too little to carry than too much. The making and filling of the case will be performed in exactly the same manner as described for the other rockets. The tools required for this size will be of the same description as those given in the frontispiece, but of course will differ in measurement. The sizes of the tools for the ½oz. rocket are, nipple ⅜in. in diameter.

⅜in. long; spindle 1½in. long, and ⅛in. diameter at the nipple, and gradually tapering to a point; the former should be of brass, and measure 8in. in length, and ⅜in. in diameter. The mallet should measure in the head 4in. long, and 2in. in diameter, and the handle 6in. long. The drifts and choking piece will be in proportion to the size of the case, for which I have given directions. A cheap plan to make this sized mould is to have the block and nipple turned out of one solid piece of wood, and the spindle made of taper brass wire; this answers very well indeed, and will turn out some good work, but it will not last so long as one made of steel—the brass wire is apt to get bent or driven down into the block. I have only given an idea what can be done in a case of emergency by any country joiner; but I do not advise the adoption of this plan. The best tools are always the cheapest in the end, and save time and money, besides annoyance from failures. The proper composition for these rockets will be given under the head of 1oz. rockets.

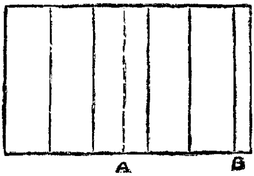


FIG. 33.

The next rocket on the list is the 1oz. or ½in. bore. For making these cases the same kind of paper as that described under the ½oz. size, viz., the 35lb. bag cap, will be required. This should be cut into strips 4⅜in. wide and 19½in. long, *vide* diagram of whole sheet of 35lb. paper: Fig. 33, A, natural crease of full-sized sheet; B, strip wasted after cutting the cases. One of these sheets of paper will furnish enough material for five 1oz. cases. It will be seen by the sketch that the strip is cut from the short side of the paper, the long side of the strip giving the length of the cases. The directions for making and choking cases that have already been given will also apply to this size. The composition that I use for the 1oz. rocket answers very well for the smaller kind, viz., the ½oz. It is very rapid in combustion, but, provided the proper sized stick be used, there will not be any cause to complain of its performance. The case can be filled in the manner already described, but especial care must be taken not to use the mallet too freely for the composition over the spindle, as these small moulds are very apt to get injured, and the drifts rendered useless, if this precaution is neglected. The same description of tools will be required for this rocket as for the others. The brass former should be 12in. long and ½in. in diameter: nipple ½in. diameter and ½in. long; spindle a little more than 3-16in. diameter (nearly ¼in.) at the base near the nipple, and should taper to ⅛in., and measure in length 3in.; the mallet for the 1oz. case measure 4½in. long and 2¼in. diameter, and the handle same as before; the drifts will also be in proportion to the size of the cases.

Composition of ½oz. and 1oz. rockets.

No. 1.	No. 2.
Nitre, 8oz.	Nitre, 8oz.
Sulphur, 1½oz.	Sulphur, 1½oz.
Meal powder, 2oz.	Meal powder, 2oz.
Fine charcoal, 4oz.	Fine charcoal, 3½oz.
	Charcoal (No. 2), ½oz.

I have given two formulæ; both will answer very well in either sized case, and give very satisfactory results. I consider No. 1 more suitable for the $\frac{1}{2}$oz. case, and No. 2 for the 1oz. size; but this is simply a matter of choice.

I now come to the $\frac{1}{2}$lb. (or 1in. bore) rocket. The 70lb. imperial brown paper and two sheet imperial board will be required for these. Too much care cannot be taken in rolling the cases; for unless they are hard and well made, they will be totally unable to withstand the strain put upon them by the combustion of such a large quantity of composition as they contain. Each case of the $\frac{1}{2}$lb. size is composed of a strip of 70lb. brown paper, 8$\frac{1}{4}$in. wide and about 29$\frac{1}{4}$in. long, and a piece of imperial board, 14$\frac{1}{2}$in. long, and 8$\frac{1}{4}$in. wide. Fig. 34 is a diagram, showing the most economical way of cutting the board. Each sheet will furnish sufficient for four cases, A, B, C, and D. The narrow strip, E, at the upper part of the diagram, can be divided into four equal pieces; each of these will be the exact size of board required for the 1oz. wheel-cases, so that there will not be any waste in cutting up the material in this manner. With the brown paper this will not be the case; each sheet will only furnish paper wide enough for two $\frac{1}{2}$lb. cases; these are cut the long way of the paper and must not be less than 8$\frac{1}{4}$in. wide. There will be a strip left in cutting the paper which will be useless for the $\frac{1}{2}$lb. case, but the odd bits of paper and board will always be found useful for smaller cases, asteroid pellets, guards, &c. The instructions given for rolling the $\frac{1}{4}$lb. rocket, and also heading the rocket with clay, will apply to this size. The drifts for this rocket should be exactly 1-16in. less than the diameter of the brass former; this is 1in., the length of the spindle is 5in., and measures $\frac{5}{8}$in. in diameter at the base, close to the nipple, and tapers to the end, where it has a diameter of $\frac{3}{16}$in. Three hollow drifts for this mould will be required. No. 1 measures 7$\frac{1}{2}$in. long (without including the head, and should be turned the same shape as given, at page 11), and pierced 5in., so as to readily admit the whole length of the spindle. The second drift must be about 5in. long and pierced 3in.; the third hollow drift is 2in. long, and pierced with a hole $\frac{1}{4}$in. in diameter, so as to admit the easy passage of the 3-16in. brass stud for heading the rocket with clay; this drift, which I call No. 3, should only be used for this purpose. The next drift is the solid one, 2$\frac{1}{2}$in. or 3in. long, and must fit rather tightly in the case, so that the composition above the top of the spindle may be driven down quite solid. The mallet for this size is 6in. long and 3in. diameter, without including the handle. The head drifts should fit easily in the case, but not be too small; this is a most important point to remember. The length given above does not include the head.

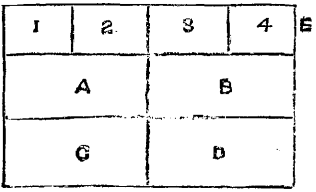


FIG. 34.

Having the cases ready to receive the composition, proceed to fill them after the instructions previously given, particular care being taken that the solid composition is well compressed. The proper quantity to use above the spindle is from 1in. to $1\frac{1}{4}$in., and the clay when driven solid above this should not be less than $1\frac{1}{4}$in. I give three formulæ for the composition :—

Composition for $\frac{1}{2}$lb. Rockets.

No. 1.	No. 2.	No. 3.
Nitre, 9oz.	Nitre, 8oz.	Nitre, 8oz.
Sulphur, 2oz.	Sulphur, 2oz.	Sulphur, $1\frac{1}{2}$oz.
Mealpowder, $1\frac{1}{2}$oz.	Mealpowder, $1\frac{1}{2}$oz.	Fine charcoal, 3oz.
Fine charcoal, 2oz.	Fine charcoal, 4oz.	No. 2 charcoal, $1\frac{1}{2}$oz.
No. 2 charcoal, 2oz.		

The formula No. 2 is an old one, and gives very good results, Nos. 1 and 3 are my own, the latter being given for those who wish to dispense with meal powder in the construction of $\frac{1}{2}$lb. rockets. Each of these formulæ have their distinguishing character, and the amateur must judge from their performance which he prefers.

It will be found much cleaner work, in filling any of the rocket cases with the ingredients, to slightly moisten the composition with methylated spirits ; a few drops will be quite sufficient. It is not necessary to make it damp, only to render the material less dusty, and, therefore, more comfortable to work with. In using the drifts, after adding each batch of composition, take great care not to press them straight down into the case on to the top of the loose composition, but gently *screw* them down with the thumb and finger. This simple operation prevents any part of the mixture being forced out at the top of the case by the pressure of the contained air, makes the work much cleaner, as also does the addition of the coarse, or No. 2, charcoal.

I come now to consider the best plan of finishing rockets, *i.e.*, forming the rocket cap, priming, and attaching the finished piece to the stick. All the rocket caps that I use for ordinary purposes are made from thin cartridge or demy paper, about three rounds of which will be found quite sufficient substance for all these appendages. The height of these should be (making a rough calculation) about half the length of the rocket they are intended to be worked with, but a great deal will depend upon the nature and contents of the rocket head.

The rocket is now ready for its cap or pot which is to contain the stars or other decorations that are to be used. Capping the rocket is a very easy operation and quickly performed. *Par exemple*, take a strip of demy or glazed cap paper,—that which is usually sold at 6d. or 8d. per quire—and cut a strip about $5\frac{1}{2}$in. long, and $2\frac{3}{4}$in. broad (Fig. 35), and paste it for about $\frac{1}{2}$in. in the direction of the dotted lines given on the diagram ; then take the 2oz. case and place it on the pasted strip of paper in the position given at Fig. 36, and roll it up straight to the end of the paper, the perpendicular edge of which being pasted will prevent it becoming unrolled. The rocket cap (Fig. 37) is now ready to receive the stars. After these are put in with their necessary composition, take the upper part of the cap and pinch it tightly between the thumb and fingers, so as to give it the conical appearance shown at Fig. 38, it should then be tied with string. It will be seen by the illustration given at Fig. 39 that the upper part of the cap should be tied tightly above the stars so as to prevent them rolling about.

There is another plan for finishing the large-sized rockets, such as the ½lb. and 1lb. size—this is with a conical cap fixed on to the rocket-pot—which gives the larger rockets a greater power in flight, as they offer less resistance to the air. This method can be applied to the ¼lb. size; but I find from a number of experiments that very little advantage is gained

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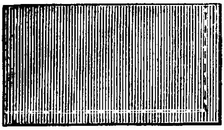

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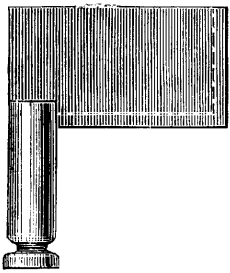

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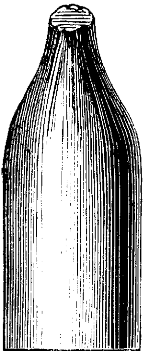

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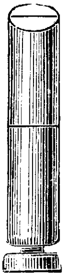

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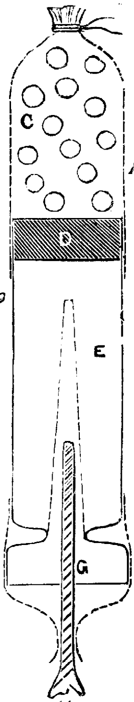


Fig. 39.—Finished rocket, ¼lb. size; A, rocket cap; B, top tied with string; C, stars; D, composition to ignite the stars and burst the cap; E, rocket cave; F, blue cap paper for quick-match; G, quick-match; H, igniting point of rocket.

with any rockets under the ½lb. size. For these caps a pot former, turned out of hard wood (Fig. 40) will be required. This must be about 5in. or 6in. long, without taking the length of the handle into consideration, and in diameter should measure exactly 1-16in. more than the external diameter of the case for which the pot is made; so that when the rocket pot is made on this former it will fit easily over the top of the case. Fig. 41 is the conical cap former, and is used to make the cones (Fig. 42), which are to be neatly pasted on the top of the rocket pots or caps. The base of these cones (A) should be exactly the same diameter as the pots, and should be placed in a perfectly upright position.

The rocket cap or pot is made by pasting and rolling a strip of thin cartridge (or brown) paper round the pot former, Fig. 40; when this is done draw out the former (by the handle) for about ½in., this will leave the

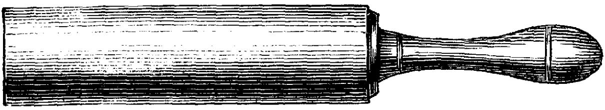


Fig. 40

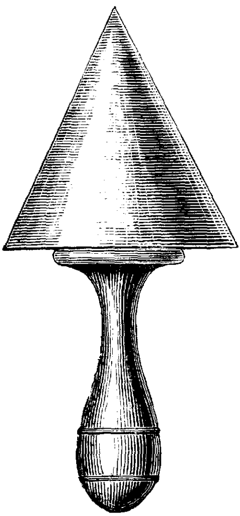


Fig. 41

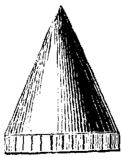


Fig. 42

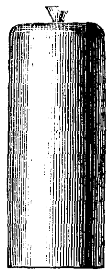


Fig 43.

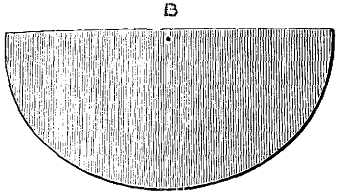


Fig. 44.

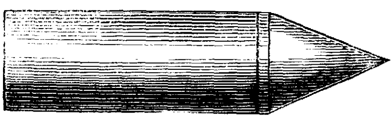


Fig. 45.

pot unoccupied for that distance; then take the upper part of the paper and turn it over the end of the former, and stamp it down on the work-bench board, so as to close the end, Fig. 43; this when dry is ready for the cone. These are also made out of thin cartridge or brown paper for the arge rockets,

The operation of forming the cones is exceedingly simple, and is performed in the following manner: Take the paper and cut out as many circular pieces as there are cones, the semi-diameter of which should be a little larger than the height of the cones required; cut these circular pieces of paper in half, then take one of these halves, and paste it all over on one side, and place it on the cone former (pasted side *uppermost*), taking care that the apex of the cone is at the point marked B in the diagram, Fig. 44; the paper is then to be folded neatly round the cone former, and made to sit nicely and smoothly on its surface. When this is accomplished take the other half circle of paper and place it over the top of the first one, pasted side *downwards*; the cone can then be covered with thin paper, which should project for about ½in. over the base of the cone, Fig. 42 (A). The lower part of this being nicked with scissors, so that it can be pasted evenly on the top of the rocket pot. When this operation is properly performed the finished pot and cone should present the appearance sketched at Fig. 45; these when thoroughly dry are ready to receive the stars.

The proper quantity of stars having been weighed out (suitable for each sized rocket) and put into the pot, some explosive compound to accompany them that will burst the pot and ignite all the stars when the rocket arrives at its proper elevation will be required. The best composition that I can give for this purpose is one composed of meal powder and fine charcoal, and which I designate as rocket pot composition. The formula for this is, meal powder 5oz., fine charcoal 1½oz., to be mixed well and kept in a bottle ready for use. Meal powder alone is too rapid in combustion to answer the purpose; it bursts the pot, and discharges the stars too rapidly, without giving them time to ignite; the addition of the charcoal renders the combustion much slower (without preventing the charge bursting the pots), and, therefore, gives the stars a much better chance of firing. With this composition and a properly constructed pot I have fired from my rockets ten out of twelve coloured cubic stars that have been condemned as useless for rocket purposes. The chief thing is not to have the rocket pots made too thick with paper—the thicker these are the greater the power required to burst them, and consequently the stars are discharged with such force that they have not time to ignite. After all the stars have been put in the pot, take a ladleful of the composition given for that purpose, and strew it amongst the stars. The finished cap can then be pasted over the top of the rocket; ½in. or a little deeper will be quite sufficient to give it a firm attachment.

Priming the finished rockets comes next. There are two methods of priming rockets—the one for exhibition purposes is to make a thick paste with meal powder and water. For this take a piece of flat stick or a small spatula and smear some of the paste in the cup at the choked end of the case, taking great care not to let any of this mixture enter the choke hole; should it do so, it must be removed when dry with a wire or bent pin. If this precaution be neglected, the rocket will be sure to explode when ignited, and so destroy the anticipated spectacle. The other plan of priming is the one that I have given in my illustrations, and is the one that I adopt for nearly all my ordinary rockets. It will be seen by the sketch given at

Fig. 39 how to make use of this form. Take a piece of thin blue demy paper, and paste it on its upper border and roll it round the choked end of the case, *vide* dotted lines F; this should project about 1in. over the end of the case, and is used to twist round the quickmatch G; the next step is to take some uncased quickmatch (about 2in. long for 2oz. rockets, the other sizes in proportion) and pass it through the choke hole into the body of the rocket for about 1in.; the other part of the match which is outside, should be twisted tightly round, with the blue paper, so as to give it the appearance seen at Fig 19. Should it project too far a small portion can be cut off.

The best method of priming for exhibition purposes is the following. Take a piece of quickmatch, long enough to reach up the hole of the rocket for half its length, and project half an inch through the choked part; divide or untwist the part projecting into two parts; one of these can be fastened to the cap of the rocket with meal powder paste, and the other will be in a line with the match in the body of the composition. The end of the case should then be covered over with cap paper pasted quite tight, in the manner in which preserve jars are covered. To ignite these, all that is necessary is to press the end of the lighted portfire through the paper, and the rocket immediately fires.

The rocket will then be ready for the stick, and the accompanying table will give an idea as to the size and weight of stick required for each different kind.

Rockct Sticks:

No. 1, ½oz. size, 16½in. long, $\frac{3}{16}$in. by ⅛in. square.
No. 2, 1oz. size, 2ft. 8½in. long, ¼in. square.
No. 3, 2oz. size, 3ft. 3in. long, ¼in. square.
No. 4, ¼lb. size, 4ft. long, ⅜in. by $\frac{5}{16}$in. square.
No. 5, ½lb. size, 5ft. long, ⅜in. square.
No. 6, 1lb. size, 6 ft. long, ⅜in. by ½in. square.

These should be cut out of pine or white wood, and be perfectly dry, straight, and free from knots. Too much care cannot be taken about the sticks, for unless the stick is light, dry, and perfectly straight, the result will be a failure. A very good plan is to have the sticks cut up at a saw-mill with a fine circular saw, from dry pine, free from knots, and selected for the purpose.

For those of my readers who wish to purchase their sticks ready for use and of the proper size given in the above table, I may state that Mr. T. G. Priddey, Steam Saw Mills, Droitwich, can supply them very cheaply from wood selected for that purpose, and constructed from models expressly prepared by me for rockets constructed on my principle.

One or two hints with respect to this subject will not be out of place here. If the stick be heavy the rocket will be over-weighted, and burn too long on the stand, consequently the flight will be diminished, and the proper effect lost. Should the stick not be dry the heat given out during the combustion of the rocket will cause it to bend, and the flight will be in a spiral instead of a straight direction. Do not make use of any kind of wood for rocket sticks, use only pine or white wood, the former is the one I most strongly recommend. Do not be tempted to try red wood. It is very cheap but too heavy for the purpose; and if it is attempted to reduce their weight by making the sticks thinner, the resin they contain will cause them to twist, and so render them useless. The most essential points to remember are to have the stick light, straight, free from knots and perfectly dry, and of exactly the dimensions given in the table.

On a former page of illustrations (Fig. 22), there is a design for a portable rocket stand and rings that I have constructed, which answers the purpose most admirably for firing rockets; the height of this stand is 6ft., and the rings are made of wrought iron, japanned or galvanised, to prevent them corroding. A full-sized ring is given at page 13 (Fig. 21). It will be seen by the sketch that the stand carries four rings on each side, placed at equal distances from each other, but, if wished, the four sides can be employed. When rockets are fired from this apparatus, place the foot or base of the stand perfectly level on the ground, choosing a firm foundation, then take hold of the upper part of the stand and tilt it towards you, so that you can conveniently slide the two or four rocket sticks through the rings, taking care that they pass through (not over) any of them—the mouth of the case with its end of twisted paper and quickmatch should rest just outside the upper part of the top ring (see Fig. 23). The rocket is now ready for firing, and this can be accomplished with the spirit flame or a portfire; the latter is more suitable for an exhibition or large number of rockets, the former is the one I always adopt for all experimental purposes. The spirit flame is made in the following manner: take a stick (a 5ft. rocket stick will answer very well indeed) and fix to the end a loop of soft copper wire, in the loop must be twisted a small ball of lint or cotton wick, this when moistened with wood naptha or methylated spirits gives a small flame, free from smell, soon ignited, or extinguished, and very suitable for firing rockets or small pieces.

Before I commence with the subject of rocket decorations, viz., stars, gold rain, and tailed stars, it will be best to give instructions for making touchpaper and quickmatch, &c.

Very good touchpaper can be made from white or blue double crown paper. Take a sheet of this and open it to its full extent on the table, and, having procured a flat brush or sponge, pay the surface of the paper over lightly with a warm solution of saltpetre (nitre); the proper strength of which is about 1½oz. of nitre to 40oz. of warm water, and only one side of the sheet need be wetted. The damp paper can then be hung on a line in a warm room to dry. This must be kept in a dry place ready for use. Very little of this paper will be required, but what is used must be *perfectly dry and clean*, for if this be neglected, some of the Roman candles may very possibly be suddenly "snuffed out," from the composition beneath the damp or dirty touchpaper refusing to fire after that above it has discharged its star. Touchpaper-making is not only a clean but a very simple operation, and this is much more than I can say with respect to quickmatch making, which I consider the most dirty operation we have in the whole range of pyrotechny, and, unfortunately for the amateur, if he procure this material ready made from the professional pyrotechnists, he will find it a most expensive item. It is the cheapest thing to make, but the dearest one to purchase. If the reader can face such dirty work, and has courage enough to carry it out, he will be amply repaid for his trouble by the production of one of the most useful articles connected with the art. I make all my own quickmatch, and I strongly advise others to do the same. It may be considered bigotry on my part when I say that I would sooner hold myself responsible for the perfect performance of a large and complicated fixed piece, not made by myself, if I had the making of the quickmatch and connecting the cases, than I would if the work were made by myself but connected with match made by other hands than my own.

The best plan to make quickmatch is to take some common round cotton wick (the same description as that employed for oil lamps, and sold in round balls at the ironmonger's or oil shops), damp it with the touchpaper solution, and place on one side to dry; then make a thick paste of meal powder and gum water (the proper strength for which is gum acacia 1oz., hot water 20 fluid oz.), and then unroll about 2yds. of the damp cotton and rub it well with the meal powder paste, so as to give it a thick even coating of this substance. It must be kept well twisted, so that the finished match is as round as possible. When the operation is complete tie a loop of string to the end and hang it up on a nail by the side of the wall to dry in a warm place. In summer it dries in the sun in an hour, but in winter it will take a much longer time indoors. When perfectly dry it should be hard and stiff, and the less it is handled the better; it can be kept in a tin box in a dry place free from dust. For rocket purposes this match only requires to be cut into the proper lengths, suitable for each size; but for connecting cases that are to be fired in numbers at the same time a different plan will have to be adopted. Thin paper tubes to receive it (or clothe it, as we say) must be made. These tubes are made out of thin demy or cap paper, round a former $\frac{3}{16}$in. in diameter, and each strip of paper must be wide enough to go three times round the former, and measure about 16in. in length. For large exhibition pieces tubes containing the match are sometimes more than a yard in length. These can be made simply by connecting the short pieces and pasting a small strip of paper round the joints to give them strength. The principal things to remember in making a great length of cased quickmatch is to have the ends of the match in close contact (if the length be made up of more than one piece) with each other, and the joints well covered with paper, so as to prevent it taking fire from any stray sparks before its proper time. I have laid great stress on this point as it will be found a most important one, and one not to be lightly passed over.

I now come to the most interesting part of our work—the construction of the various decorations required for rocket purposes.

The first decorations that I shall notice are rocket stars. The simplest form of these are in small cubes, and are called cubic stars, to which order belongs brilliant and tailed stars.

The second class are those of a cylindrical form, made in a tubular mould, having a small hole through their centre, by which they receive a priming of quickmatch. These are principally used for Roman candle purposes, but will answer very well indeed for large rockets.

The third kind are called pill box stars, and are the simplest form for the amateur to make. They are small tubes or boxes $\frac{3}{8}$in. in diameter and about $\frac{1}{2}$in. long, into which the coloured star composition is pressed together with a projecting end of quickmatch, which insures it igniting with much greater certainty than the ordinary cubic star.

The changing star is the next decoration, and one that no exhibition should be without; the beauty of rockets containing these stars cannot be too highly praised; and when we come to consider how easily they are made, we cannot hesitate about adding them to our stock, and so give us that variety which all pyrotechnic displays require.

We have another exceedingly beautiful decoration for our rocket heads, which is called golden rain; it is very simple to make, but requires a little patience on the part of the amateur. It requires a small paper case 2in. long and $\frac{3}{16}$in. in diameter, which is filled with a sparkling composition, and its mouth primed with mealpowder paste. It is then placed with its priming on the composition in the head of the rocket, and when ignited by the bursting of the rocket cap, describes a series of beautiful ringlets of sparkling fire.

Before I commence with the first star (the brilliant star) on my list, I have to call attention to two most important points on the production of coloured fires or stars.

First, the success or failure depends upon having the chemicals pure, in fine powder, quite dry, and the ingredients thoroughly mixed; the amateur cannot be too particular on these points.

Secondly, the safety or freedom from explosion (of coloured fires and stars) depends upon having the sulphur free from acid (sulphurous and sulphuric acids). If by chance any sulphur with acid properties is used with potassium chlorate, the compound containing it is liable at any time to spontaneous combustion—this danger can easily be avoided by washing the sulphur free from acid. The plan I adopt for this purpose is to take about 2lb. of flowers of sulphur, put it into a large stone jug, pour over it a quart of boiling water, and stir the sulphur about well. This water when cold should be poured off, and a second (or even a third) quantity of water used, until the water poured away from it ceases to have an acid reaction or cause a precipitate in a solution of barium chloride. The wet sulphur can then be thrown on a calico filter and washed with a pint of soda solution. This is made with common washing soda, the strength of 1oz. of soda to the pint of water. After all the solution has drained away from the mass, wash it again with *cold water* to free it from all traces of soda, and let it drain well, then spread it out in thin layers on plates, and place in a warm oven or room to dry; it can then be crushed down to powder with the fingers, and should be kept in a stoppered bottle for use. This sulphur is now perfectly safe for all coloured stars or fires, and *I must strongly impress upon the amateur the absolute necessity of only using sulphur that has been washed by himself or under his own superintendence, for all compositions containing potassium chlorate.* For any other star (*i.e.*, brilliant or tailed) or case composition ordinary unwashed flowers of sulphur will answer very well indeed, and is perfectly safe.

With respect to drying stars (and these directions apply to all kinds), the best plan is to take a common square biscuit-tin lid, or tin sheet with the edges turned up, and use it as a tray on which to arrange the stars; this can be placed on the oven top if not too hot; if hot place a fold of paper underneath the tin, and another over the top of the stars, which will thus dry in a few hours if the place be only warm. In summer they dry and get hard very rapidly in the sun; when dry the stars are ready for use.

The first formula that I shall commence with is that for common brilliant stars; but let me again strongly advise that all the ingredients for star composition be in very fine powder and perfectly dry; they cannot be too fine, or the composites too well mixed.

Composition for common brilliant stars.

No. 1.	No. 2.
Nitre, 8oz.	Nitre, 4oz
Sulphur, 4oz.	Sulphur, 2oz.
Black sulphide of antimony, 2oz.	Black sulphide of antimony, 1oz.
Meal powder, 1oz.	

The ingredients for both these formulæ must be in fine powder and well incorporated. They should be passed through the mixer (or 40-mesh sieve) three or four times. No. 1 is much more rapid in combustion than No. 2, and, therefore, better suited to the $\frac{1}{4}$lb. and $\frac{1}{2}$lb. rocket that carries large stars. No 2 will answer well for small rockets. These compositions can be made up into a damp mass with gum water, the proper strength of which for the brilliant stars is $1\frac{1}{2}$oz. of gum acacia to 20 fluid ounces of hot water; the less solution used the better, only just sufficient being required to make the material bind well when pressed into the shape of cubes. Stars of this shape can be rapidly moulded with the fingers, or a batch of the damp composition can be rolled out flat like a thick cake about $\frac{1}{4}$in. thick, and scored all over in squares or dice $\frac{1}{4}$in. wide with a spatula, after which the mass can be placed in a warm place to dry. When ready for use the cake can be broken in the direction scored by the knife. These will give a number of small cubes of brilliant stars of the size given above. With a little practice these stars may be made very rapidly, and as they are a very important article in rocket decorations, time and patience cannot be better expended than in acquiring dexterity in their manipulation.

The same plan of operation will be required for the next star on our list, and for which I give the following formula:—

Composition for tailed stars.

Nitre, 4oz.	Sulphur, 1oz.
Meal powder, 3oz.	Fine charcoal, 1oz.
Black sulphide of antimony, 2oz.	

For mixing this star composition raw linseed oil must be added to the gum water. The proportions that I generally use are $\frac{1}{2}$oz. of oil to 4oz. of gum water; the strength of the latter should be 2oz. of gum acacia to 20 fluid ounces of hot water. The gum water and oil should be put in a 6oz. bottle and made quite hot by placing the bottle in boiling water, afterwards shaking well until the oil and gum water are thoroughly mixed, or at least until no oil can be seen. This fluid must be used *quite hot* in exactly the same manner as directed for brilliant stars. If these directions are carefully carried out, the stars are exceedingly beautiful in their performance. When first fired by the rocket they have an ordinary appearance like the common brilliant star, but, after the illumination is over, each star forms a globular incandescent mass, which rapidly falls to the earth, leaving a bright tail of fire behind it not unlike a small comet; and, if they are properly made, the effect will continue until the stars reach the ground, forming a splendid contrast to other rockets containing golden rain or coloured stars. These stars can be made very cheaply, and are also very effective; they are therefore used in a much larger proportion than any other. They will keep well any length of time if kept in bottles in a dry place, and are perfectly safe, so that I should advise my readers to keep a small stock by them in readiness.

I now come to a most important subject, viz., the manufacture of coloured stars for rocket purposes.

When speaking of star composition in general, I have laid great stress on the importance of having the ingredients finely powdered. The chemicals for all coloured stars should be perfectly dry, in fine powder, and kept separately in well stoppered bottles ready for use, and I strongly advise that no more composition for these than is absolutely required should be made, as some, especially the crimson, are much better newly prepared.

One of the chemical salts mentioned in my formula for crimson stars requires great care in having it perfectly dry, this is the strontium nitrate, a very deliquescent salt; and unless it is thoroughly free from all moisture when used, the star composition made with it will be utterly useless. Messrs. Bolton and Co., or Mr. Page (late Page and Tibbs) will supply the dried strontium nitrate ready for use; but before using it I think it always best to make assurance doubly sure by placing the salt on a plate in a warm oven to drive off any moisture that may be present.

There are two forms of coloured stars used for decorations, the cubic stars employed by professional pyrotechnists (which is the quickest and most economical way of making large numbers) and the pill-box stars, more suitable for amateurs who only require a limited number, and expect these to appear to the best advantage. The latter form of star I shall only treat of in these papers.

The paper cases (or pill boxes, as they are called) are very simply made in the following manner: Procure a straight piece of brass tubing, 12in. long and ⅜in. in diameter, the same tube will answer that was used as a former for the ½oz. rocket cases. Then well paste all over on one side and neatly roll round the brass former some thin brown or cartridge paper cut into strips 7in. wide and 10in. long. When this is accomplished remove the case from the tube and set it on one side to dry. When dry, it will be very hard and stiff, and can be easily cut with a sharp knife into lengths of ½in. each, or rather less if wished. These will furnish a number of short cases or open pill boxes, into which the coloured star composition is compressed.

To fill these, procure a small wooden drift that will fit easily in the case, then pass a small piece of quickmatch through the empty case so that it will hang out at each end for ½in. or rather less. The case may then be filled by taking the moistened star composition and pressing it into the box with the drift, the overhanging quickmatch serving as a handle by which to steady it during the operation. If it be wished to make any trial with the composition (to test its colour) before using it in the rocket, the case may be filled with the star material in dry powder. The fluid employed in moistening these stars is a solution of gum shellac in methylated spirits of wine or wood naptha—the latter I prefer, though it is objectionable (unless used in the open air) on account of its smell; the former answers very well for all ordinary purposes, and is best suited for the amateur with limited space at his command; the proper strength of the solution is 1½oz. or 2oz. of shellac to 20oz. (fluid) of spirit, but this point is not very particular, provided the mixture be not too rich with shellac, as this injures the colour of the star. Do not make any of the composition wet with the solution; a very slight moistening is all that is needed to make the material bind well. When pressed into the cases, the less that is used the better the star will burn, and the deeper it will be in colour.

The first star that I give is the crimson, and it is in the production of this colour *that the greatest care must be taken with respect to the perfect dryness of the materials.*

Composition for Crimson Stars.

No. 1.	No. 2.
Strontium nitrate, 12oz.	Strontium nitrate, 8oz.
Potassium chlorate, 4oz.	Potassium chlorate, 3oz.
Pure sulphur, 3oz.	Pure sulphur, 1½oz.
Mercurous chloride, 2oz.	Chertier's copper, ½oz.
Fine shellac, 1oz.	Fine shellac, ½oz.
Chertier's copper, 1oz.	Fine charcoal, 1dram.
Fine charcoal, ¼oz.	

Both these formulæ give very good results. No. 2 is not so deep in tint as No. 1, but will be found useful for many purposes, especially when it is wished to prepare a number of stars at a small cost, the expensive article, calomel, being dispensed with in this composition.

The purity of colour in the crimson star depends entirely on the dryness of the ingredients, more especially in that of the strontium nitrate. It may not be out of place here to state that there are two kinds of colours used in pyrotechny. The first possesses a considerable depth of tint without a corresponding illuminating power—these colours are most suitable for wheels and lance work; the other kind has an intense illuminating power, with a slightly diminished effect in colour, and burns with great brilliancy. This is the one I choose for rocket purposes, and I do not think that my readers would be disappointed with the effect when the stars are seen from their proper height, remembering that all the colours appear of a deeper tint when seen from a distance. The next formula is for the

Composition for Rose-coloured Stars.

Precipitated strontium carbonate, 2oz.
Potassium chlorate, 6oz.
Mercurous chloride, 2oz.
Pure sulphur. $1\frac{1}{8}$oz.
Fine shellac, $\frac{1}{2}$oz.
Fine charcoal, $\frac{1}{4}$oz.

This is one of the most useful colours we have, it is not at all liable to suffer from damp in the autumn or winter months, and the stars when made will keep good for a long time, if kept in stoppered bottles. The strontium carbonate used for this colour is not a deliquescent salt, like the nitrate, and can be obtained in the form of a very fine powder, as the precipitated carbonate; there is another cheap form of this preparation called the native carbonate; this will not answer the purpose in such a satisfactory manner as the former. The colour of these stars is not as deep in tint as those prepared from the formulæ containing strontium nitrate, given for crimson stars, but when contrasted with a deep blue gives a very beautiful effect. There is another method of giving a pale rose tint to stars, viz., by the combustion of calcium with potassium, as calcium carbonate and potassium chlorate, but as these are only suitable for cubic stars, it is not my intention to enter into this subject at the present time.

The third colour is the green, and one that will require great care in the manipulation and the purity of the barium nitrate to give satisfactory results.

Composition for Green Stars.

Barium nitrate, 12oz.
Potassium chlorate, 6oz.
Mercurous chloride, $2\frac{1}{2}$oz.
Pure sulphur, 3oz.
Fine shellac, $\frac{3}{4}$oz.
Chertiers copper, $\frac{1}{2}$oz.
Fine charcoal, $\frac{1}{4}$oz.

This colour is very fine indeed, providing the barium nitrate is quite pure; it is on the purity of this salt that the success depends. If the salt be of good quality, and the ingredients well mixed, there will be a lovely colour of a rich emerald tint, leaving nothing to be desired. These stars form a beautiful contrast with the crimson, or mixed with the blue and crimson.

The fourth formula is for the production of golden-yellow stars. This colour is not very often used in pyrotechny; the best effect is seen when this colour is used in conjunction with an intense blue, when it produces a most magnificent effect.

Composition for Golden-yellow Stars.

No. 1.
Sodium oxalate, 4oz.
Barium nitrate, 7oz.
Potassium chlorate, 5oz.
Pure sulphur, 3oz.
Fine shellac, $\frac{3}{4}$oz.

No. 2.
Potassium chlorate, 3oz.
Sodium oxalate, 1oz.
Pure sulphur, 1oz.
Fine shellac, $\frac{1}{2}$oz.

The preparation of sodium used in these formulæ is a very satisfactory one, and not at all liable to deterioration from damp. The colour produced by this is very satisfactory, but does not possess that depth of tint which is given out by the combustion of the sodium nitrate; this chemical, although giving a richer colour, has the disadvantage of being a most deliquescent salt, and, therefore, unsuitable for the purposes of the amateur.

The blue and the purple stars are the most beautiful of all. I give three formulæ for this colour, and a fourth I shall designate by the name of purple stars, in contradistinction to the pale brilliant blue of the two former.

Composition for Brilliant Blue Stars.

No. 1.	No. 2.	No. 3.
Potassium chlorate, 5oz.	Potassium chlorate, 6oz.	Potassium chlorate, 4oz.
Copper sulphide, 4oz.	Chertier's copper, 3oz.	Copper sulphide, 1oz.
Chertier's copper, 3oz.	Pure sulphur, 2½oz.	Copper oxide, ½oz.
Pure sulphur, 2oz.	Mercurous chloride. 1oz.	Pure sulphur, 2oz.
		Mercurous chloride, 1oz.

Composition for Purple (or Violet Blue) Stars.

Chertier's copper, 6oz.
Potassium chlorate, 8oz.
Mercurous chloride, 3oz.
Pure sulphur, 1oz.
Shellac, ½oz.
Copper oxide, ¼oz.
Stearine, 1oz.

The first colours are not deep in tint, but have a very brilliant effect; the sulphide of copper, given in this composition, should be the *fused, not the precipitated sulphide.* The proper kind required for this purpose can be obtained from Messrs. Bolton and Co., or Page (late Page and Tibbs), either of which firms will undertake to supply any of the chemicals mentioned in these papers. The formula given for purple stars is one of my own, and when contrasted with a rich crimson or golden yellow, forms a truly magnificent effect; the colour appears of a deep violet blue (if I may be allowed to make use of such a word), rich in tone, and not deficient in a relative proportion of illuminating power. The composition for the Nos. 1 and 2 brilliant blue stars, can be made up with gum water, but I find that the solution of shellac answers best for the purple. These stars are perfectly safe, and not at all liable to spontaneous combustion, but if gum water be used for mixing them, it is always best to ascertain that the solution is not acid from being made too long before adding it to the composition, this prevents any risk; should there be any doubt as to its age, make a fresh solution.

The principal thing to remember in making the stars is to use shellac solution for the crimson, rose, green, golden, and purple, and gum water for the brilliant blue, or the shellac may be used for all the stars on the list, except the common brilliant and tailed stars.

I have made use of a preparation (in my blue stars) called Chertier's copper, so called from its inventor Chertier, the French pyrotechnist: this is a treble compound of copper chlorate with potassium and ammonium

When using any of these stars for rockets, do not forget to strew some of the rocket pot composition (recommended before) among them to insure their ignition—the projecting ends of quickmatch to these pill box stars, render them much more certain of firing than the ordinary cubic star.

The next decoration is called golden rain; these are small thin cases filled with a sparkling composition and primed with meal powder; to make these cases a brass former $\frac{3}{16}$in. in diameter, and 6in. long is required; also some thin brown or cartridge paper cut into strips 2in. wide, and long enough to go round the former three times; having well pasted one of these strips of paper, roll it round the former in the manner indicated by the sketch given at p. 10 (Figs. 9 and 10); this, when removed from the former and quite dry, is ready for use.

Before commencing to fill the cases with composition, close the end by turning it in; this is performed by taking one of the dry cases, and passing the brass former into it nearly to the end, the part unoccupied by the rod should then be neatly turned in so as to close the cavity of the case, and then stamped down on the board to render the end quite solid and firm; this part should be afterwards touched with warm glue and placed on one side to dry.

The filling is performed by the aid of a small funnel and wire, the funnel is usually made of tin, and has at its mouth a small brass tube, about $\frac{1}{4}$in. long and just wide enough to fit tightly into the mouth of the case, this will be equal in size to the external diameter of the brass former; the wire should be of brass, 1-10in. in diameter, and 6in. long, and may be attached to a small handle for convenience of working.

Composition for Golden Rain.

Meal powder, 9oz.	Fine charcoal, 3oz.

These must be well mixed before commencing work; when ready for use take one of the cases and place in its mouth the tube end of the funnel, then pass the wire down the neck of the funnel to the bottom of the case; having half filled the funnel with the above composition, steady the case with one hand, raise the wire a little by its handle, and drive it down again, repeating this operation, giving the wire a number of short but rapid strokes, until the composition is well compressed and reaches up to the mouth of the case. Each time the wire is raised a small portion of this powder falls round it into the case, and the descent gives pressure enough to consolidate it in the case. All that is required now is to fill up the cavity left by the tube of the funnel with meal powder paste, taking great care that the priming is well pressed in and fills it up to the mouth.

The beauty of changing stars cannot be overrated, and when we consider the simplicity of construction we cannot wonder at any exhibition being incomplete without them. The stars are made by taking some $\frac{1}{2}$-dram pill boxes, and charging them with two different colours, and matching them in the manner directed before. The colours I advise to be used in combination for this purpose are, purple and gold, purple and crimson, green and crimson, brilliant blue and crimson. Take one of the pill boxes and fill it half full with the moistened crimson star composition, pressing it well down with the drift, then fill the remaining portion of the case with the purple composition, and finish with quickmatch. This gives a magnificent effect when used in the ½lb. rocket, carrying eight or ten stars.

The portfires employed for firing rockets and fixed pieces are generally made in the following manner: Procure a brass former, 16in. long and ⅜in. in diameter, and also some thin brown paper, having the substance of 32lb. to the ream. Cut this into strips 8in. or 10in. wide, and long enough to go two or three times round the former. These can be pasted and rolled in the manner directed for golden rain cases and the finished case, when dry, can be filled by the aid of the "funnel and wire." The wire should be about ⅛in. in diameter, and the funnel correspond to the size of the case.

Composition for Portfires.

Nitre, 6oz. Sulphur, 2oz.
Meal powder, 1oz.

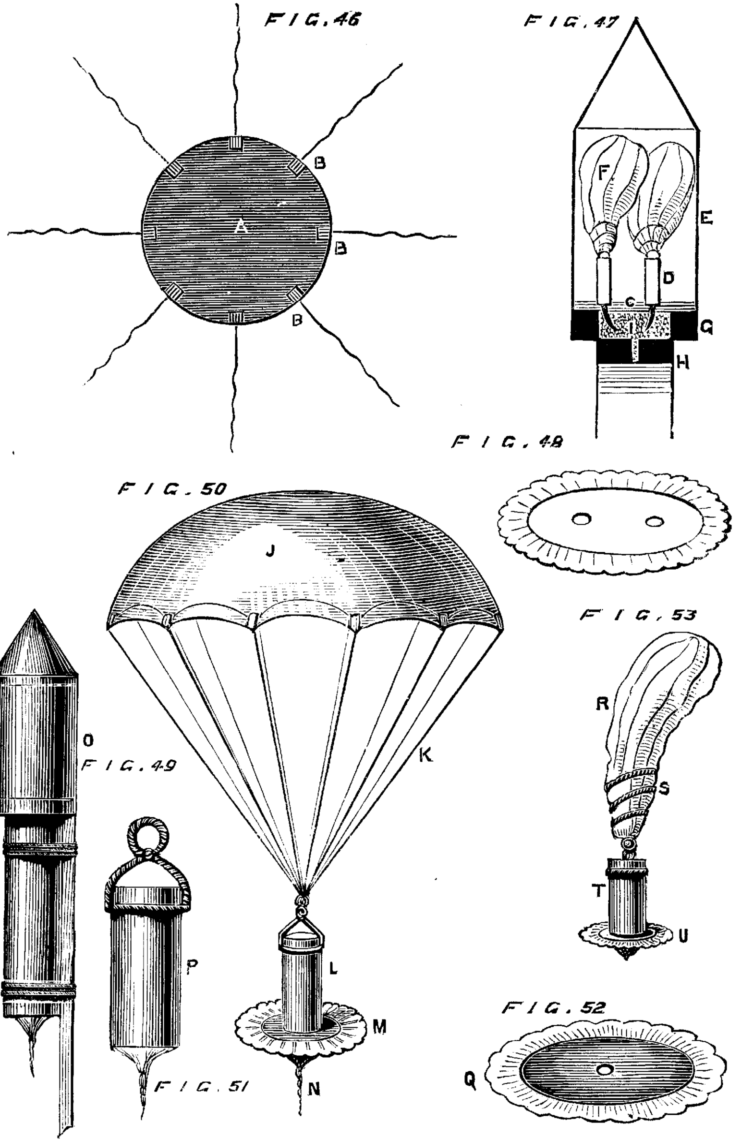
These must be primed with meal powder, as directed for golden rain. For firing large fixed pieces, raised some distance from the ground, a long rod made of wood will be required, to the end of which the portfire must be attached, by having a small piece of brass tube into which the end will fit; this should be quite tight, or a better plan is to have a steel spring made, like a port-crayon, to clasp the end of the case, by this means the old case is easily got rid of, and a new one quickly substituted in its place: for firing rockets the port-fire can be simply attached to a short stick.

The Asteroid Rocket.—The class to which this piece of pyrotechny belongs is in the first rank; as the rocket is the king of fireworks, so is the asteroid considered the queen of rockets. Very little published information has been given for the construction of this work, each professional adopting some different plan by which to obtain the desired object, viz., a floating parachute carrying a case of burning coloured star composition, which changes in rapid succession. These rockets were invented by the French pyros, and fired in this country, at the Royal Gardens, Vauxhall, by Darby, in 1849. One of the great drawbacks to the use of asteroid rockets has been the numerous failures that have occurred, and the danger (in agricultural districts) from fire, from the destruction of the parachute, and the consequent rapid descent of the burning case, not always in the exact spot that is wished. This tends to hinder its employment in places where accidents from fire are likely to take place; but with a properly prepared rocket and short-coloured fire case, there will not be anything to fear on this score.

The first step towards the desired object will be the selection of the proper sized rocket. Those usually employed are of the ½lb., 1lb., and 2lb. capacity; the two former will be all that any amateur need require. First, we must have a rocket of rapid flight, so as to attain the greatest elevation possible; and, secondly, the power will have to be greater than that employed for ordinary rockets of a like capacity, to counterbalance the resistance offered to their upward flight by the enlarged cap and case containing the asteroid apparatus. These are obtained by employing composition selected for the purpose and by carefully compressing it in a solid manner in the case.

With respect to case making the same directions given before will apply to both sized rockets. The ½lb. before mentioned will answer very well for the asteroid, and should measure exactly 8in. long and 1in. internal diameter. The 1lb. case measures 9¾in. long and 1¼in. internal diameter; the strip of paper for making this is the same length and substance (70lb.) as the ½lb. size, except that it is 9¾in. wide; and the imperial board should be the four sheet imperial pasteboard, supplied by Messrs. Bolton and Co.; the size of this strip of board is 14½in. by 9¾in., and will furnish a very stout case, that answers most admirably. The nipple is the same size as that given before for the ½lb., viz., 1in. in diameter; but the spindle differs in proportion to the size of the case—it must be 5½in. long, and measure at the base, near the nipple, ⅜in. in diameter, and tapering towards the point, where it measures ¼in. or a little less. A long hollow drift about 8½in. long will be especially required for this spindle. The 1lb. nipple is 1¼in. diameter, and the spindle measures 6½in. long and ½in. in diameter at the base, tapering to the point, where it measures ¼in., and the drifts for this mould will be made of a size corresponding to the others. The mallet for the 1lb. case should measure 6⅝in. by 3⅜in., and its handle 6in. long. The cases are constructed in exactly the same manner as given for other rockets, with this exception, the thick imperial four-sheet board used for the 1lb. size must be well soaked in hot water (before pasting) to soften it, before commencing to roll the case. Unless this is attended to there will not be sufficient pliancy to allow the aperture at the end to be choked close enough.

Fig. 46 is a circle of material A for parachute, with strings, B B B, attached; Fig. 47, section of asteroid cap, showing position of contents, two changing stars, C guard, D colour cases, E cap, F parachute, G collar attached to upper part of case, H clay with hole in rocket, I cavity for gunpowder charge between the guard; Fig. 48, asteroid guard for two cases; Fig. 49, sketch of finished rocket; Fig. 50, open parachute, with fixed case and guard ready for folding, J parachute, K strings, L case on guard M, N quick match; Fig. 51, colour case finished ready for attaching to the guard and parachute; Fig. 52, guard for single case, Q edge showing position of lint covering; Fig. 53, folded parachute ready for the rocket, S strings of the same wound round the lower part, T colour case, U guard with quick match passing through it.



ASTEROID ROCKETS.

Composition for the ½lb. Asteroid.

Nitre, 8oz.		No. 2 charcoal, ½oz.
Fine charcoal, 3½oz.		Sulphur, 2oz.
	Meal powder, 1½oz.	

This will give an excellent result if it be carefully prepared.

For the 1lb. rocket I use the following formulæ of my own:—

Composition for 1lb. Asteroid Rocket.

No. 1.	No. 2.
Nitre, 8oz.	Charcoal, ½oz.
Fine charcoal, 3½oz.	Sulphur, 2oz.
	Meal powder, ½oz.

Both these compositions must be well and evenly driven in the case.

As one description for this kind of rocket will suffice for the two sizes given, I have chosen the ½lb. in preference to the larger, as the one more likely to be employed by my readers.

The first thing to do is to choose some material for the parachute. This can be either thin cambric, silk, cotton, or tissue paper, the two latter are those that I recommend; glazed calico is a very good material, but must be thin and light; but tissue paper is the most economical, and gives results leaving nothing to be desired. These parachutes are constructed by taking a large full-sized sheet of thin tissue paper, and cutting out a perfect circle 22in. or 24in. in diameter—or a larger one if preferred—this helps to form the floating apparatus; next fold this sheet of paper in half and again in quarters, pressing the edges well down so as to leave a crease in the paper, which will give the circle a mark at its four equal divisions, again making a mark between each division; this divides the circle into eight segments, and these are the points to which the strings of the parachute will have to be attached. Next eight small square pieces of tissue paper, or, better still, small squares of blue double crown, the same kind as that used for touch paper, about ⅝in. square will be required, and also eight pieces of thin twine, 12in. or 14in. long. These latter are attached to the circle of tissue paper by placing them in position at the points indicated at the sketch Fig. 46 B B B, and, pasting one of the squares of blue paper over the end of the twine on to the circle of paper to make it secure. When all the strings (eight in number) are attached, the parachute is ready for folding. Fold it so as to form a cone, the base, being formed by the edge of the circle with its strings, and the apex by the centre of the circle. The ends of the strings and the edges of the paper should be all in close contact; the lower part of the strings can then be tied in a firm knot. By these means they are made all of one length and in the exact position for the colour case. To complete this apparatus, go over every inch of the circle of tissue paper, and rub it gently between the fingers so as to crease it well. The more that the paper is crumpled the better, but do not tear it.

The colour case comes next: this is made on a brass former, ½in. in diameter, and measures about 2in. long; four turns of 35lb. bag cap brown paper will give substance enough for the purpose. The case when dry is stopped at the end with a plug of thin paper, and the remaining length of the case nearly filled with coloured star composition pressed in dry, each different colour occupying about $\frac{1}{8}$in. the length of the case; the three colours that I use for this purpose are purple, crimson, and green, but others can be added if desired. When the case is nearly full, press into its mouth the end of a piece of quickmatch, $1\frac{1}{2}$in. long, and cap it with thin blue paper; this should be twisted tightly round the case end of the match, the other end must be left quite bare. The next step will be the forming of the rocket cap to contain the appendage.

On referring to Figs. 47 and 49, it will be seen that the upper part of the case has a collar or flange, so as to enlarge the cap to its proper dimensions; this is very simply made by taking narrow strips of well pasted brown paper and winding it round the upper part of the rocket case until the proper diameter is obtained; this is about $2\frac{3}{4}$in.

When quite dry, take a strip of 70lb. brown paper, 13in. long, and $5\frac{1}{2}$in. or 6in. wide, and having pasted the edges, roll it round the end of the collar so as to form the cap to the case (Fig. 47 E). This when dry should be lightly touched with glue at the collar part of the case. The cone can be made with a former turned to the size of the cap in the manner before directed; this cone is only fixed to the upper part of the cap with very thin tissue paper, so as to be easily blown off. Fig. 52 is the asteroid guard. This simple but indispensable article I have introduced on purpose for paper parachutes; they are easily made by taking a piece of strong pasteboard and cutting out a circle that will fit well but easily into the cap. Be very particular that the cap fits the guard well; this must be covered on its lower surface with a circle of lint, exactly $\frac{1}{4}$in. in diameter larger than the size of the guard. The object is to protect the apparatus from injury when being propelled from the rocket by the explosion of the powder charge.

The next step is folding the parachute, and this is done by simply bringing the lower parts closely together, and then doubling the parachute in half, the string with the attached case hanging down loosely all the time; next take the strings in a mass and wind them carefully round the lower end of the folded parachute—this prevents it from unfolding before its proper time, and also very materially lessens its bulk. The guard being in readiness, place it lintside downward on the table and bore in the centre a small hole that will admit the quickmatch from the colour case; the guard should then be pressed close to the end of the case, and the uncovered match project about $\frac{3}{4}$in. through the lower part of the guard, so as to insure ignition from the charge contained in the rocket cap, the paper case containing the changing colour (colour case) must be attached to the stump of the parachute by simply dividing the strings just below the knot and tying four of them on each side of the case, so that it may hang perfectly straight (mouth downwards) when burning.

The finished and folded parachute is represented in the sketch given at Fig. 53. I have only given directions for using one floating star in this rocket, and I think that it will be found quite sufficient for all ½lb. asteroids that amateurs may wish to make. The most important part of the work is placing the apparatus in the rocket cap. Everything being in readiness, place the rocket upright and examine it carefully and see that the cap is perfectly straight and the hole through the clay or plug free from any foreign substance at all likely to prevent the charge from firing; these points having been attended to, pour a drachm of gunpowder down the hole in the plug, and over this ¼oz., or a little less, of meal powder, this will completely cover the upper part of the case; next take the changing colour case, with guard attached, and gently press it down with its parachute on to the top of the powder charge. If this be carefully done at first, not a trace of powder can come in contact with the tissue paper; even should the rocket be roughly handled or turned upside down, the lint, acting as a valve round the guards, prevents all communication with the paper, and when discharged by the explosive force of the powder the cap guards the parachute from the fire. I have frequently been able to obtain these discharged parachutes, and in very few instances have I found them damaged so as to interfere with their proper performance. Having placed the apparatus in the cap, the next thing to be done is to fix the cone on the upper part of the case. This should be very lightly attached by a thin strip of pasted tissue paper, so that very little force will be required to blow it off.

The sticks that I use for my ½in. asteroid rockets are 5ft. long by ⅜in. square, and will just balance the rocket 1in. from the choke. I have before mentioned that I strongly advise the amateur not to attempt using more than one floating star in the ½lb. rocket, as it may only lead to disappointment. From my own experience I prefer to use only one changing star in each rocket, increasing the size of the parachute, bore and length of case in proportion to that of the piece with which it is used.

I have given a description of the tissue paper parachute used solely for the smaller rockets, containing only one changing star. I have now to deal with a more permanent but expensive form of floating apparatus that is used with rockets containing two or more colour cases, or those in which the case is increased in diameter and length, and consequently requires greater buoyancy to support it during its combustion.

The form of the parachute is square, and the material I employ is thin lining, only slightly stiffened or dressed, of a dark slate colour. Each piece of material should measure 22in. square, and any piece falling short of this size can have another piece neatly sewn to it so as to form a square of the right dimensions; four strings are then to be attached to the square, by simply tying them in a knot, one at each corner, and the parachute folded so as to bring the four corners together; the strings can then be tied at the end in a firm knot, ready for attaching to the colour case. Fold the square parachute so that the four corners, with the attached strings, are in juxtaposition ; then fold it in half, the strings and colour case hanging down at the same time ; it should again be gently folded in its long diameter, so as to take an oblong form, the strings should now be carefully wound round the colour case; this will not interfere with the rapid expansion of the parachute when discharged from the rocket. The case and guard are attached in precisely the same manner as described before. The advantages gained by this description of parachute are the simplicity of form and construction, and its greater buoyancy, by offering a larger surface for resistance in its passage through the air.

With the 1lb. asteroid rocket, I frequently use three small parachutes with colour cases 2½in. long by ½in. bore, containing eight changes, or I employ two large parachutes 24in. square each with a 2oz (⅝in. bore) case, 2½in. long, containing ten changes. The plan I adopt for filling these cases is a very simple one, and performed in the following manner: take a small drift 3½in. or 4in. long, of a size proper for each, and have it marked in the lathe into divisions of ¼in. wide all round; by this it is seen at a glance when the proper quantity of composition for each colour is in the case, by the drift rising to the height of one mark or division for each colour. The stick that I use for the 1lb. asteroid is 6ft. long by ½in. by ⅝in. square, of white wood; this sized rocket will carry three changing stars, if the cap be made 3in. larger than that given for the ½in. asteroid; but I strongly advise my readers not to employ more than two stars in *any* rocket.

A very simple plan for avoiding the trouble of cone-forming is to cover the upper part of the asteroid cap with a strip of demy paper, this should be about 3in. wide and sufficiently long to go twice round the cap. The middle of this strip must be on a level with the top of the rocket cap, the lower part being pasted to the piece; the upper part of this thin paper can then be pinched in and tied with twine, so as to form an imperfect kind of cone, in the manner described under the head of rocket caps. This plan answers very well indeed, and offers very little resistance to the passage of the parachute and appendage.

The remaining form of pieces I have to describe are the detonating, peacock's plume, comet, and magnesium rocket, and coloured cubic stars for rocket decorations and roman candles.

Detonating Rocket.—This is so called from the rapidly succeeding detonations which follow its explosion, after reaching the proper elevation. The sizes usually employed for this purpose are of the ½lb. and 1lb. capacity, and are simply classed under the head of pilot rockets, being used as a signal for commencing large exhibitions They are constructed in the following manner: take the rocket selected and attach to it a square cap, made on a former the size given for the asteroid; in this cap place (over the powder charge) a number of mine crackers with the quickmatch projecting in the direction of the hole in the clay, and between each layer of these place over the meal powder charge a small quantity (¼oz. for the ½lb. size) of the following composition: gunpowder, FF., 2oz.; No. 3 charcoal, ¼oz. When the rocket cap discharges its contents, a sparkling cloud of fire is seen intermingled with bright detonating flashes, not unlike forked lightning. The crackers used for this purpose are the same as those employed for mines, and can be obtained from Mr. Darby, Lambeth, London; or Mr. Copley, South-street, Moor, Sheffield, at 3s. 6d. per gross. They are very inexpensive, and therefore not worth the amateur's trouble making.

Peacock's Plume Rockets.—The rocket containing the peacock's plume is a simple but beautiful aërial decoration, constructed so as to give a resemblance to the tail of the gaudy bird from which it takes its name. The cap required for this is the same as that used for coloured stars. The brilliant part of the tail is produced by the aid of what professionals call Italian streamers; the coloured portion by that of small cubic stars. The manufacture of Italian streamers is anything but a clean or interesting operation, and will no doubt give the amateur some lessons in patience.

Composition for Italian Streamers

Meal powder, 8oz. Lamp-black, 4oz.
Black sulphide of antimony, ½oz.

The composition must be moistened with hot gum water, the bottle containing the solution must be kept quite hot by being placed in a small pan of boiling water (in the manner directed for tailed stars) during the time it is being used. Sufficient of the solution to form a stiff mass, or cake of the same consistency as that for brilliant stars, must be added, and this mass must be rolled out into a thin cake, a quarter of an inch thick, and scored with a spatula, to form (when dry and broken up) small cubes the size of peas. The object in making them of this size is to limit the brilliancy of their combustion, and to give a multitude of streams of fine sparkling fire of a rich red tint.

The Comet, or Shooting Star Rocket.—This is constructed with a cap containing a number of ½oz. rockets, to the head of which are attached small ½dr. pill boxes, containing white or brilliant star composition; the boxes are simply filled in the manner described in the instructions given for pill box changing stars, and firmly glued on to the head of the small rockets, the fire and case being both matched. I use six of these for the ½lb., and eight or ten for the 1lb. rocket. If this description of rocket be properly constructed, it will have a most pleasing effect. On the discharge of its contents bright lines of fire will pass rapidly in all directions, each tail of fire having a brilliant head.

Magnesium Stars and Fires.—These are decorations of comparatively modern invention. They are certainly the most brilliant, but, at the same time, the most costly ones we have to deal with, and, therefore, will be sparingly employed by those amateurs who make economy their study. There are two different forms of magnesium, viz., the powder or magnesium filings, and the metal in wire or ribbon; the first form of this is the one that I shall select for the requirements of the reader, the second is that employed where effect is the first item, and cost is only a trifling consideration.

The metal in the shape of filings is used in conjunction with a pure white fire, and employed either in the form of stars for rockets and shells, or in a case for parachutes or Bengal fire; the white fire that I use for this purpose is as follows :—

Composition for White Fire.

Finely powdered dry nitre, 8oz.	Realgar, 1oz.
Washed sulphur, 1oz.	Red lead, $\frac{1}{2}$oz.
Regulus antimony, $1\frac{3}{4}$oz.	Fine shellac, $\frac{1}{4}$oz.

All these ingredients must be in fine powder, and thoroughly incorporated.

The magnesium stars for rockets, &c., are constructed and matched on the open pill box principle—the formula for these is :—

Composition for Magnesium Stars.

White fire, 1dr.	Magnesium filings, 6gr.

This composition must be very slightly moistened with weak shellac solution, and well pressed into the open case with the accompanying quick match. These stars give a very grand effect when used in numbers; but should the amateur wish to increase the brilliancy of the stars, a greater quantity of the metal can be used, *i. e.*, 10 grains to the drachm; but the length (not the diameter) of the pill box will have to be increased, so as to make up for the rapid combustion. The most beautiful effect is obtained when a thin $\frac{1}{4}$in. case, $\frac{1}{2}$in. long, is employed with a composition containing two parts of white fire and four of magnesium; this preparation can only be used in thin cases, well compressed during the moist state, and perfectly dried.

Cased Composition or Magnesium Lights are used solely for asteroid rockets. The cases are of the $\frac{3}{8}$in., $\frac{1}{2}$in., and $\frac{5}{8}$in. capacity, and range from $1\frac{1}{2}$in. to 3in. or 4in. long. The same formula and directions will apply to these as for the latter mentioned stars, remembering that an addition (up to a certain point) of the metal means increased brilliancy and rapid combustion. After having chosen the case which is to be filled, stop up the end with a thin layer of powdered clay, firmly driven down ($\frac{1}{4}$in. will be quite sufficient), then fill four-fifths of the case with the moistened magnesium fire, the remaining fifth can be divided into two equal portions, for crimson and purple fires. We have then first a purple star changing to crimson, concluding with the brilliant (but short lived) magnesium light.

If a flight of magnesium rockets be required, it is much better to dispense with the two colour changes and use simply the whole length of case filled with the metallic composition.

Magnesium Coil Rockets.—The metal for these is used in the form of a large spiral coil, the band of magnesium being grooved for the introduction of a preparation to support its steady combustion. The large size of rockets (2lb. and 3lb.), and expensive coils of magnesium entirely place this piece beyond the reach of most amateurs, however ambitious they may be; the cost of these coils alone is from 18s. to 30s., and the parachute 3ft. and 4ft. diameter of fine silk, rendered waterproof, so as to be serviceable for stormy weather. A flight of asteroid rockets with short cases of rich magnesium fire, is a sight very rarely to be equalled, but the beauty of the 3lb. coil magnesium rocket (especially if fired on the coast and the light reflected from the sea), is one of the grandest spectacles that modern science can produce. The pure brilliant white light, the long duration of the effect, and marvellous appearance of the surrounding scenery, is a sight once seen never to be forgotten.

Cubic Rocket Stars.—I simply give the formulæ for their composition, with a few plain directions, leaving the minute details of the mould employed in their manufacture for the next chapter, under the head of Roman candles. The various sized moulds employed for this species of star range from ¼in. to ⅝in., according to the size of shell or rocket used with them. The amateur can (with very little assistance), construct several of these, so that he will have any size he is likely to require. The compositions can be made up into small cubes (without the mould) simply with the fingers, and will be found to answer best in this shape for shells and small rockets.

Composition for Cubic Stars.

No. 1. Crimson.

Strontium nitrate, 8oz.
Washed sulphur, 3oz.
Fine charcoal, ¼oz.
Potassium chlorate, 4oz.
Chertier's copper, ½oz.
Fine shellac, ½oz.

No. 2. Green.

Barium nitrate, 8oz.
Washed sulphur, 3oz.
Fine shellac, ½oz.
Potassium chlorate, 4oz.
Chertier's copper, ¾oz.
Fine charcoal, ¼oz.

No. 3. Violet-Blue.

Potassium chlorate, 6oz.
Copper sulphide (fused), ½oz.
Washed sulphur, 2oz.
Fine shellac, ½oz.
Chertier's copper, 4oz.
Mercurous chloride, 1½oz.
Stearine, ¼oz.

No. 4. Golden-Yellow.

Potassium chlorate, 6 oz.
Sodium oxalate, 3½oz.
Fine shellac, 1oz.
Barium nitrate, 7oz.
Washed sulphur, 3oz.

No. 5. Rose.

Potassium chlorate, 6oz.
Murcurous chloride, 1½oz.
Washed sulphur, 1½oz.
Strontium carbonate, 2½oz.
Fine shellac, ½oz.
Fine charcoal, ¼oz.

This last form of star is that which I employ for all large rockets, Roman candles, and also for some of my shells; the composition must be moistened with shellac solution, and made in a tubular mould described in the chapter on Roman candles. In all these formulæ I have endeavoured to give the richest colour possible, with the least amount of calomel, in some of these I have dispensed with this expensive article entirely, and I do not think that the colour effect of these compositions will dissatisfy the most scrupulous. These formulæ are my own (prepared especially for the requirements of the amateur), cheap, perfectly safe, and will keep all their rich properties unimpaired for months, if the stars be only perfectly dried and kept in a dry place in stoppered bottles.

CHAPTER II.

ROMAN CANDLES.

THE second firework on the list is the Roman candle. This variety of firework is rather complicated, and therefore difficult to construct, and will, to some extent, tax the skill and patience of the amateur; but the difficult manipulation is well worth mastering, for the beauty of the firework, when fired either singly or in numbers, surpasses any other fixed piece.

I shall first give a brief outline of the essential points to be observed in the construction of Roman candles, and then describe the three sizes that I use, giving all necessary details required for their construction. A Roman candle is a species of paper mortar, from which a number of brilliant or coloured stars are forced into the air in succession; giving at the same time a jet of sparkling fire between the performance or discharge of each star. The important points to remember are, first, to have the case well made of 70lb. imperial brown paper, and board hard, quite dry, and perfectly straight, so as to be able to withstand the explosive force of the successive discharges of gunpowder which accompany the stars. Secondly, to have a composition that will give a rich sparkling jet of fire, to burn in the intervals between the stars, which will produce as good an effect at the finish as at the beginning, or one that will throw a perfect jet of fire uniformly good throughout. Thirdly, to regulate the charges of gunpowder for each star, so that they will be blown out of the case to their proper height, without injury to the case or breaking the stars. Fourthly, to remember to have the stars quite hard (the harder the better), so as to withstand the pressure of the drift and the force of the explosion from the charge accompanying them. Fifthly, to have the composition between each firmly and evenly compressed; if this last point be neglected the composition will burn too rapidly, and a number of the stars will be fired in rapid succession or simultaneously.

The size or sizes of Roman candles must now be considered. I use three—No. 1, the 1oz.. $7\frac{1}{2}$in. long; No. 2, the 2oz., $9\frac{3}{4}$in. long; No. 3, the 2oz., $14\frac{1}{2}$in. long, and occasionally one of the same capacity, 12in. long, containing six stars. If made for firing singly, or in numbers without any other fixed piece, then the 2oz. Roman candle, $14\frac{1}{2}$in. long, will be found to answer best. The large-sized Roman candles will be the first to be described. The cases for these are constructed with a strip of imperial pasteboard, and a half-sheet of 70lb. imperial brown paper. A brass former will be required 18in. long and $\frac{5}{8}$in. in diameter, on which to make the cases, and particular care must be taken, after the case is made, to have the folds of the paper well rolled with the rolling board. The paper is used in the narrow direction of the sheet, and must be pasted well all over, and rolled after the direction given for rocket cases (*vide* former illustration). The sheet of board should be divided into six equal pieces, one of these being sufficient for each case; they require great care in drying, or they will twist and warp, and become utterly useless.

The case being dry and in a proper condition for use, the next step is the manufacture of stars; these are made in a tubular mould (Fig. 54), and, when finished, primed with quickmatch. The formulæ given for cubic rocket stars will furnish the composition most suitable for Roman candle stars; the cheapest and best for brilliant stars suitable for this purpose will be found at No. 1, and consists of nitre 4oz., sulphur 2oz., black sulphide of antimony 1oz., meal powder $\frac{1}{2}$oz.; if this be prepared with strong gum water, and the finished stars well dried, they will be nearly as hard as stone.

The tools required for manufacturing Roman candles will be found on the page of illustrations drawn full size. Fig. 54, brass tubular mould used for making stars; Fig. 55, brass drift, with stud (D) for star mould; Fig. 56, block (B) and settle or nipple (A) for supporting cases during the operation of filling, the end of the Roman candle case fitting tightly over the settle or nipple (A) which supports and keeps it upright; Fig. 57, finished star removed from the mould; Fig. 58, finished star primed with quickmatch, ready for the case. In addition to the above tools, a brass former (for case making) will be required, 18in. long and $\frac{5}{8}$in. in diameter; a box wood drift, 14in. long and $\frac{9}{16}$in. in diameter, that will fit easily into the case; a brass scoop (Fig. 59) for filling the case with composition, and also a small tin, or brass scoop, for measuring the proper quantity of composition used between each star.

With regard to star making; having selected the colour, moisten the composition (slightly) with the solution proper for each kind; I prefer to use the shellac solution for all the colours (except brilliant), as I am able to obtain a much harder star by this plan; the solution should be twice the strength of that employed for rocket purposes, but very little will be required, so that there need not be any apprehension about spoiling the colour with an excess of shellac. The composition having been slightly moistened, take the tube (Fig. 54), and pass the drift (Fig. 55) down it as far as it will go; the boss C. prevents it passing beyond the proper distance; on examining the lower part of the mould, a space will be found unoccupied by the drift; this is partly taken up by stud D., which forms the hole in the finished star. The apparatus should now be firmly pressed into the damp composition, taking care that the drift is not forced up

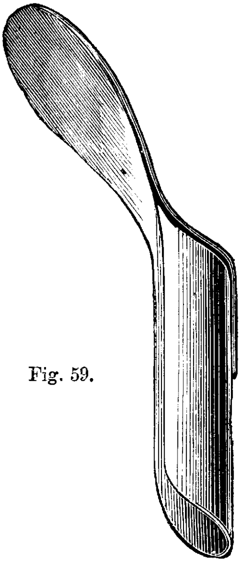


Fig. 59.

Fig. 56.

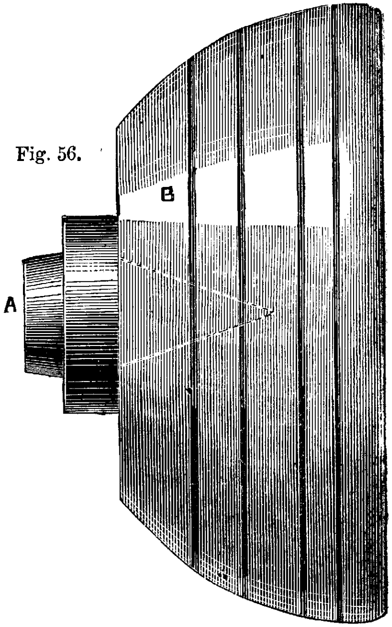


Fig. 55.

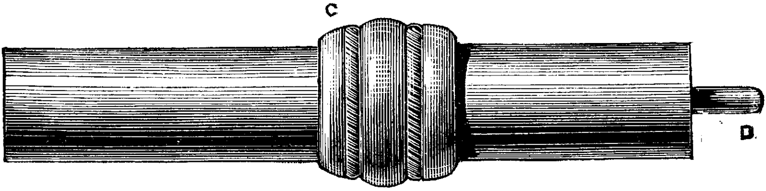


Fig. 54.

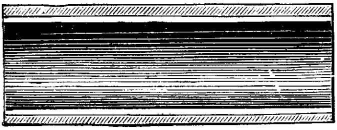


Fig. 57.

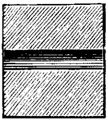
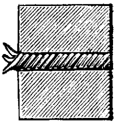


Fig. 58.



ROMAN CANDLE APPARATUS.

out of position. When the cavity at the end of the mould is full, press the drift well down on a flat surface; the stud end can then be removed and the other plain end substituted; this will push the star out on to the plate ready for drying. With a little practice these stars can be very rapidly made, and if large-sized rockets are to be made, the stars will be found very useful for this purpose if a small number are kept in stock. They can be dried in the manner described under rocket decorations, and kept in stoppered bottles ready for use.

The next consideration is, how to insure the rapid ignition of the star in the case, just before it is blown into the air? A great number of directions have been given on this subject, some of which are as absurd as they are useless; I shall select two of these as an example. One is to have the star coated with a combustible material, like meal powder, to make sure of the star taking fire; a second is to have a small hole in the centre of the star, in which a piece of touch paper, or quick-match is placed for a like purpose. From a great number of experiments, I have come to the conclusion that all priming used solely to insure the ignition of the star, is not only unnecessary, but absolutely injurious to the proper performance of the piece. All Roman candles that I have made (or seen made) with unprimed stars have fired all their stars, without exception, in a perfect manner, and, from that fact alone, I should consider the operation useless.

The great disadvantage under which I have laboured (in trying to produce a first-class piece equal to our French pyrotechnists), has been the inability hitherto to ignite the star and discharge it from the case at the same time; this difficulty, I am happy to say, I have overcome. By referring to the design for the tubular mould, it will be seen that the brass stud D in the drift does not reach to the bottom of the mould (when the drift is in position), by $\frac{1}{16}$in. The object of this is to keep the end of the stud out of harm's way when pressure is being made on the composition with the drift in the tubular mould, and also to prevent the end from becoming rough or bent; should this occur, the mould would be quite useless for producing a perfectly smooth star fit for Roman candle purposes.

The finished star turned out of this mould will have a hole through the centre, with the exception of $\frac{1}{16}$in., and before this part can be used it must be drilled or bored out with a pointed wire. This is easily accomplished, by taking the perfectly dry star and placing it quite flat on the table and passing a sharp pointed steel wire through the hole, so as to break a small portion of the bottom away (or drill it); if this be neatly done, there will be a perfectly round hole right through the centre of the finished star, Fig. 57.

The stars will now be ready for the quickmatch, some of which must be made the exact size of the hole, so that it will fit in easily, but not fall out; it should just reach to the bottom of the star, but not project out of the hole, and at the upper part should stand $\frac{1}{8}$in., or rather less, above the top of the star. By this method the star is fired by the quick-match, which at once conveys the fire to the charge of gunpowder beneath it, and is in its turn propelled from the case, so that it appears in the air in its young and vigorous form, and in all its full beauty. The advantages gained by this plan are—first, the increased distances which the stars can be thrown; secondly, the greater length of time they burn in the air; thirdly, their large size, and consequently increased brilliancy. In the old method the composition ignited the star and composition surrounding it, and burned for some time in the case before it could fire the charge of gunpowder beneath; consequently the case was weakened by the intense heat given out by the combustion of the star, and this when blown into the air, only represented one half the size it was intended to do, and very often split from the force of the explosion.

The composition that I use is as follows :—

Composition for Roman Candles.

Nitre, 8oz.	Fine charcoal, 3oz.
Meal powder, 4oz.	Sulphur. 3oz.

This formula is a very old one, and one usually employed by professional pyrotechnists; it answers either in the 1oz. or 2oz. case. Having weighed out the above proportions, pass them through the twenty-mesh sieve so as to thoroughly incorporate the mixture. The composition should be kept in a wide-mouthed bottle, well corked ready for use.

The next important step is charging the case with composition and stars. To accomplish this, take one of the perfectly dry cases and fit it over the end of the nipple A, which is made of the exact size to receive it and fits tightly into the case; by this means it will be kept perfectly upright and steady during the time it is being filled. The next thing to be done is to close up the end of the case; this operation is performed in the manner directed for the heading of rockets with clay, with the exception of using the brass stud. Sufficient powdered dry clay should be used as, when driven firmly down, will occupy from ⅜in. to ½in. at the lower end of the case, and form a strong foundation to the first charge of powder placed in the case.

The next part of the process is the most difficult and important one we have in Roman candle construction. This is the regulation of the charges of gunpowder which are required to blow the stars into the air. These differ in quantity, becoming larger as they get nearer the mouth of the case, the lower charges of course decreasing in a like proportion as they recede from the upper part of the piece. Great accuracy will be required in regulating these charges; if too small, the star will only roll out of the case, and not be thrown to its proper height; and on the other hand, if the charge be too large, the star or case (perhaps both) will be injured by the violence of the explosion.

The following table is the one I employ for my 14½in. 2oz. Roman candle, containing eight stars:—For the first star, 3gr.; second, 4gr.; third, 4gr.; fourth, 5gr.; fifth, 5gr.; sixth, 6gr.; seventh, 7gr.; eighth, 30gr. The gunpowder that I use is Curtis and Harvey's common F.F. sporting gunpowder, which can be purchased at any of the ironmongers. These charges of powder are smaller than those usually employed; but as they have to force a whole star out of the case (not one partially consumed, and consequently in a soft condition), they are quite large enough for Roman candles constructed on my principle. The rule is, that all explosive compounds exert more or less force in their combustion in proportion to the amount of resistance they have to overcome; therefore we must remember that the same charge of powder required to blow a star to the proper height from the lower part of the case would be found utterly useless when employed for one situated 2in. or 3in. from the mouth of the piece. The quality of the material will also have to be taken into consideration, for if the charges given in this table be not found sufficient with the quality of powder employed, some slight addition must be made, until the desired result is obtained. I make use of eight stars in my case, and I do not think that it would be wisdom to use more, or yet cheaper, on the other hand, to use less. If a smaller number be desired, use a shorter case, so as to save the composition. My rule is not to have more than 1½in. or less than 1in. of composition between each star, and also to have the charge of powder for the last star not shorter than 2in. from the mouth of the case. This is about the position of the last star in the case, if the directions that I have given be followed.

A very good method of measuring the charges of powder for the stars is to have some small brass scoops made which will contain the exact quantity for each charge, and marking each of them (on the handle) with the number of grains that they will contain, so that it can be seen at a glance which to select for any other size Roman candles. The way that I manage is (after having arranged the exact number of stars in rotation on my table) to weigh the proper quantity of powder for each charge with my apothecaries' scales and weights, and place it on a small square of paper opposite each star; by this simple means all mistakes are avoided, and a much greater degree of accuracy obtained.

After the clay has been driven down with the drift it is best to turn the case and block upside down, so as to shake out any loose clay or dust that it may contain; if this be neglected, very possibly the small charge of powder (3 grains) for the first star will be so adulterated with dust as to be useless, and the star will remain in the case and be wasted. The next point to be attended to is the arrangement of the colours in the order in which they are to be fired (*remembering that the first star that I speak of is not the first to be discharged when the piece is fired, but simply the first put into the case, and, consequently, the last one fired out of it*); this is quite a matter of taste, but whatever order of arrangement is chosen I should advise that the stars be placed in a straight line before the operator on his table (the first being nearest to him) about 2in. apart, and in front of each star be placed a piece of smooth paper 1½in. square, containing the gunpowder charge proper for each. A small tin scoop or measure to contain exactly the proper quantity of composition required between each star will be wanted. A good plan for obtaining a proper-sized measure (to have the tin or brass one made from) is to take a 1oz. chip ointment box and gradually cut it down with scissors until the proper capacity is arrived at. This should contain about 80 grains of the composition, when levelled at the top by drawing the edge of a spatula across it, and, when pressed into the case, occupies about 1¼in., or a little less.

The stars having been arranged in proper order, each one must be primed with quickmatch, in the manner previously directed, the first charge of powder should then be placed in the case, and on the top of this, the first star, with the long end of the match upwards; the drift should then be passed lightly down the case, to ascertain that the star is in position, and resting on the charge beneath. It is quite as well to do so with all the number, as the extra trouble is very slight, and often saves a great deal of annoyance from failures.

Next take the measure and lightly fill it with composition, passing the edge of a spatula over the top to level it; when this is done, the composition in the measure should weigh exactly 80 grains; this batch should be placed on a square of paper, to be divided into two equal portions, the first should be put into the case with the scoop (Fig. 59), and gently pressed down; the weight of the hand and the drift will be found quite sufficient without using any mallet. When this is done, take the second half of the composition and proceed in exactly the same manner; the advantage of this division is soon apparent, for if it is attempted to put the whole batch of material into the case at once, it will not get properly pressed down, and consequently the combustion will be too rapid, and a number of the stars will be fired in rapid succession; it will also occupy a greater space, so much so that the proper number of stars cannot be got into the case. The first batch of composition being in the case, a number of small pieces of touch-paper 1in. square will be required; take one and press it down on to the top of the composition, in the same manner in which a gun wadding is driven upon the top of the charge; the object in having this touch-paper is to prevent the charge of powder which is above from disturbing in its explosion the composition placed below it. On the top of this touch-paper place the second charge of powder (4 grains), and over this the second star, and following this the first half of the second batch of composition, then the second half, after this the touch-paper and third charge of powder (4 grains), and third star, and so on until the Roman candle is complete.

For firing these for exhibition purposes, meal powder paste can be used, a little being pressed into the mouth of the case, and a strip of paper 1½in. wide rolled round the mouth to receive the leaders from the other pieces; if it be wished to fire these singly, a strip of touch-paper pasted round the top and twisted will be all that is necessary.

The 1*oz. Roman Candle.*—This is filled in exactly the same manner as the 2oz. size; but, of course, a special mould for making the proper-sized star will be required. The strip of paper for this case measures 7½in. wide, and about 22½in. long, and is made round a brass former ½in. in diameter and 12in. long. A sheet of 70lb. brown paper will furnish material enough for four cases. This is exactly the same sized case as I use for my double Saxons or Chinese flyers, and it is in combination with these that they are principally used. Each case will easily carry four stars. The charges for these will be—for the first star, 3grs.; second, 4grs.; third, 5grs.; fourth, 20grs.; and the proper quantity of composition to use between each star is about 50grs.

The Short 2oz. Roman Candle.—The next size is called the short 2oz. Roman candle, and measures 9¾in. long; each sheet of 70lb. imperial brown paper will make three cases. Divide the full-sized sheet of paper into three equal parts in its narrow direction, and the sheet of imperial board into nine equal parts, so that three sheets of paper and one of board will furnish material enough for nine stout cases. These are exactly the same sized materials as those employed for the 2oz. Chinese gerbs. This size is also the one most adapted for using in combination with other fixed pieces, and will be found to last quite long enough for all ordinary occasions. Each case of this size should contain five stars; and they are filled in exactly the same manner as the other sizes; the charges of powder for the five stars will be—first star, 5grs.; second, 6grs.; third, 7grs.; fourth, 8grs.; fifth, 30grs. The same quantity of composition will be required between the stars as that given for the former 2oz. Roman candle.

These short Roman candles are not only very effective but cheaply made, and when used in combination with small fixed pieces, are exceedingly beautiful. The best colours for cases containing only four stars are purple, crimson, green, and rose; with larger cases a much greater variety can be had.

If the Roman candles are to be fixed singly it matters very little in what order the colours are arranged provided they harmonise; but when they are fired in numbers, some sort of order will have to be observed, so as not to let all the cases throw up one colour at the same time; for instance, suppose it is wished to make a kind of Prince of Wales's plume with three Roman candles, then the stars must be arranged so that each case should fire a different colour at the same time; thus, No. 1 should begin with a purple star, No. 2 with a crimson, No. 3 with a green, and so on; this plan is a very simple and effective one to put into practice, and one that greatly adds to the beauty of a display, by the harmony of its colour.

Before concluding my present subject, I will give another most excellent method of star manipulation which obviates the necessity of perforating the star, or for employing quickmatch. The composition for these stars can be made from the formulæ given for pill-box stars. These are slower in combustion than the cubic form; but with the plan I employ for keeping up the combustion during their expulsion from the case, they will not cause disappointment in their performance. The stars having been made with the proper composition, removed from the mould, and perfectly dried, are then ready for the operation. This is performed in the following manner: Take one of the dry stars and fill up the hole with a composition composed of equal parts of meal powder and coloured cubic star composition (*the same colour being selected as that of the star which is to be used*); this composition should be made into a thick paste with shellac solution, and pressed into the cavity of the star, and allowed to project about $\frac{1}{16}$in. above the top of the hole. The finished star should now be placed on one side to dry; next a small brass ladle that will contain from 4grs. to 5grs. of meal powder must be obtained, and this completes the armament.

To make use of this form of star for Roman candles, take one of them and drop it into the case over the gunpowder charge (meal powder part uppermost); next take the small ladle full of meal powder, 4grs. or 5grs., and pour it gently down the sides of the case on to the star, so that the greater part falls round the star, *i.e.*, between the inside walls of the case and the outside of the star, part of this also covering its upper surface. This small charge of meal powder acts as a quickmatch, and insures the rapid expulsion of the star from the case after its ignition, the strong composition contained in the cavity preventing its fire from being extinguished by the resistance it meets with in its passage through the air.

I have given these two different methods of manipulation for those of my readers who wish to compare one with the other, leaving them to decide which they consider the better to adopt.

CHAPTER III.

GERBS AND JETS OF CHINESE SPARKLING AND BRILLIANT FIRES.

THESE are some of the most beautiful and effective fixed pieces we have in the whole range of pyrotechny. They require a certain amount of care and dexterity in their construction, but if my instructions are accurately carried out, I have no doubt but that the amateur will consider he is amply repaid for any trouble he may be put to in mastering the details of their manipulation. There are no end to their arrangement or combination, and as the tyro becomes more proficient in the art, new designs will, no doubt, occur to his imagination, by which his displays will become more artistic and scientific. In these gerbs and jets we possess grand pieces for beauty and magnitude but with the great disadvantage of instability, the principal material required to produce Chinese and brilliant fires (and on which their beauty depends) consisting of cast iron borings for the former, and bright steel filings for the latter. These must be perfectly clean, bright, and free from oxidation, and unless this point is strictly adhered to, the piece will be simply a wretched imitation of what should have been a brilliant fountain of glowing scintillations.

Remember that all compositions containing cast iron borings or steel filings, with nitre or mealpowder in combination, are prone to rapid oxidation, and should such chemical change take place in the ingredients before being fired, the result is simply worthless, and the time and money thrown away. The question will naturally arise, how are we to prevent this? and the only answer I can give is to have the cases filled as shortly before they are used as possible. In winter, two or three days is the full extent that they should be kept, but in summer, this time may be exceeded by a few days. My rule, in constructing all large fixed pieces containing gerbs or cases of brilliant fire, is to complete the fixed pieces with these exceptions, and fill these cases a day or two before they are to be fired. By such an arrangement all failures are avoided, and the full effect obtained. A great number of experiments have been tried to preserve these metallic particles from corrosion; their number is legion, but one and all have failed to give first class results, any coating given to the metal to prevent oxidation interfering with its combustion on the presence of oxygen, and it is in the rapid and complete combustion alone that the beauty of this fire depends.

The cases for Chinese fire should be of the 2oz., ¼lb., and ½lb. capacity; the first is the one I most strongly recommend for fixed pieces, the two others answer best for mine purposes or firing singly. It will not be wisdom to attempt to use a smaller case than the 2oz. size for this fire, as the coarse particles of cast iron injure the neck of a smaller case. These 2oz. cases are made round a brass former ⅝in. in diameter (the same former that I described for the 2oz. Roman candles will answer this purpose) and 18in. long. One sheet of 70lb. imperial brown paper will furnish enough materials for three cases, this is cut into three equal parts, the narrow direction of the sheet (*vide* Fig. 60, diagram of full-sized sheet of paper A dotted lines showing natural crease), each strip will measure about 22½in. long, and 9¾in. wide; with each of these a strip of imperial board will be required to give substance enough to the case, the board must be divided into nine equal parts (Fig. 61), *i.e.*, three divisions on the long and the same number on the narrow direction of the sheet, so that three sheets of paper and one of board will furnish material for nine cases. These must be well pasted, and rolled in the manner directed in my former papers, when speaking of case-making, and choked on the principle of rocket cases, only remembering that the rule in choking all gerb, brilliant, and wheel cases, is to compress the neck of the case until the choke aperture is only half the diameter of that required for rockets, the exact size (on which the proper performance of the piece depends) is given to the orifice when driven down over the nipple, before commencing to fill the case.

The case having been properly rolled and choked, it should then be lightly driven down over the nipple (Fig. 64), and placed on one side to dry; the choked hole should not be more than one-third the interior diameter of the case when driven down.

Chinese fires.—We have two different descriptions of Chinese fire, viz., the red and the white, the former is that which contains particles of coarse charcoal, and, therefore, has some red sparks intermingled with those produced by the iron; the white (on the other hand) is formed by the combustion of the particles of iron alone.

Composition for Red Chinese Fire for 2oz. or ¼lb. cases.

Mealpowder, 10oz. Nitre, 2½oz.
Cast iron borings, 4oz. Sulphur, 1½oz.
No. 2 charcoal, 1oz.

The charcoal given in this and the following formula is the No. 2 used for rocket composition, but if the No. 1, fine, be used in place of the coarse, it will have a very pleasing effect.

Composition for Red Chinese Fire for ½lb. cases.

Mealpowder, 6oz. Sulphur, 2oz.
Nitre, 4oz. No. 2 charcoal, 2oz.
Cast iron borings, 8oz.

FIG. 60

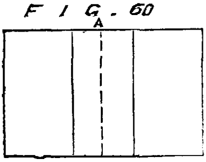


FIG. 61

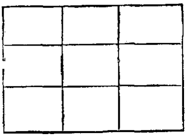


FIG. 62

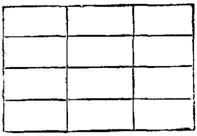


FIG. 64

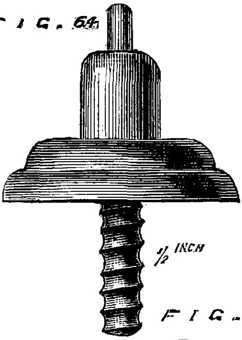


FIG. 63

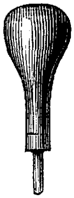


FIG. 65

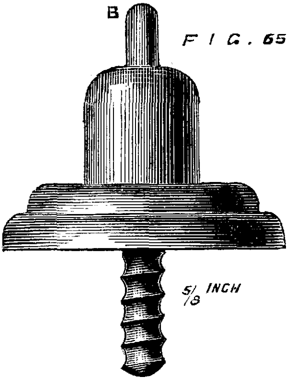


FIG. 66

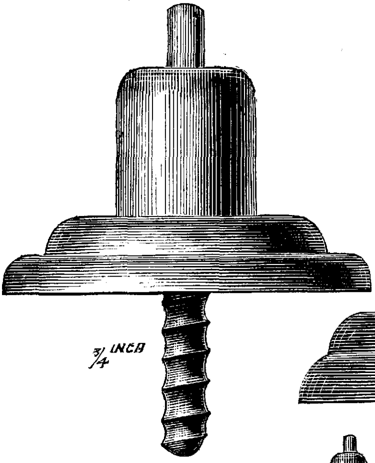


FIG. 67

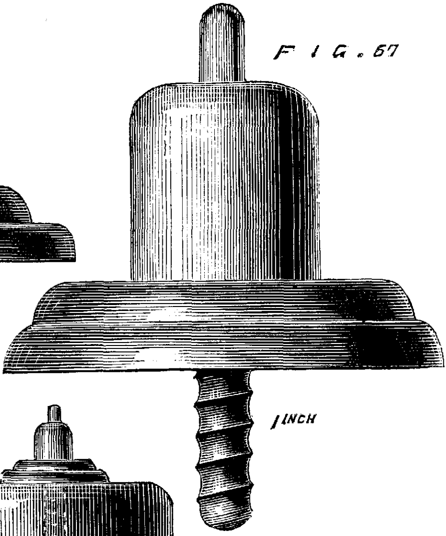


FIG. 68

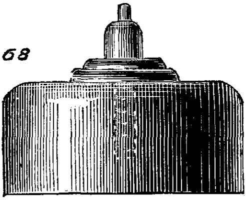


Fig. 60. Diagram of paper for 2oz. gerb, and 1oz. brilliant fire cases. Fig. 61. Diagram of board for 2oz. gerb cases. Fig. 62. Diagram of board for 1oz. brilliant cases.
Fig. 63. Priming tool. Fig. 64. 1oz. nipple. Fig. 65. 2oz. nipple. Fig. 66. $\frac{1}{4}$lb. nipple. Fig. 67. $\frac{1}{2}$lb. nipple. Fig. 68. Sketch of nipple attached to the block.

This composition answers very well indeed in half-pound cases, and if it be wished to do things on a grand scale, I know of no better finale to a small exhibition than a bouquet of five ½lb. Chinese gerbs, 8in. long, connected to a large crake mine or shell mortar.

For general purposes I use rocket cases for the ¼lb. and ½lb. Chinese fire, choked to the proper size, these are quite long enough for most purposes.

Composition for White Chinese Fire.

For 2oz. and ¼lb. cases.	For ½lb. cases.
Mealpowder, 7oz.	Mealpowder, 4oz.
Sulphur, 1½oz.	Nitre, 3oz.
Nitre, 3oz.	Sulphur, 2oz.
Cast iron borings, 4oz.	Cast iron borings, 5oz.

For general purposes the 2oz. size will be found quite large enough, especially when used in combination, and not fired singly.

Now comes the filling of the cases. The illustrations are sketches of four full-sized nipples, required for filling the various sized cases that I have already described. Figs. 65, 66, and 67, nipples employed for Chinese and sparkling; Fig. 64, used for brilliant fixed cases; Fig. 68, small sketch of nipple and block; Fig. 63, priming tool for priming cases. These nipples can be made out of wood with a brass stud, but a better plan is to have them made in brass or gun metal, and each firmly screwed into a stout block (Fig. 68). For the various sized nipples three solid drifts will be wanted that fit well into the case; the first should be a little longer than the case it is intended to fill; the second two-thirds the length, and the third one-third the length of the case. Also a choking and setting down piece proper for each size. The mallets and scoops should be the same as those employed for rockets of a corresponding size.

The mealpowder, nitre, and sulphur, should be first weighed out and thoroughly mixed by passing it through the coarse sieve, the coarse charcoal and borings can then be added to the composition, and mixed well on paper with a spatula.

Everything being in readiness for commencing operations, take one of the dry 2oz. cases and press it well over the point of the nipple, taking care that its point B enters the choked aperture of the case and is perfectly upright. Then put into the case a ladleful of the preparatory (or priming) composition, and drive it well down with sixteen blows of the mallet, repeating this operation until the composition reaches within 2in. of the upper part of the case; on the top of this, put into the case a gun charge and a half of gunpowder (the same kind as that employed for charges with Roman candle stars). One or two of the inner folds of the case should be then separated with the point of a knife and turned down over the charge, and driven down with the drift; the remaining cavity of the case can then be charged with powdered clay, well compressed, in the manner directed for the ends of Roman candle cases; this should give a good report from the charge; bursting the case, but not blowing the end out. All that remains to be done now is to prime the case, but first I think it will be better to retrace a little, and give one or two hints with respect to filling the cases.

First, in filling the case, it is necessary to keep it perfectly upright, for unless this is done, the neck is sure to be injured, and consequently burst when fired. It will also be found a very difficult matter to drive the composition down solid, unless the weight of the blow falls in a direct line over the point of the nipple. At Fig. 69 there is a sketch of an apparatus

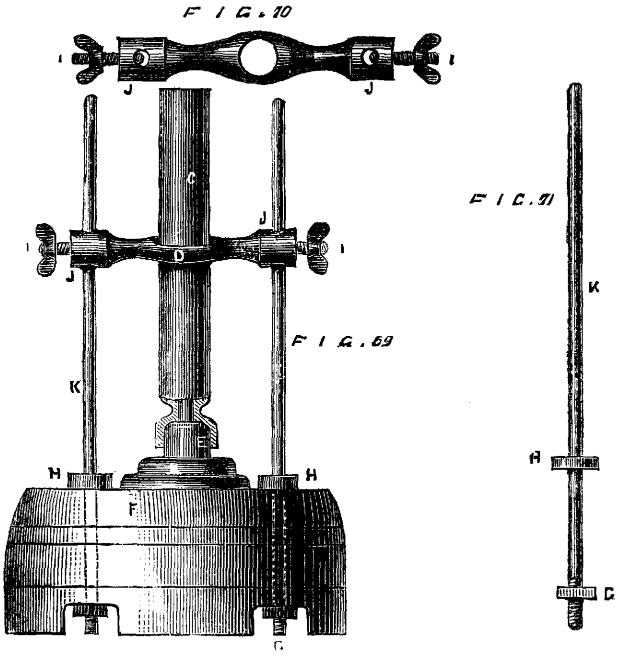


Fig. 69. *c*, gerb case; *d*, metal band to support the case; *jj*, supports for band, with hole for steel rods, *kkk*; *h*, base of rod, resting on the upper part of lower part of rod, with nut and thread to fasten them to the block, dotted lines showing the lower part passing through the block; *ii*, thumb screws for fixing the block; *e* and *f*, block and nipple. Fig. 70. Band removed from the upright. Fig. 71. Rods (or uprights) removed from the band and block.

that I have constructed for this purpose. The drawing will sufficiently explain itself, so that any mechanic can make one either for the 1oz. or 2oz. cases, the only sizes that this machine is required for.

Secondly, to have a composition of rather slow combustion for the first charge, for all fixed or revolving cases carry strong compositions; this is a most important point, as it will save the annoyance of seeing some of the cases explode, or not firing at the proper time.

The next part of the work is priming the finished case, and such directions will apply to all choked cases, whether employed for fixed or revolving pieces. This is an exceedingly simple operation, but requires a certain amount of care, for if it be not properly performed, some of the cases will refuse to fire, and so bring the anticipated spectacle to an ignoble termination. The best substance for the purpose is a thick paste, made of mealpowder and water ; this should be pressed into the choke hole and cup end of the case, taking care that the hole formed by the point of the nipple is filled up ; the damp priming can then be dusted over with mealpowder, and the finished gerb placed on one side to dry. This priming process can be very much simplified by using the tool sketched at Fig. 63 ; this is made with a small piece of brass wire $\frac{1}{8}$in. or $\frac{9}{13}$in., in diameter, and $1\frac{1}{2}$in. long, fixed into a common wood handle, and used to press the priming into the choked aperture of the case.

If these cases are to be fired in numbers, a strip of paper 3in. wide and 4in. or 5in. long should be pasted and rolled round the choked end of the case, to which the leaders are to be attached. For single cases, it is a much better plan to press a piece of uncased quickmatch into the choke with the priming, and twist the paper round it so as to make all secure. This match should project a short distance beyond the paper for the convenience of lighting.

Sparkling Fire.—This fire is produced by the combustion of granulated charcoal with mealpowder, and gives a rich sparkling fountain of fire, very suitable for certain fixed pieces, that are required to be made for some time before being used. The sizes usually employed for this purpose are of the 1oz. and 2oz. capacity, and about $9\frac{3}{4}$in. long. One sheet of 70lb. brown paper will supply material for three cases for either size. The board must be cut up into nine pieces for the 2oz., and twelve pieces for the 1oz. case (*vide* diagram, Figs. 61 & 62). The smaller size is the one most suitable for fixed pieces, and is also the same size as the brilliant fixed case (which I have to describe), with which they are sometimes used in conjunction. The sheet of imperial board for the 1oz. fixed brilliant and sparkling case, should be divided into twelve pieces (Fig. 62), three in the long, and four in the narrow direction of the sheet, so that four sheets of paper and one of board will give the necessary material for twelve 1oz. cases $9\frac{3}{4}$in. long.

Composition for Sparkling Fire for 1*oz. or* 2*oz. cases.*

No. 1.	No. 2.
Mealpowder, 9oz.	Mealpowder, 8oz.
Charcoal (No. 2), $2\frac{1}{2}$oz.	Nitre, 4oz.
	Sulphur, 2oz.
	Charcoal (No. 2), $2\frac{1}{2}$oz.

Both these formulæ give very good results. No. 1 is the one I usually employ, and I think it is the more economical, as some of this composition is also required for 1oz. and 2oz. wheel cases, so that the same batch of material will answer equally well for the fixed or revolving cases of sparkling fire. These cases are filled in exactly the same manner as before directed for gerbs, the nipple given at Fig. 64 being used for the 1oz. size; should other sizes be required, the ¼lb. and ½lb. rocket cases will come in very well for this purpose. Do not forget that all these fixed cases should be reported, for, if this be neglected, the exhibition will have a very tame finish, which will give the spectator a bad impression of the whole piece, however good the first portion may have been.

The last (and certainly not the least pleasing) fixed case is one used largely in combination for fixed pieces, or compound fireworks, as they are sometimes called; this is brilliant fire. The same kind of case will answer as that described for 1oz. sparkling fire, and it is this size alone that should be used for all fixed pieces.

Composition for Brilliant Fire.

No. 1 for 1oz. cases.	No. 2 for 2oz. cases.
Mealpowder, 10oz.	Mealpowder, 10oz.
Bright steel filings, 3oz.	Bright steel filings, 4oz.

The formula given at No. 2 is for single cases, employed for mine purposes. Both compositions are rapid in combustion, and will therefore require to be driven into the cases in small quantities hard and solid, and they must also be reported and primed after the manner given for gerbs, &c.

I have now given the formulæ for all the composition for fixed cases that are likely to be required. Care must be taken not to run any risk by leaving small quantities of these strong compositions about for meddlesome people to experiment with; put them either into cases or bottles out of the way of temptation, as by so doing accidents will be avoided.

Do not prime cases in a careless manner, or they may miss firing at the proper time. Remember also to use a ladleful of slow fire or priming, such as the following, for the first charge of all the fixed and revolving cases.

Composition for Slow Fire, or Priming.

Nitre, 5oz.	Fine charcoal, 1½oz.
Sulphur, 2oz.	Mealpowder, 1oz.

Or the formula given for Roman candles may be used for this purpose; they are both very satisfactory, but the above is perhaps the better, being rather slower than the other. These cases play an important part in exhibition pieces, and will be again considered under the head of compound fireworks.

There is another plan for stopping the end of fixed cases, for gerbs, &c.; this is by pouring into the cavity of the case, over the gunpowder charge, a quantity of melted bottle wax, or a composition composed of three parts of common resin and one part of beeswax, just sufficient being used to fill up the end; this sets very hard in a few minutes. If a very loud report be required, the cavity at the end of the cases (2in.) should be filled with gunpowder, and then driven down (a plug of paper having been previously placed on the top of the charge). If this be well compressed, a space of ½in., or a little more, will be left at the end of the piece, one or two of the inner folds of the case should then be turned down on the powder and the cavity filled up with melted wax or the composition before given for this purpose; by this means the loudest report possible is obtained.

The Coloured or Peacock Gerb.—Coloured or peacock gerbs add greatly to the beauty of the amateur's collection; these, like the ordinary Chinese gerb, are adapted either for single or compound pieces, but their full beauty is seen to perfection when they are fired in numbers in combination with lancework, as a concluding piece to any exhibition.

These gerbs are constructed after the principle of Roman candles; but the charges of the stars must be composed of mealpowder, in the place of gunpowder, as the explosive force necessary is much less than that employed for the latter piece, and an increased combustion only is required under each layer of stars, rather than an explosive force.

This variety, like all other pieces employed in pyrotechny, can be made of any capacity, but every advantage will be gained that can be desired with the 4oz. peacock gerb. There are certain slight drawbacks to the use of these coloured gerbs; first, the spectator must not be at too great a distance from the piece during its performance, or the full beauty of the coloured blossoms thrown out by the fire will be lost; secondly, with cases requiring such an open choked aperture, it is found impossible to give a report to the piece; this is really the only serious disadvantage, but I shall treat of this subject again, when speaking of compound fireworks, and try to remedy the evil as far as possible.

The case for this gerb should measure 8in. long, and ¾in. internal diameter (or bore), *i.e.* the same internal capacity as the ¼lb. rocket case; this is composed of a strip of 70lb. imperial brown paper, 8in. wide and about 22in. long, and a strip of imperial board the same size as that employed for the ¼lb. rocket case, viz. 8in. by 5½in.; this will be rolled in the long direction of the board, the reverse of that employed for the rocket case; each strip of paper and board must be well pasted and tightly rolled round the former, and, when removed, the tube is ready for choking. This part of the operation requires a certain amount of care and judgment; if the aperture at the end of the case be too large, the jet of fire is small, and the stars (or blossoms, as they are called) are not thrown to the proper height, and consequently the beauty of the piece is lost; on the other hand, if too small, the combustion is extremely rapid, and the stars are destroyed, and the case often ruptured or injured from the violence of the ignited composition. With respect to choking these cases, very little construction is required; the proper diameter of the opening should be about two-thirds the internal diameter of the case, and if this size be strictly adhered to, there will be very little cause to complain of the performance of gerbs constructed on this principle.

The peculiarly shaped stars required are usually made from the ordinary cubic or Roman candle star; those intended to be used for these gerbs should contain a rather larger percentage of shellac than those employed for other purposes, as the harder they are, the easier it is to cut them to the proper size without waste, and they will be less likely to get injured by the drift when filling the case. To manufacture these, take one of the selected stars and divide it with a sharp knife into small cubes or chips $\frac{1}{16}$th inch square or rather less, it matters very little what shape they are, providing they are not cut too large, as otherwise they will be destroyed by the pressure of the drift, and so fail to have the proper effect. The object to be aimed at is to have small hard fragments of coloured stars that can be imbedded in the mealpowder charge, by the force of the blow given to the drift, without breaking them, or yet interfering with the proper consolidation of the gerb composition contained in the case.

The usual number of stars employed for the $\frac{1}{4}$lb. size is eight, and it will not answer to use less, in order to obtain a glowing fountain of fire, interspersed with bouquets of bright coloured blossoms.

When the stars are properly prepared and each colour placed separately on the table, the next step is mixing the composition and dividing the case.

Composition for Coloured or Peacock Gerbs.

Mealpowder, 6oz.	Nitre, $1\frac{1}{2}$oz.
Cast iron borings, $2\frac{1}{2}$oz.	Fine charcoal, $\frac{1}{2}$oz.

These ingredients must be carefully mixed after the directions given before for the 2oz. Chinese gerb.

The division of the case (for the beginner) is an important item, but when the proper sized measures for the composition and meal powder charge have been obtained, and the amateur becomes somewhat proficient in the art of coloured gerb construction, this division can be dispensed with, and the piece constructed in the same manner as that given for Roman candles. If the case be properly constructed, it should measure 7in. from the choke (or neck) to the end of the case. At this end make a mark with pencil on the outside of the case, so as to leave a space of $\frac{1}{2}$in. from the end, this will be occupied by the clay after the gerb is finished. Next divide the space of $6\frac{1}{2}$in. (by marking the case with pencil on the outside) into eight equal parts; each of these divisions will contain the batch of composition, stars and mealpowder charge. When filling the case, use the $\frac{1}{4}$lb. nipple and block (Fig. 56, given on page 59); this nipple should be fixed in the choked end of the case, which must be perfectly upright. The first ladleful of composition must consist of the slow fire described on page 63, or the Roman candle composition given in a former chapter. This having been well driven down with sixteen blows from a mallet, take some of the gerb composition and proceed in a like manner until the composition reaches within $\frac{1}{4}$in. or 3-16ths of an inch, of the first mark or division on the outside part of the case; this small space is to contain the stars and mealpowder charge. Next take ten or twelve of the (mixed colour) small stars and place them in the case, and over these put about 1 dr. or a little more of mealpowder, and drive this well down in the manner described for the composition; this, when compressed, should just reach up to the first mark of the eight divisions, and constitute the first charge of the peacock gerb, each of the remaining seven divisions being filled in the same manner. A certain amount of practical experience will be required to obtain a measure capable of holding the requisite proportion of material for each charge of gerb composition, and also for the mealpowder charge; but if the hint thrown out in Roman candle construction be adopted, or some such method that may occur to the imagination of the operator, it will not be found difficult to construct measures or scoops of any capacity from tin or sheet brass, with the aid of pliers and a pair of stout scissors. When these are provided the division of the case will be found unnecessary, and the work can be performed in a much more rapid and satisfactory manner.

With respect to the colours, the three principal—viz., crimson, purple, and green, should be employed in equal proportions to give the best effect. Gerbs are sometimes made containing purple and gold stars, but they have not the fresh beauty of the above combination of colours; however, those who thirst for variety can make the experiment and judge for themselves.

After the composition reaches up to the last mark on the case, there will be a cavity of half an inch at the end; this is to contain the powdered clay, which must be well driven down with a short drift in the manner directed for heading rockets with clay. The piece is now ready for priming; but especial care must first be taken that the hole left in the composition by the stud is filled up with the slow fire, and, over this, the priming of mealpowder can be used; this should be well spread over the inner surface of the choked end of the case to insure ignition. These cases can be fired either singly with touch-paper, or in numbers with quick match, by the aid of leaders.

CHAPTER IV.

WHEEL CASES AND SMALL WHEELS.

WHEEL cases filled either with white, sparkling, or brilliant fire are employed to give motive power to wheels or frames upon which they are placed; and as they play a most important part in compound pieces, the details of their construction should be carefully studied, so as to avoid failure with exhibitions containing these pieces. The first question to consider is the size and weight of the frame or wheel with which they are to be employed; in the concluding part of this work (on compound fireworks) the subject will be more fully discussed when describing the revolving pieces requiring these cases.

Wheel cases can be made of any capacity, but for general purposes the three sizes given below will be found very satisfactory; these are the 1oz. size, 5¾in. long; 2oz., 5½in. long; and the ¼lb., 7¼in. long. If a shorter case be preferred for the latter, make use of one of the ¼lb. rocket cases, which will answer very well indeed for vertical wheels; but if this size be intended for the horizontal description, the length given above (7¼in.) can be more satisfactorily increased rather than diminished. The 1oz. case is made with a strip of 70lb. imperial brown paper, 22in. long and about 5¾in. wide; this will give substance enough for a very stout case without employing board. Each sheet of paper will supply material for five 1oz. cases, diagram Fig. 72; this is cut into five equal parts in the narrow direction of the sheet. Two oz. cases are composed of one strip of 70lb. brown paper, 14½in. long and 5½in. wide, and a strip of imperial board, 7¼in. by 5½in. On referring to the diagram, Fig. 73, it will be perceived that the full size sheet of paper is divided at the natural fold A in the middle, each half is then divided into four equal parts; so that one sheet of 70lb. brown paper will give sufficient material (with the board) for eight 2oz. cases. Each sheet of board is divided into sixteen equal pieces, Fig. 74, one of these being used with a strip of paper, to form the 2oz. wheel cases. The ¼lb. cases, for the large vertical or horizontal wheels, should measure about 7¼in. long; but the former wheels can be made to carry a shorter case if desired, as for instance ¼lb. rocket cases for the vertical and the longer case for the horizontal. The larger case is composed of a strip of 70lb. brown paper, 22in. long and about 7¼in. wide, and a piece of board 7¼in. square; the diagrams, Figs. 75 and 76, will give an idea as to the most economical manner of dividing the materials. The tools required for filling these cases are the 1oz., 2oz., and ¼lb. nipples, described under the head of Chinese and brilliant fires, and also the solid drifts and scoops proper for each size. Preparing the composition for these cases will be the next part of the performance; and with the formulæ that follow, as much variety may be obtained as the most ambitious could wish to produce, or the most critical spectator desire to behold.

Composition for White Fire.

1oz. and 2oz. size.

Mealpowder, 9oz.
Nitre, 2oz.
Sulphur, 1½oz.
No. 2 charcoal, 1oz.

Composition for Red Sparkling Fire.

No. 1. 1oz. and 2oz. size.	No. 2. ¼lb. cases.
Mealpowder, 10oz.	Mealpowder, 10oz.
No. 2 charcoal, 2oz.	No. 2 charcoal, 2oz.

Composition for Chinese Fire for large vertical and horizontal wheels.

¼lb. cases.

Mealpowder, 9oz.
Fine cast-iron borings, 4oz.
Nitre, 2oz.
Sulphur, 1½oz.
Fine charcoal, 1oz.

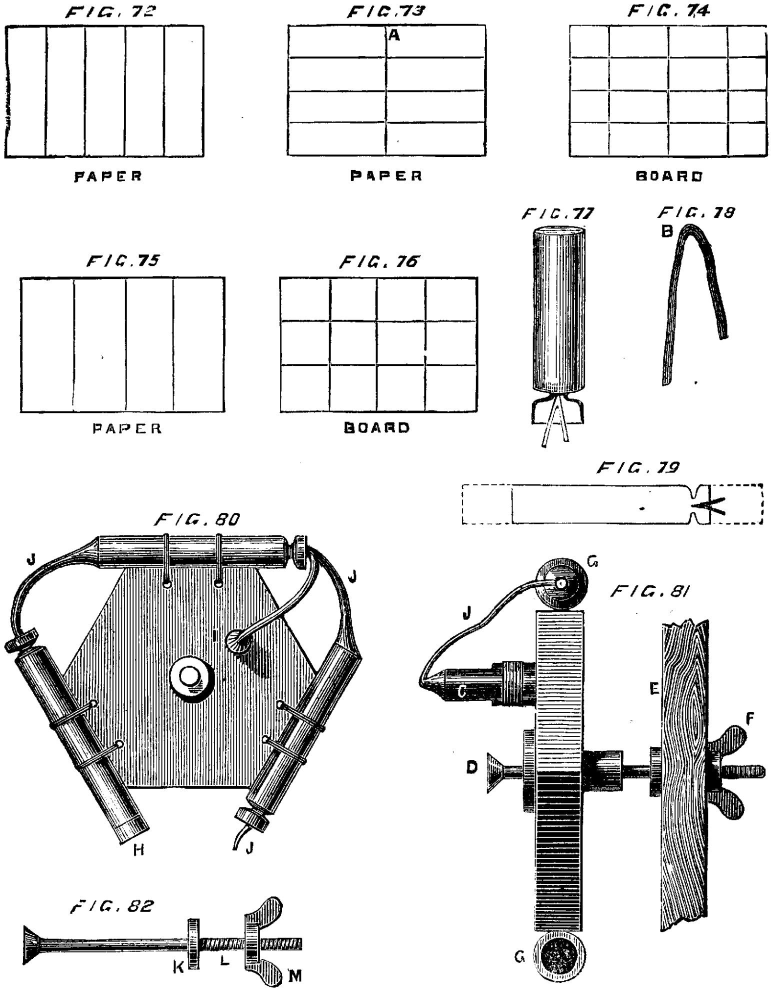
Composition for Brilliant Fire.

No. 1. 1oz. size.	No. 2. 2oz. cases.
Mealpowder, 8oz.	Mealpowder, 10oz.
Bright steel filings, 2oz.	Bright steel filings, 3oz.

No. 3. ¼lb. cases.

1.	2.
Mealpowder, 9oz.	Mealpowder, 10oz.
Bright steel filings, 4oz.	Bright steel filings, 4oz.
Nitre, 3oz.	Nitre, 3oz.
Sulphur, 1½oz.	Sulphur, 1oz.
Fine charcoal, 1oz.	Fine charcoal, ¾oz.

These formulæ give very satisfactory results, but great care will have to be used in seeing that all the materials are perfectly dry, and the cast-iron borings and steel filings clean, bright, and free from dirt or other impurities. All the ingredients (except the metallic particles) should be thoroughly incorporated by being passed through the mixing sieve three times at least, the borings or filings can then be added and mixed with the composition with a spatula or piece of cardboard on a large sheet of brown paper. All compositions for wheel cases are the strongest used in the whole range of the art, and will therefore require perfect incorporation and compression to give the best results; any neglect in mixing or filling the case will be sure to end in disappointment. Filling them is a very simple operation, and is performed after the manner described under the head of Chinese Gerbs, &c.; the composition should be driven down evenly and well in



WHEEL CASE APPARATUS.

Figs. 72 to 76. Diagrams of paper and card for cases. Fig. 77. Primed case. Fig. 78. Raw match. Fig. 79. Clothed case. Fig. 80. Triangle wheel. Fig. 81. Side view of triangle wheel. Fig. 82. Spindle.

small quantities, taking care also that the case is perfectly upright, and the neck or choked aperture in proper position. Each case should be filled up to within a quarter of an inch, or three-eighths of an inch of the top (or tail end as it is called) of the case; this, when completed, should be removed from the nipple and placed on one side for the next operation, viz., that of priming and clothing, proceeding in a like manner until the requisite number of cases are charged.

Priming wheel cases is best performed with mealpowder paste and quick-match, thus: take a piece of raw match (*i.e.*, uncased), and double one end up (*vide* Fig. 78 *B*); this end, *B*, should be covered with a little meal-powder paste, and, while still damp, pressed firmly into the choked aperture of the case (*vide* Fig. 77), so as to be in close contact with the composition. For this operation the little priming tool before described (Fig. 63) will be found a very handy instrument; the cup end of the case can then be coated with a small quantity of the mealpowder paste, so as to insure the ignition of the priming match, this being afterwards dusted over with a little mealpowder to complete the priming operation.

Clothing the case (Fig. 79) is simply the ornamentation and furnishing of its ends, so as to place it in the best condition for receiving the quick match, or leader as it is called. The paper usually employed for this purpose is white demy; take one of the cases intended to be covered and cut a strip of this paper exactly 2½in. wider than the length of the case, and sufficiently long to go round it three times (dotted line *a* Fig. 79 shows position of the paper). This strip is only pasted at each end, one fastens it to the case, the other to the paper when rolled up. A very good plan after clothing all the cases is to choke the case by lightly passing a piece of thin string or cord round the choked end, so as to choke or press the white paper level with the neck; it will then be easy to see at a glance which is the proper end of the case for fixing.

When filling these wheel cases, do not forget that the first ladleful of composition should be the slow fire or Roman candle composition recommended for gerbs, &c., and also that the last case on all the wheels must have a stopping of clay, H (Fig. 80) so as to prevent the tail end of the last case taking fire from the mouth of the first; this is a most important point to remember.

Before concluding this chapter, I shall give a brief description of the simplest form of vertical wheel. This is what is called the single triangle wheel, being constructed to carry three cases, of the 1oz. or 2oz. capacity. It is usually made from a piece of light, hard wood, of hexagonal form, each of the sides being 2½in. long and about ½in. thick. A hole should be bored exactly in the centre, in which is firmly glued a turned wood bush, having a smooth hole through it for a ¼in. iron spindle; this must run smoothly and evenly on the iron rod, the extra length of the bush, or nave, being to steady it during its revolution, and also to keep the cases and wheel clear of the framework of the piece.

Fig. 80 is an illustration of the common single triangle wheel, carrying three wheel cases and one colour case, I and J H—clay stopping $\frac{1}{4}$in. thick to end of last case. J J J, quickmatch connecting the several cases.

Fig. 81 is a side view of the wheel, showing the position of the spindle and firing post, D spindle passing through the centre of the triangle wheel and upright post E, F winged nut for fixing, G G wheel cases, J quickmatch case leading to the mouth of the colour C.

Fig. 82 is an improved form of spindle that I have introduced for small wheels and saxons; its great advantage will be more readily understood when studying the mechanism of compound fireworks. This spindle is made from $\frac{1}{4}$in. rod iron. K is a movable nut, L the thread part carrying this and the winged nut M.

When the triangle wheel is ready, the next part of the operation will be fixing the cases and connecting them with quickmatch. For this purpose three 1oz. or 2oz. wheel cases, two brilliant, and one sparkling fire, are required; the latter should be placed first on the wheel in the position given at Fig. 80. This is accomplished by boring two holes in the wheel at each case in the position indicated by the illustration (Fig. 80), and passing string through these holes, so as to encircle the case and bind it firmly to the segment of the wheel in its proper position. This fixing operation can be very much simplified if the edge of the wheel be grooved so as to receive part of the case, and soft iron or brass wire used instead of string, a couple of turns of this, fastened off with the pliers, binding it firmly to the rim of the wheel. When the first case (sparkling fire) has been placed in position, proceed in the same manner with the second case (brilliant fire), and so on with the third and last, the latter case being the one with the clay end H. If a colour case be desired with this wheel, take two pieces of iron wire about one inch long and drive them into the face of the wheel, midway between the bush and the rim; these should be placed so that they will stand forwards about half an inch, or a little more, and be sufficiently wide apart to admit a 1 oz. case between them (*vide* Fig. 81); this can be bound to the wire pegs with string or wire, in the manner before mentioned.

Connecting these cases is done by taking short pieces of quickmatch cases, JJ, and cutting them to the proper length, so as to reach from the tail of one case to the choked aperture of the other; into these empty cases are introduced lengths of raw match, which should extend about $\frac{1}{2}$in. beyond the ends of the case, this will allow of its being bent so as to lie across the mouth of the case, and in close proximity to the primary match and composition. The white paper left over the end of the first case can be twisted round it. ready for firing, the tail end of this has now to be connected with th mouth of the second by the aid of the cased match J, thus: take one of the tubes and press it into the opened tail end of the first case, tying it round with string on the outside to secure it; this can then be led on to the mouth of the second case and fastened in the same manner. If, however, a colour case is to be employed, a second case of match will have to be carried from this point to the mouth of the colour, and secured, the next case being finished in exactly the same way. It is a most important point to remember that all the ends of the raw match must be in close contact with the priming and composition contained in the cases. If a colour case be desired on these wheels, it will be best to use some of the coloured composition given for pill-box stars. The cases should be of the 1oz. size, and about 2in. long, made of two or three rounds of bag cap paper, and their ends stopped up with clay. This will fill the cases half-way up, so as to form a firm foundation for their attachment to the wires on the wheels, ½in. of composition or ¾in. being quite sufficient to last the two brilliant cases out; this should be very lightly driven in the cases, and primed with mealpowder paste, in which is placed a bit of quickmatch.

The rule in filling colour cases is never to finish with crimson fire, as the priming always ignites it. If crimson be used, place on the top of it, near the mouth of the case, a layer of green or blue fire, and over this the priming; by adopting this plan the colour can never miss firing, nor its beauty be injured by the priming. By far the most satisfactory plan with colours for these small wheels is to use three changes, first blue, next crimson and lastly green, a layer of each, so that the crimson is in the centre, and the blue in contact with the mealpowder paste; three pretty changes will then be seen during the wheel performance.

By referring to the sketch (Fig. 81), it will be perceived that the colour case fires with the second case, simply for the sake of variety; this is quite a matter of taste, and must depend entirely on the will of the operator.

CHAPTER V.

CASE COLOURS FOR WHEELS, &c.

THE present chapter will be devoted to considering the manufacture ot colour cases (*i.e.*, cases containing coloured fire composition) for the decorations of wheels, saxons, comets, pigeons, &c., and also for the smaller illuminated stars and crosses, used in the centres of large fixed pieces.

The cases are usually of the 1oz. 2oz. and 4oz. capacity; but the two former are the more generally useful. They are generally constructed out of thin cartridge or brown paper, two rounds being quite enough to give sufficient substance; the thinner they are the better, they only require to be strong enough to support the composition and to resist injury during the operation of filling. The length will depend in a great measure on the time they have to burn, but 2in. to 3in. will be quite long enough for all purposes for which they are likely to be required. The strips of paper must be pasted and well rolled, and, when the case is dry, one of the ends should be stopped with powdered clay; this should occupy a half-inch or more, so as to afford a firm foundation for attachment to the wheels, &c.

The usual plan adopted for fastening these cases to wheels, saxons, &c., is to drive two pieces of stout iron wire into the wooden centres of the saxons, or spokes of the wheels; these should be sufficiently wide apart, to allow of the case fitting tightly between them; this can then be tied or bound to the wire pegs with strong twine, or better still, with two or three turns of fine soft iron wire, the clay end, or incombustible portion forming a firm foundation for their support during the revolution of the piece.

With respect to filling the cases with composition, the best plan will be to use only a very small quantity at a time, and each batch of colour should be carefully and evenly driven down with a few light blows (or rather taps) of the ½oz. mallet. When the colour reaches within ⅛in. of the mouth, the case can be primed with mealpowder paste and quick-match, in the manner directed in the last chapter, when speaking of small wheels, &c.; this method of *priming*, however, only applies to colours not containing the strontium nitrate, those that have this chemical in their composition, such as red, crimson, and mauve, must have a layer of blue or green fire above the crimson, &c., and, on the top of this, the meal-powder, priming paste and match; if this be strictly borne in mind, failure will be impossible, and the colour decoration will obey the charge of the quick-match at the right moment. Colours containing strontium nitrate should be prepared as shortly as possible before firing, and on no condition should the salt be damp, or the finished colour case exposed to a moist atmosphere; these are the essential points to remember in making colours for wheels, as unless this care is bestowed upon them, their performance would be unsatisfactory.

The following formulæ will give any amount of variety, and further hints as to what colours to employ in the various designs for fixed pieces will be found under the head of compound fireworks:

Composition for Case Colours.

No. 1. *White.*

Nitre, 10oz.
Sulphur, 3oz.
Regulus antimony, 2oz.
Realgar, 1oz.
Red lead, ½oz.
Shellac, ½oz.

No. 2. *Golden Yellow.*

Potassium chlorate, 8oz.
Barium nitrate, 2oz.
Shellac, 2oz.
Sodium oxalate, 1½oz.
Stearine, ½oz.

No. 3. *Orange.*

Potassium chlorate, 8oz.
Strontium chlorate, 1oz.
Barium nitrate, 2oz.
Shellac, 2oz.
Sodium oxalate, 1½oz.

No. 4. *Mauve.*

Potassium chlorate, 12oz.
Mercurious chloride, 4oz.
Strontium nitrate, 2oz.
Copper subsulphate, 2oz.
Shellac, 2oz.
Stearine, ½oz

No. 5. *Rich Crimson.*

Potassium chlorate, 9oz.
Strontium nitrate, 5oz.
Shellac, 2oz.
Mercurious chloride, 1½oz.
Copper sulphide (fused), 1oz.
Lamp black, ¼oz.

No. 6. *Red.*

Potassium chlorate, 8oz.
Strontium nitrate, 5oz.
Shellac, 2oz.
Mercurious chloride, 1oz.

No. 7. *Brilliant Green.*

Potassium chlorate, 10oz.
Barium nitrate, 5oz.
Shellac, 2oz.
Mercurious chloride, 2oz.
Pure sulphur, 1oz.
Copper sulphide, ¾oz.
Fine charcoal, ½oz.

No. 8. *Rich Emerald Green.*

Potassium chlorate, 18oz.
Barium nitrate, 9oz.
Barium chlorate, 5oz.
Shellac, 4oz.
Mercurious chloride, 2oz.
Copper powder, 1oz.
Pure sulphur, 1oz.

No. 9. *Bright Blue.*

Potassium chlorate, 7oz.
Mercurious chloride, 4oz.
Chertier's copper, 4oz.
Dextrine, 1½oz.
Stearine, ½oz.

No. 10. *Bright Blue.*

Potassium chlorate, 8oz.
Chertier's copper, 7oz.
Mercurious chloride, 3oz.
Shellac, 1oz.
Stearine, 1oz.

No. 11. *Rich Blue.*

Potassium chlorate, 8oz.
Copper sub-chloride, 2oz.
Shellac, 1½oz.
Mercurious chloride, 3oz.
Stearine, 1oz.

All the ingredients for these colours must be perfectly dry and fine enough to pass through the forty-mesh sieve; they should be thoroughly well mixed and kept in stoppered bottles ready for use. The crimson, red, and mauve are the only colours that are likely to suffer from keeping, so that it is better to make them only a few days beforehand. All case colours have to burn a certain time, and their proper appearance and disappearance will add to the finish and beauty of the piece; the exact time required for their duration can only be obtained by practical experience, as it depends in a great measure on the manner in which the composition is compressed in the cases. The usual length of time that half an inch of colour in a 1oz. or 2oz. case burns, is (making a rough calculation) of about the same duration as the combustion of one of the 1oz. or 2oz. wheel cases, 5½in. long; but it is much better to obtain this information by experiments than to trust to calculations.

CHAPTER VI.

BRILLIANT, WHITE, AND COLOURED BENGAL FIRES.

THE present chapter will be devoted to the construction of Bengal case fires, for the illumination of gardens, avenues, shrubberies, buildings, &c. They not only possess the advantage of extreme simplicity in their manipulation, but of creating a fairy-like scene in the surrounding landscape, not attainable by any other means, adding a most important and beautiful feature to an exhibition, and being often more admired than any other single piece by the majority of spectators.

The sizes for cases most generally useful for ordinary display are the 1½in. and 1¾in. diameters and about 4in. long; the most suitable paper for this purpose is the 35lb. bag cap, described under the head of 2oz. rockets; each full-sized sheet of brown paper of this weight will furnish enough material for six cases, either for the 1½in. or 1¾in. bore; these strips of paper are cut in the narrow direction of the sheet, and measure 4in. by 9¾in. When the paper is cut ready for use in the manner described, the only tools required will be two formers, of the dimensions given above, made either of wood or brass; also two solid drifts 4½in. long, to correspond to each size case. It must be remembered that the cases are not only to be extremely thin but that the smallest quantity of paste possible must be used in rolling them. *These cases are intended to burn evenly with the composition*, and if too much paste be employed the intended effect will be lost. The strip need only be pasted at each end, one to fasten the first turn round the tube, the other when all the paper is rolled round the former and finished; the latter is simply to keep the folds from getting loose. The case when complete should be placed on one side in a warm place to dry.

The next operation is the preparation of the various plain and coloured fires for the Bengal cases, and as success or failure entirely depends on the fineness and dryness of the ingredients, and the perfect incorporation and purity of the chemicals employed; the following rules must be strictly adhered to, or failure is almost certain to follow, and then one of the most pleasing features of the exhibition will be destroyed.

The first formulæ are for the brilliant Bengal fires, or lights, as they are sometimes called. They possess a fair illuminating power, with a corresponding brilliancy, of a bluish white tint, very suitable for extensive illumination where a great number of cases are required to burn at one time ; these fires should not be used in cases of a less diameter than 1½in. The ingredients for these compositions must be accurately weighed out and well mixed by being passed at least three times through a 30-mesh sieve, so as to have the batch of material thoroughly well incorporated.

Composition for Common Brilliant Bengal Fires.

No. 1.	No. 2.	No. 3.
Nitre, 8oz.	Nitre, 12oz.	Nitre, 6oz.
Sulphur, 4oz.	Sulphur, 4oz.	Sulphur, 2oz.
Black sulphide antimony, 2oz.	Black antimony, 1oz.	Realgar, 1oz.

No. 4.
Nitre, 4oz.
Sulphur, 2oz.
Orpiment, 1oz.

These are inexpensive, and give very good results. The next formulæ are for the production of white fires for Bengal cases. These give a bright white light of great illuminating power, without the blue tinge of the above, very suitable for moonlight effects in situations surrounded with trees.

The first formula is for the white fire, introduced by Chertier, the French pyrotechnist, and is remarkable for the purity of its tint.

Composition for Chertier's White Fire.

Nitre, 8oz.
Sulphur, 2oz.
Regulus antimony, 3oz.
Red lead, 2½oz.

The following is one of my own, but does not possess the pure white tint given by the formula of Chertier ; therefore, it will have to be decided for what purpose these cases are required, and then choose that composition which answers best. The advantages that I claim for this colour are its brightness, combined with intense illuminating power when seen from a distance, its long duration and steady combustion. Should a bright, pure white light be wished for, to illuminate short distances and only burn a few feet from the ground, then Chertier's formula will give the best results ; but if distant hills or great elevations are intended to be illuminated, then the second formula will be found to give the most brilliant, lasting and pleasing effect, especially if employed in cases 6in. or 8in. long and 2in. diameter. If a case of this dimension be filled with composition prepared from my formula and fired on some elevated place in a thickly timbered and mountainous district, the spectacle is truly magnificent.

Composition for White Fire, W. H. B.

Nitre, 12oz.
Sulphur, 3oz.
Regulus antimony, 2oz.
Red lead, 1½oz.
Orpiment, ½oz.
Realgar, ½oz.
Finely-powdered metallic arsenic, ¼oz.
Shellac, ¼oz.

We now come to the most important part of the work—viz., the manufacture of the coloured fires for these cases. The first colour described is the golden yellow; this is not often employed in pyrotechnic exhibitions on account of the peculiar appearance given to the dresses and faces of the spectators by its combustion.

Composition for Golden Yellow.

No. 1.	No. 2.
Barium nitrate, 5oz.	Dry sodium nitrate, 12oz.
Sodium oxalate, 1oz.	Common sulphur, 4oz.
Potassium chlorate, 1½oz.	Realgar, 1½oz.
Fine shellac, 1oz.	Fine charcoal, ½oz.
Pure sulphur, ½oz.	

The colour produced by the sodium oxalate is not so rich in tint as that given by the nitrate; but the great deliquescent properties of the latter salt prevent its being employed in those cases that require preparing some time before being used. If this formula be chosen, the salt must be perfectly dried by being placed on the top of the oven, or in some warm place, before being added to the other ingredients, and the case containing this composition should be fired on the same day or at the latest on the day after it is made; if this plan be followed, a rich golden yellow colour, with a fair illuminating power will result, and, although peculiar in itself, it will find admirers amongst the spectators.

The next formula will be for the red and crimson Bengal fires; these are, without exception, the gems of this species of pyrotechnic art. The same advice will have to be observed, as was given when speaking of crimson rocket stars, with respect to the perfect dryness of the strontium nitrate, as unless this salt is perfectly free from all traces of moisture, the colour will be utterly spoilt.

Composition for Brilliant Red.

Strontium nitrate, 10oz.
Potassium chlorate, 3oz.
Pure sulphur, 2oz.
Fine shellac, 1oz.
Fine charcoal, ¼oz.

Composition for Rich Crimson, W. H. B.

Strontium nitrate, 16oz.
Potassium chlorate, 6oz.
Pure sulphur, 4oz.
Copper sulphide, 3oz.
Mercurious chloride, 2oz.
Fine shellac, 1oz.
Lamp black, ½oz.

The rich crimson tint is best seen when employed in a case 1¾in. diameter. Only pure sulphur, *i.e.*, sulphur washed free from acid, must be used for all Bengal fires containing potassium chlorate, and if this precaution be observed, the formulæ given for these fires will be found perfectly safe and trustworthy.

The next colour is the green, and for this tint several formulæ are given. When intended for illuminating buildings the colour should be of a rich tint, and, on the other hand, when for lighting up trees or avenues, the depth of colour can be slightly sacrificed, so as to give place to a greater intensity of illuminating power, the foliage of the surrounding scene supplying any deficiency in colour effect, if the place be well illuminated. By referring to the various formulæ given for green fire, it will be perceived that the richer the tint the more costly the production, so that if the object or scene that is required to be illuminated be first considered, remembering at the same time the rules laid down for this purpose, the expense of production will be very much lessened, and the best results will be produced at a minimum cost.

Composition for Pale Green.

Barium nitrate, 8oz.
Potassium chlorate, 3oz.
Pure sulphur, 1½oz.
Fine shellac, ½oz.
Realgar, ½oz.
Fine charcoal, ¼oz.

Composition for Brilliant Green.

Barium nitrate, 12oz.
Potassium chlorate, 3oz.
Pure sulphur, 2oz.
Fine shellac, 1oz.
Mercurious chloride, 1oz.
Fine charcoal, ½oz.

Composition for Rich Green.

Barium nitrate, 16oz.
Potassium chlorate, 5oz.
Pure sulphur, 3oz.
Barium chlorate, 2oz.
Mercurious chloride, 2oz.
Fine shellac, 1oz.
Fine charcoal, ½oz.

These formulæ will conclude the subject of colour compositions for Bengal cases. A blue tint for these fires is not at all satisfactory for the colour is anything but pleasing, and the illuminating power entirely wanting, therefore it is much better to use only the above formulæ which will give any amount of variation.

The next step to consider is the best method of filling the cases with the necessary composition. For this purpose, some drifts are required (one for each sized case) that will fit easily but perfectly in the cases. The drifts should be about 1-16th inch less than the diameter of the former, and they will then be found to fit the cases easily without interfering with their consolidating powers.

Before commencing to fill the case with composition the end should be stopped up with powdered clay in the manner directed for Roman candles. This is accomplished in the following manner: Take a small square of demy paper a little larger than the diameter of the case, and place it over the end of the drift; this can then be passed down to the bottom of the case. Next pour into it sufficient powdered clay to reach up about ½in. or a little more; this must then be carefully driven down with the drift and a light mallet (a 2oz. size will be quite heavy enough), then add more clay, until the end of the case containing this is about 1in. in height. This will give a good firm foundation for the colour composition, and attachment to the object from which it is to be fired.

The composition for Bengal fires should be very evenly and carefully compressed, and each batch must not reach higher than ½in. in the case, and should be lightly driven down with a few blows of the 2oz. mallet, and so on until it is level with the mouth of the case. To finish these ready for firing, take a square of thin blue double crown paper, a little larger than the circumference of the case, and paste it only at the edges; this can then be placed over the mouth, and the pasted edges pressed well over the sides of the case to make them secure, not unlike the operation of covering jam pots, so well known in every household. This concludes the manufacture of the Bengal fire.

The following are two different methods adopted by pyrotechnists for firing these cases. They are intended to burn in the horizontal position, so that the scoria or product of combustion shall fall clear of the mouth of the case, and not interfere with its free combustion or illuminating power.

The common plan to support these during combustion is to drive two large nails into the place where it is wished to fix them, about 1¼in. apart for the smaller size, and 1½in. apart for the 1¾in. case, so that the cases can rest as it were in a cradle between the two nails.

Another method, and the one I adopt, is to have some pieces of stout sheet iron, cut in the form of the Greek letter Δ; in the upper part or apex

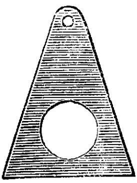


FIG. 82

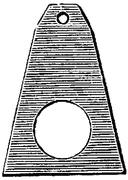


FIG. 83

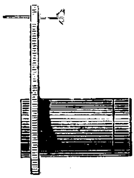


FIG. 84

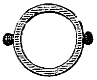


FIG. 85

should be punched a small hole, so as to admit a nail for fastening to the firing post or woodwork; the lower part or base should have a circular hole cut out, exactly the size of the external dimension of the case. To make use of these take one of the empty Bengal cases, and pass the end through the circular opening, so that it shall extend about ¼in. on the other side, next pass the square of paper on the end of the former to the bottom of the case, and proceed to fill the end with clay in the manner before described, the composition also being driven down in the same manner. On examining the clay end of the case after the Bengal fire is complete, it will be found that the clayed portion on the outside of the sheet iron will have bulged or thickened from the pressure of the clay, and so wedged itself tightly in the hole; this prevents it becoming displaced, and forms one of the simplest and most effectual plans of fixing these kind of cases. The value of the pieces of sheet iron is very trifling, and they last for years, and are extremely portable. At Figs. 82 and 83 will be found illustrations of the metal strips for these cases. Fig. 84, side view of strip with case attached ready for firing; Fig. 85, front view of Bengal case resting between the two nails in position for lighting.

CHAPTER VII.

LANCES AND LANCE WORK.

Lances are employed for making up devices, such as crests, mottoes, monograms, names, &c.; and, when artistically arranged, they have a magnificent effect—in fact, an exhibition without one specimen of this description of work is certainly incomplete.

They may be briefly described as small, thin cases, containing compositions which burn with a white or coloured flame. In length they vary from 2in. to 4in., according to the time they are required to last; the bore or capacity of these cases will also depend on their duration. The sizes usually employed are from 3-16th of an inch to 5-16th of an inch in diameter. The most economical, as regards effect and duration, is one of 2½in. long and ¼in. bore.

The cases employed for lances are made from double-crown paper, about the substance of 15lb. or 16lb. to the ream; two or three rounds of this quality will be quite sufficient for the cases.

The same rules must be observed with respect to pasting and rolling the strips as those given in the chapter on colour cases. As the cases are intended to burn evenly with the composition, very little paste must be used, so as not to interfere with the perfect combustion of the material. Proceed in the following manner: Take the double-crown paper and cut it into strips 2½in. wide (or wider, if it be wished to make a longer case), and sufficiently long to go round the former two or three times; then arrange these strips in a line on the pasting board, with their edges slightly overlapping each other, so that a number of the ends can be pasted at one and the same time. It will be seen by these directions that only about ¼in. at the end of the strip is pasted, the remainder being perfectly free from paste. Having all the strips pasted in readiness, commence to roll each of them evenly round the former; this is a very quick and simple operation, and one in which the labour of children can be utilised if necessary. The paper having been rolled in the manner indicated, take the end of the former and withdraw it a little, so that the end of the case can be turned in, then stamp it down on the board so as to stop up the end; this finished case can then be placed on one side to dry.

The small cases, when perfectly dry, should be filled by means of the funnel and wire, as directed for gold rain, and their mouths primed with mealpowder paste; except with those containing composition in which strontium nitrate is employed, when it will be necessary to place a layer (⅛in. at least) of either green or blue lance composition, and over this the priming of mealpowder paste, as this will prevent any disappointment in firing.

The compositions for coloured lances, like those for case colours, will be classed under the head of safe colours, *i.e.*, colours in which sulphur is dispensed with in their composition. Readers must understand that the term "safe," when speaking of colours, merely implies absence of sulphur in the formulæ, as opposed to those containing a large percentage of this ingredient, from which numerous accidents have originated by the material being in an impure form.

All the formulæ given in this work have been well tested by time and experience, so that if pure chemicals are employed, the amateur will be perfectly safe in making use of any of the colours mentioned. The first formula will be for common lances, that are so extensively used in large decorations.

Composition for Common Lances.

No. 1.	No. 2.
Nitre, 8oz.	Nitre, 8oz.
Sulphur, 4oz.	Sulphur, 3oz.
Mealpowder, 3oz.	Mealpowder, 3oz.

The following blue-white and brilliant lances are both very effective and cheap formulæ.

Composition for Blue-White Lances.

Nitre, 8oz. Sulphur, 2oz.
Antimony sulphide, 3oz.

Composition for Brilliant Lances.

No. 1.	No. 2.
Nitre, 10oz.	Nitre, 12oz.
Regulus antimony, 3oz.	Regulus antimony, 6oz.
Sulphur, 3oz.	Sulphur, 3oz.
Realgar, 1½oz.	Realgar, ¾oz.
Shellac, ¼oz.	Shellac, ¼oz.

The first colour for lances is the golden yellow. This is not often employed by professionals in pyrotechnic exhibitions, but the reason for this is not easy to understand, as the beauty of compound fireworks, containing gold and blue-lance centre pieces, surrounded with crimson and green, is beyond question.

Composition for Golden-Yellow Lances.

No. 1.	No. 2.
Potassium chlorate, 5oz.	Potassium chlorate, 9oz.
Sodium oxalate, 2oz.	Sodium oxalate, 2oz.
Fine shellac, 1oz.	Sodium carbonate, 1½oz.
Stearine, ½oz.	Fine shellac, 1½oz.
	Stearine, ½oz.

Composition for Brilliant Orange Lances.

Potassium chlorate, 9oz.	Strontium carbonate, 1½oz.
Sodium oxalate, 2oz.	Fine shellac, 1¼oz.
Stearine, ½oz.	

The next formulæ are for the red lances.

Composition for Red Lances.

No. 1.	No. 2.
Potassium chlorate, 10oz.	Potassium chlorate, 12oz.
Strontium carbonate, 3oz.	Strontium oxalate, 2oz.
Mercurous chloride, 1oz.	Fine shellac, 2oz.
Fine shellac, 2oz.	Mercurous chloride, 1oz.
Stearine, ¼oz.	Stearine, ½oz.

The advantages claimed for these formulæ are their non-liability to suffer from atmospheric influence, and their fair colour effect when contrasted with a rich green or blue. Owing to the hygrometric properties of the strontium nitrate, it is necessary sometimes to sacrifice depth of colour for general effect, in certain seasons and in special conditions of the atmosphere.

The next is one of the finest colours on the list.

Composition for Crimson Colour Lances.

No. 1.	No. 2.
Potassium chlorate, 10oz.	Potassium chlorate, 8oz.
Strontium nitrate, 2oz.	Strontium nitrate, 2oz.
Fine shellac, 2oz.	Fine shellac, 2oz.
Mercurous chloride, 1oz.	Mercurous chloride, ¾oz.
Chertier's copper, ½oz.	Copper sulphide, ¼oz.
Fine charcoal, ¼oz.	Fine charcoal, ¼oz.

Composition for Rich Crimson Lances.

Potassium chlorate, 12oz.	Mercurous chloride, 1½oz.
Strontium nitrate, 3oz.	Precipitated copper, ½oz.
Fine shellac, 2oz.	Ammonium picrate, ¼oz.

These colours should be prepared only a short time before they are wanted; the lances must not be filled with any of the composition containing strontium nitrate an hour longer than is absolutely necessary, and undue exposure to the damp night atmosphere must be avoided when practicable. In filling lance cases with the above compositions, remember to leave a small space at the mouth of the case, into this cavity press a thin layer of blue or green lance fire, and, over this, the priming of meal-powder paste; this prevents the lances missing fire, from the effects of the damp priming.

The following compositions will give the best effect for green lances the formula for the emerald green gives a most superb colour, but it is rather expensive :—

Composition for Green Lances.

Brilliant Green.	*Rich Green.*
Barium nitrate, 12oz.	Barium chlorate, 10oz.
Potassium chlorate, 8oz.	Potassium chlorate, 8oz.
Fine shellac, 3oz.	Barium nitrate, 8oz.
Mercurous chloride, 1½oz.	Fine shellac, 4oz.
Stearine, ½oz.	Mercurous chloride, 2oz.

Emerald Green.

Barium chlorate, 10oz.	Mercurous chloride, 3oz.
Fine shellac, 3oz.	

These formulæ give very rich results, if the chemicals employed are perfectly pure. The barium chlorate is an expensive salt to use; but when richness of tint and depth of colour is desired, no other preparation of barium can be found to supply its place.

The last in the list, and certainly one of the most effective of all the colours, is the blue.

The first three formulæ are for the production of a brilliant blue, the last, for the rich cobalt blue, used with such magnificent effect when in combination with a rich crimson or a golden yellow; these colours are not affected by atmospheric changes, and will keep their properties unimpaired for any length of time.

Composition for Brilliant Blue Lances.

No. 1.	No. 2.	No. 3.
Potassium chlorate, 12oz.	Potassium chlorate, 8oz.	Potassium chlorate, 10oz.
Chertier's copper, 6oz.	Chertier's copper, 2oz.	Mercurous chloride, 4oz.
Mercurous chloride, 3oz.	Mercurous chloride, 2oz.	Precipitated copper, 2oz.
Fine shellac, 2oz.	Fine shellac, 1oz.	Fine shellac, 1½oz.
Stearine, ½oz.	Stearine, ¼oz.	Stearine, ½oz.

Composition for Rich Blue Lances.

Precipitated copper, 1oz.	Copper subchloride, 1oz.
Potassium chlorate, 8oz.	Fine shellac, 1oz.
Mercurous chloride, 3oz.	Stearine, ½oz.

The composition for the rich blue given above, is one of the most effective colours that can be employed in lance work. Red, white, and yellow lances do not contrast well with the fire of wheel cases; the blues and greens are much more satisfactory in their effect.

The design desired to be executed in lance work must first be chosen; but, before the manufacture of the framework for this is begun it must be decided in what manner the cases are to be fixed. The two best plans are, undoubtedly, the peg and the hole systems. The first is carried out by driving pieces of thin iron wire into the framework, at the proper distances for the design; these should stand forward about ¼in. or a little more, and are intended to receive the ends of the lance cases, which must be pierced to receive them. The wire for the pegs should be pointed at the end, so that the cases will fit tightly when pressed on the end of the pegs. This plan is best for large pieces of lance work, and brass wire should be used instead of iron, as it lasts a longer time and is much less liable to injury from the product of combustion.

The second plan, or hole system, is certainly the simplest, but it is, at the same time, the most destructive to the framework; and if this should be of an elaborate design, it is soon rendered useless. Trace out the design on a board or large flat framework; when complete, take a pin or centre-bit, and bore out holes at equal distances, suitable for the design, to correspond with the position of the lance cases; these holes are intended to receive the turned-in ends of the cases. This is the better plan when large-sized cases ½-inch bore are used, such as crosses, stars, &c., for the centres of large wheels; but to protect the lance framework, the end of the cases should be plugged with clay, in the manner directed for colour cases for wheels, &c. This simple plan prevents any destruction to the perishable portion of the set piece, as the colour finishes before it reaches the woodwork.

The manufacture of the lance frames will, of course, depend on the subject to be produced, and one or two illustrations of these will be given in the chapter on compound fireworks. One method is to have thin laths of wood bent into the required position; another is to have a flat board with the design sketched out, and the lances placed in position by one or the other methods described above; but, whatever plan is adopted, the same rules will have to be observed as to the size of letters, or monogram, combination of colour and method of connecting. The design can be made of any dimensions; but it will not be wisdom to attempt any of this work less than 2ft. high. Letters should be from 12in. to 16in. high, or larger if necessary; but 12in. will be found to give very bold letters for most purposes. The distance at which lances should be placed will depend on the size of the design; 2in. apart is the usual distance, and this will be found to answer well for the 12in. or 16in. letters; if, however, very large designs, stars or geometrical figures are used, then 2½in. to 3in. apart will not be too far.

When the framework and lances are ready for commencing operations, the next part of the programme will be fixing and matching them. This is carried out in the following manner: take the finished lances, one at a time, and touch the unprimed end with a little melted glue, then press this on to the wire peg, or into the hole of the framework (according to the method adopted); proceed in a like manner with all the lances until the design is completed, and allow them to get perfectly dry before commencing to match them.

Connecting or matching lance work is a rather tedious but extremely simple operation; it is best accomplished in the following manner: Take a length of cased, or piped match, as it is sometimes called; this must be of good quality and free from fractures or weak places. Lay this along the primed mouths of the lances ready for operation; then ommence at the first lance case, and fix the match and its pipe to the primed mouth of the lance, by passing a pin down through the case and match, through the priming into the composition of the lance. This pin should be placed as near the edge of the case as is possible, but so as not to injure it; then lead the cased match on to the next lance, secure it with another pin, in exactly the same manner, until all the work is connected, taking care to leave a long end as a leader to fire it with.

The best method of igniting all the lance primings simultaneously by the aid of this match is to bore a small hole with a bradawl or stiletto down through the match case and lance priming and slightly into the composition, exactly in the centre of the case; this will effectually convey the fire from the match to the lances without any danger of failure. The work is completed by taking some narrow strips of thin double-crown paper and pasting it over this hole and down the sides of the case, to secure it; this paper should be sufficiently wide to completely cover the mouth of the case, the pin and hole and sides of the lance.

Great care will have to be exercised with lance work after it is connected (or clothed as it is called), as any rough handling will be pretty sure to destroy part of its beauty; and, as this kind of work is usually employed at the finale of an exhibition, care should be taken to make this, the concluding piece, the gem of the evening.

It is not at all necessary to employ either thick or very strong quick-match for lance work, but what is used for this purpose should be perfectly free from injury.

It must be remembered that the beauty of this work entirely depends on the harmony of colour, which should contrast well with the sparkling fire from the wheel cases.

CHAPTER VIII.

SAXONS, PLAIN, BRILLIANT, AND ILLUMINATED.

THIS species of firework is used largely in the construction of set pieces they are sometimes called Chinese flyers.

The object of the Saxon is to produce a perfect circle of white or brilliant fire which can be easily introduced into large pyrotechnic designs, and which is, at the same time, more portable and simpler of construction than small wheels. There are two kinds of Saxons, known as the single or double, employed in compound fireworks; the single Saxon is that in which only one end of the piece burns at a time, whereas the double description burns at both ends simultaneously, and consequently only lasts half the time of the former. The common plan adopted in making the single Saxon is to roll the case in one length, and then to bore a hole in the centre for the spindle; this method need not be further described, as directions for making a double Saxon are given below, and the operator can decide whether he intends his piece to burn at one or both ends.

The cases are usually of the 1oz. capacity, and about 7¼ inches long, two of such sized cases being required to form a double or single piece of this description. They are constructed in the following manner: Take one sheet of 70lb. Imperial brown paper, and divide it into four equal strips in the narrow direction, Fig. 92; these strips must be thoroughly well pasted and tightly rolled round the half-inch brass former; the case, when dry, will be quite stout enough for the composition given for double Saxons, but, for the single variety, a stronger case will be required, therefore a strip of Imperial board will have to be used with each piece of the above paper. Fig. 93 is a diagram showing the manner of dividing the material, each sheet will give board enough for one dozen cases.

Composition for Double Saxon.

Mealpowder, 16oz.	Sulphur, 6oz.
Nitre, 9oz.	Antimony sulphide, 5oz.

This answers very well indeed, if it is well driven into the cases.

Composition for Single Saxon.

Mealpowder, 16oz. Nitre, 16oz.
Sulphur, 7oz.

This gives a perfect ring of white fire, when only one of the cases is burning.

I have still a formula of my own to give for brilliant Saxons, which for certain purposes has a very pleasing effect, but possesses the disadvantage of instability, which, of course, is a most serious drawback, as Saxons are stock fireworks largely employed in set pieces, and are therefore prepared some time before they are required for use.

Composition for Brilliant Saxons.

Mealpowder, 3oz.	Sulphur, 1oz.
Nitre, 2oz.	Bright steel filings, 1oz.

This composition should only be prepared a day or two before it is wanted, and kept in a perfectly dry place.

The apparatus required for filling the cases consists of a settle and block, similar in shape to those given for Roman candles, but of a different size, viz., $\frac{1}{2}$in. settle instead of $\frac{5}{8}$in., three drifts, of different lengths corresponding to the size of the case, and a scoop and mallet.

To fill a Saxon case, place one of its ends over the projecting piece at the top of the settle, taking care that it stands perfectly upright. Now put into the case a small quantity of powdered clay and drive it firmly down with the drift and mallet; the clay when driven should occupy (with that part of the case on the settle) exactly half an inch at the end of the case; this gives a firm foundation, and prevents the end of the case from being blown out. Next take a scoopful of composition and drive it well down with twelve blows of the mallet, then add another scoopful, and so on until the composition reaches to within half an inch of the upper part of the case; place over this some powdered clay and drive it down, so that it occupies the same space (about $\frac{1}{4}$in.) as the clay at the other end, the cavity above this being represented by the settle; this completes the filling of one of the Saxon cases.

Figs. 86 and 87 are the wooden centres used for these cases. In length they measure about $5\frac{1}{4}$in., being $4\frac{1}{2}$in. for the centre part A B C, and $\frac{3}{8}$in. for each end D D, these ends fitting tightly into the cavity of the Saxon cases. The usual diameter of these centres is $\frac{7}{8}$in., but if the shape given at Fig. 87 be employed, the diameter for the middle of the centre will be about $1\frac{1}{4}$in.

To prepare the Saxon ready for fixing, take one of the filled cases and bore a hole at the end at right angles to the case in the position given in the sketches (*vide* illustration, Figs. 88, 89, and 90). This must be about $\frac{7}{8}$in. from the end of the case, so as not to disturb the clay foundation. The best tool for this boring operation is what is called a leather punch, $\frac{1}{8}$in. in diameter, and this sized hole is the one to employ with the compositions given in the various formulæ.

The hole having been carefully bored through the case down into the

FIG. 86

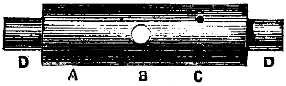


FIG. 87

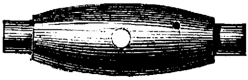


FIG. 88

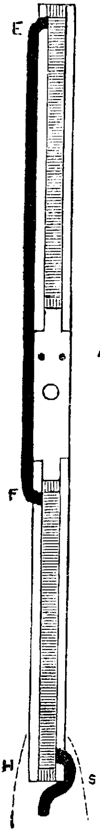


FIG. 89

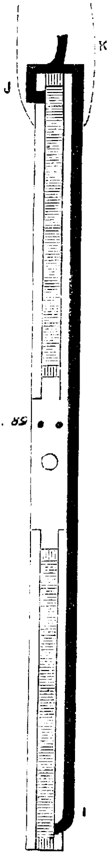


FIG. 90

FIG. 91

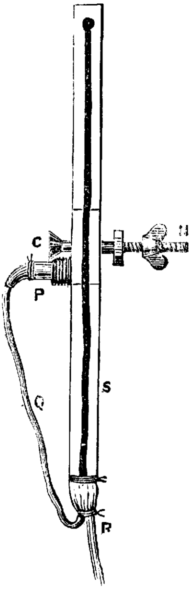
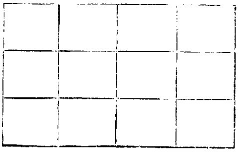


FIG. 93

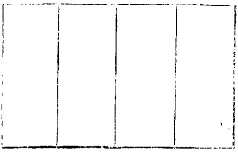
BOARD



12 STRIPS

FIG. 92

PAPER



4 STRIPS

SAXON APPARATUS.

composition for a short distance ($\frac{1}{16}$in. is quite deep enough), proceed to prepare another case in exactly the same manner, two of these being required to form either a double or single Saxon. The next operation is fixing them to the wooden centre. For this purpose take a little melted glue and touch each end, D D (Fig. 86), of the wood work, and then press the end of the Saxon case firmly on this, remembering to keep the hole at the other end of the case at right angles with the hole for the spindle B in the centre. Bear in mind also that each case must be fixed with its holes in opposite directions, so that the fire from each end propels the Saxon in the same direction. By referring to the illustration the plan that is adopted for this purpose will be seen.

It must now be determined whether the piece is to be of the single or double variety. It is the matching only that makes the difference, but I think it much better to determine which it shall be before commencing to fill the cases, as the formulæ given for the single and double Saxons are only intended for their own varieties, and if employed out of their proper places may very possibly cause disappointment both to the operator and spectator.

I shall now suppose that two of the 1oz. cases are filled with the composition given for single Saxons, with the holes bored in the ends of the cases, and tightly fixed on to one of the wooden centres. This is the first step towards completion of the single piece. Now take a length of raw quickmatch, and press one end firmly in the hole E, at the end of the case, taking care that it is not liable to fall out; it must then be led on to F, where another hole should be bored (clear of the clay), and well pressed in; the hole G should also have a small piece of match, and the end turned over the top of the case, and secured with priming paste, made with mealpowder; this end of the case can then have two or three rounds of demy paper rolled round it (see dotted lines H) ready for receiving the leaders from the other cases, and secured with string at R (Fig. 91).

Should a colòur case be employed with these (and it is always best to fire the illuminated Saxon in preference to any other), two wire pegs or nails must be driven into the wooden centre in the position given at C (Fig. 86); to these attach a 1oz. colour case, primed and capped, ready for its leader.

If the colour is to burn with both ends of the Saxon, connect it, by the aid of cased match with the end G of the piece. If, on the other hand, the colour is only wanted to appear with the latter half of the Saxon, then connect it in the above manner, only bringing the leader from the end E, instead of the one before given; this I consider the more satisfactory plan, as not only is variety obtained—a great feature in pyrotechnic displays—but the ignition of the colour case is the signal for the firing of the gerbs, or brilliant cases, which should conclude the set piece.

The next operation is covering the uncased match, and connecting the ends of the cases. For this purpose take a strip of thin blue or white double crown paper, 1in. wide, and paste it well, and then cover it over the match, and carefully press it down so as to be firmly attached to the sides of the case ; this, when dry, acts as a case to the quickmatch, and prevents it firing from any stray sparks.

The double Saxon (of which an illustration is given at Fig. 89) consists of two cases burning at the same time, and this description consequently lasts only half the time of the single piece. The cases are placed on the centres, in exactly the same position as before given, but the matching is conducted in a different manner, viz., Take the length of raw match and press it well into the hole I, Fig. 89, then lead it along the side of the case and over the end of the hole J, where it is pressed in—that part of the match which passes over the end of the case should be well covered with mealpowder priming in which a small piece of match is placed, so as to be in readiness for the leader; then secure the end with three or four rounds of demy paper, K, for receiving the leaders from the other cases; the raw match connecting the two ends of the double Saxon is covered with thin paper in the manner before described. Fig. 91 is a side view of a double Saxon, with colour case and spindle; N spindle, O head of spindle, P colour case, Q leader connecting this with end of the Saxon, R leader, S match connecting the two ends of the case.

From this it will be seen that the colour fires first from the leader R, and the case last during the performance of the piece; so that when the proper length of colour to employ is ascertained, it will answer equally well either for the single or double Saxon.

In concluding the subject of Saxons, I must beg my readers to remember that these fireworks are best seen to advantage when employed in numbers in set pieces; and they certainly have a most beautiful effect when used in combination with brilliant cases or gerbs.

CHAPTER IX.

MINES OF SERPENTS, CRACKERS, AND STARS.

I SHALL now describe some very effective and useful forms of aërial decorations, which, although short-lived in their performance, add no inconsiderable share to the beauty of pyrotechnic exhibitions—these are mines of serpents, crackers, or stars.

Serpent mines consist of a parcel of serpents, placed in a thin paper bag, and connected by quickmatch with a charge of gunpowder, and fired from a mortar (Fig. 94). This blowing charge, when ignited, discharges the serpents into the air, producing a series of fiery evolutions, each ending with a sharp report—making a very simple and effective conclusion to a small exhibition.

Iron serpent mortars are usually of two sizes, viz., 2½in. and 3in. internal diameter, the former about 8in. and the latter 9in. long. They must be made of the best charcoal iron, and carefully riveted, so that the inside of the tube is perfectly free from any unevenness. To the mouth of the serpent mortar (Fig. 94) a strong iron rim or band is firmly attached, so as to protect it from injury; to the lower part is fixed a turned wood block (Fig. 95), the upper part (A) being intended to receive the lower end of the tube for about 1 inch or a little more; this is secured to the block by four small screws, passing through the iron into the wood-work of the mortar base.

The thickness of the charcoal-plate for these mortars must not be less than No. 18 iron wire gauge. I cannot too strongly impress upon the amateur the absolute necessity of being extremely careful in the selection of his mortars for mines or shells, and in having them well and carefully tested. It is much better for the operator to purchase these ready for use, as any fault in the material or workmanship may very possibly occasion serious mischief. All mortars should have a covering of stout Manilla cord; this is not to strengthen them, as some people imagine, but to prevent accidents should the plate give way. The good effects of this I have seen on more than one occasion. With a properly constructed mortar, accidents should be impossible, if only ordinary care be used.

The serpents commonly employed for mines are about $2\frac{3}{4}$in. long, choked at the mouth, and reported, and are primed with mealpowder paste. I do not think it will be wisdom on the part of the operator to attempt to make either mine serpents or crackers, as the cost of these is so trifling, and the trouble of production heavy, as some troublesome and expensive apparatus is necessary for their manufacture. It is by far the best plan to purchase them from the professionals, the price being about 2s. 6d. or 3s. per gross.

The first thing to do towards making the serpent mine, is to procure a turned roller, $2\frac{1}{4}$in diameter and 12in. long (this is for the $2\frac{1}{2}$in. mortar); next take some strips of 17lb. white double-crown paper—each strip should measure 7in. wide and 14in. long; paste the two ends and roll it carefully round the former. When this is accomplished, withdraw the former from one end for a short distance, so that the end can be tied or pasted, and turned in, so as to form a bottom to the mine bag. Either plan answers very well. This when dry, forms the bag to contain the serpents, and blowing charge.

Fig. 100 is the sketch of a mine serpent; E the reported end, F the choked mouth—primed with mealpowder paste; the usual number of serpents to employ with a $2\frac{1}{2}$in. mortar is two dozen. Take this number and make them up into a bundle (Fig. 99), and tie them round the middle with string; next procure a circular piece of thin touchpaper, the exact size of the bundle of serpents' mouths—which will be about $2\frac{1}{8}$in. Coat the upper surface of this with thick mealpowder paste, and, while still wet, press into it the primed mouths of the bundle of mine serpents. These must be placed on one side until they are perfectly dry, and they will not be ready for use unless in that condition. Then make the blowing charge for the mine; this is done by taking a thin piece of tissue paper, and placing in its centre a charge of $\frac{3}{4}$oz. of F. F. F. gunpowder, and afterwards gathering up the edges and tying them with string (B), so as to form a round flat cake (Fig. 102) that will just fit in the bottom of the mine bag. This is placed with its flat surface uppermost. When the priming of the serpents is perfectly dry, take a pointed brass wire, 3·16in. thick (the former used for quickmatch cases will answer very well), and pass it down the centre of the bundle of mine serpents and through the touch-paper and priming, so that the wire appears at the other end. Having thus formed a passage right through their centre, pass into it a length of good stiff raw quickmatch, which should reach about 2in. below the mouth of the cases (D, Fig. 99); this part can then be bent at right angles to the bundle, so as to be flat on the surface of the pad containing the blowing charge. The other part of the match above the reported ends of the serpents should be long enough to reach over the edge of the mortar, when the mine is in position, ready for firing. Next, having placed the blowing charge at the bottom, take the bundle of serpents, primed and matched, and lower it into the bag over the powder pad, taking care that the quickmatch passes through the touchpaper priming, and lies in

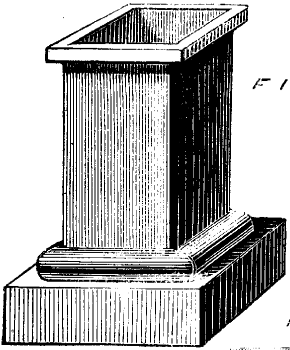


FIG. 96

FIG. 94

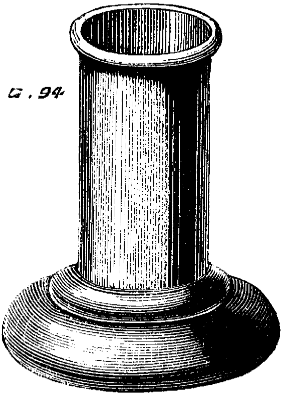


FIG. 95

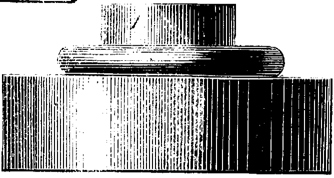


FIG. 99

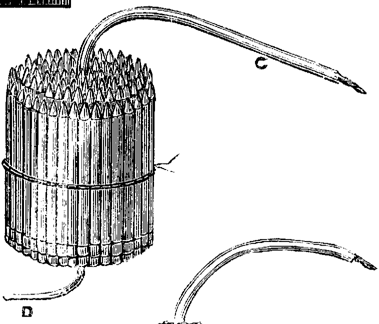


FIG. 97

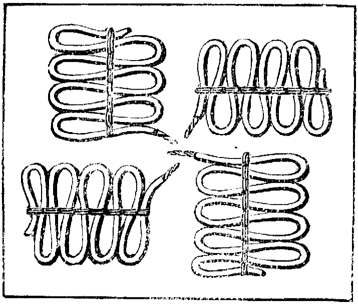


FIG. 101

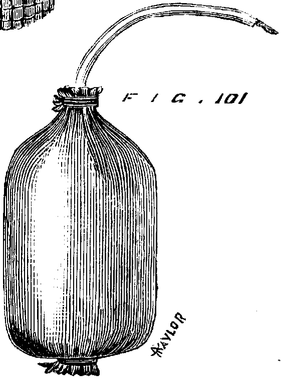


FIG. 98

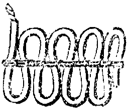
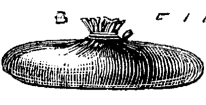


FIG. 100

FIG. 102



MINES OF SERPENTS AND CRACKERS APPARATUS.

close contact, flat against the parcel containing the gunpowder. The string binding the bundle of serpents should now be divided with scissors, and removed from the bag, for if this be neglected, the serpents will be fired in a mass, instead of singly, and the effects of the mine will be utterly destroyed. Next take some match-case, and pipe the raw match, C, above the top of the serpents; the mouth of the mine bag can then be secured with string (Fig. 101), and will then be ready for firing.

The mortars employed for firing cracker mines differ from those used for serpents in two essential points: first, they are square in shape instead of being cylindrical; and secondly, only one size is required—a mortar $2\frac{3}{4}$in. diameter, and 9in. long being quite large enough for all purposes, and capable of discharging from one dozen to three dozen crackers. Fig. 96 is an illustration of a cracker mortar. The height of this internally is 8in., 1in. being occupied by the foot; this being attached to the mortar in the manner described for mortars for serpent mines, and the other directions (with respect to the material employed, manner of construction and binding) will also apply to this variety.

For making these mines a square bag former, 7in. long and $2\frac{1}{2}$in. square, made of some light wood, such as pine, is required; the bags are made with a strip of white demy or double-crown paper, long enough to go twice or three times round the former—the height of the bag will depend entirely upon the number of crackers that are used. Having constructed the square mine bag, remove it from the former (*without closing the end*), and let it get thoroughly dry; when in that condition it is ready for its contents. Then take the former and pass it half-way down the bag or a little more, and fix the lower end of the former in a vice, or between two heavy weights, to keep it perfectly upright, and the bag in the condition indicated. Next take the mine crackers and pack them in layers, four on each tier, with their primed mouths pointing inwards towards each other, as shown in the diagram (Fig. 97). When one layer is complete, lay two or three bits of raw match on the top near the priming, and go on with the next layer, again placing short ends of raw match over these, and so on, until the proper number has been added. A parcel for gunpowder-charge of 1oz. must be made in the manner directed for the blowing charge for serpent mines; the parcel of gunpowder is passed into the bag and made to rest on the crackers; the end of the bag can then be tied with string, so as to secure it. The mine and former must then be reversed; and when the lower part containing the blowing charge rests on the table, remove the former, and place one or two ends of raw match down the centre of the mine, in contact with the cracker mouth. Then take a piece of stiff quickmatch and pass it down to the gunpowder charge, through the centre of the cracker mine; the upper part of this raw match should then be cased, and secured ready for firing in the manner before described. The order of arranging cracker mines is just the reverse of that for serpents; and unless some such plan is employed for neatly packing the contents, all the crackers will not fire. It will be seen from these directions that the manufacture of mines is extremely simple.

Mines of stars are not often employed in exhibitions. The stars for this purpose are usually made of the cubic form and matched; and are enclosed in tissue paper bags, with their powder charges, and fired from $2\frac{1}{2}$in. serpent mortars. This description of mine is best seen in bombardment pieces; and in my estimation should not be employed in any other, as the spectators are very apt to imagine from their discharge that it is simply one of the rockets blowing the clay out, and so firing the contents of the rocket pot on the stand—not a bad comparison; for the one is about as artistic as the other. The only object I had in speaking of these was to render the work as complete as possible, and not leave out any piece that might interest the reader or give pleasure to the operator.

In concluding my present subject, let me again impress upon the reader the necessity of having the mortars above suspicion; remember that any false economy in this part of the work may be dangerous, not only to the operator but to the spectators. But if only ordinary care and judgment be employed in their selection the amateur will be able to produce an endless source of amusement for his friends, without any risk or fear of accident.

CHAPTER X.

TOURBILLIONS, PLAIN AND BRILLIANT.

TOURBILLIONS are a species of firework capable of producing a startling and exceedingly beautiful effect. They revolve horizontally, whilst rising vertically, and present the appearance of an ascending spiral column or screw of fire. A tourbillion consists of a perfect cylindrical case, plugged at each end with clay, the intervening portion of the case being filled with a sparkling or brilliant fuse, the case having four holes bored in it for the exit of the fire during the performance; two of these being on the under side, and one at each end, the two latter being in opposite directions. Between the holes underneath a stick is placed to balance the tourbillion when revolving, and keep it in its proper position; the four holes in the case being connected with quickmatch to complete the piece. Having given a brief description of this form of firework, I shall now go on to minutely describe its manufacture and method of firing.

The sizes may be from 2oz. to 2lb., or even larger if desired; but if economy is to be studied it will be much better to adopt one or two sizes, keeping to these, and so simplify the work and number of apparatus. The ¼lb. tourbillion is undoubtedly the cheapest and most effective for its size that there is, and, therefore I shall select it for my illustrations on this subject. The case is rolled in exactly the same manner as described for ¼lb. rocket cases, the only difference being in its greater length. Figs. 103 and 104 are diagrams of paper and board showing the method of dividing the material. Each sheet of board will furnish twelve strips, and one full-sized sheet of paper four strips, so that one sheet of board and three of paper will give material enough for one dozen cases, without any waste, each case being about 7¼in. long.

The tools required for filling tourbillions consist of a settle, ¾in. diameter, and block, three solid drifts, of the same diameter as those employed for the ¼lb. rockets, one 7in. long, one 5in. long, and the other 2in. or 3in. long (this measurement does not include the head); and a ¼lb. brass scoop, for the composition, large enough to contain about ⅛th of the whole charge of the tourbillion, a very convenient size to use for filling any description of ¼lb. case. The tools and cases being in readiness the next thing is to prepare the composition, or fuse as it is called; this must be thoroughly well mixed and firmly driven in the case.

Composition for Sparkling Tourbillions.

Meal powder, 11oz.	Sulphur, 3oz.
Nitre, 5oz.	Fine charcoal, 3oz.

Composition for Brilliant Tourbillions.

Meal powder, 12oz.	Bright steel filings, 4oz.
Nitre, 5oz.	Fine charcoal, 2oz.
Sulphur, 3½oz.	

Each of these formulæ gives very good results; that given for sparkling tourbillions will remain unchanged for any length of time, but the brilliant composition should be prepared only a day or two before it is required for use.

To fill the piece, take one of the ¼lb. tourbillion cases, and fit the end on to the settle, and see that it stands perfectly upright; next take a pencil and make a mark all round the case at each end, A B, ½in. from the ends—this is the part of the case occupied by the clay and the settle, each occupying about ¼in. The case being perfectly upright, take a small scoopful of powdered clay, and drive it well down, so that it shall just reach level with the pencil-mark A. This cannot be too well consolidated; for unless it is firmly driven down, the end of the case will be blown out before the tourbillion can leave the cradle. Then take the composition, a scoopful at a time, and drive it down with sixteen blows of the ¼lb. mallet, taking care that each batch is evenly compressed, and so on, changing the drift for a shorter one when this becomes necessary, until the composition reaches to a level with the pencil-mark A., at the upper end of the case. Over this drive some powdered clay, sufficient being used to occupy ¼in. of the case, the cavity (C, Fig. 105) above this, corresponding to the one at the other end occupied by the settle. This completes the filling of the case.

The next part of the work is the most important, and on the careful manipulation of this branch the future performance of the tourbillion depends—this is the division and boring of the holes in the case. Fig. 105 is an illustration of a marked, or divided tourbillion, ready for boring. This division of the case is a very simple operation, and performed in the following manner: take the case, when filled, and place it flat on the table; then, by the aid of compasses, divide the piece into three equal parts, commencing from the marks A at either end of the case; this will give three spaces, G, F, G, and four marks, A, D, D, A; then divide the central space into two parts, making a slight puncture in the middle, at the point of division, F; this will be for the centre of the tourbillion stick, I, Fig. 106. Each of these marks should extend round the case, so as to form a perfect circle. Next draw a straight pencil-mark down the middle, from one end to the other, parallel with the sides of the case, C C; this will give the true position for the stick and holes on its under surface. Part of the tourbillion is now ready for boring; but, before I treat on this operation, I think it much better to describe the stick and wire-pin that I use for my tourbillions, as they differ entirely from any that I have seen employed.

First, as to the stick. This is usually of a curved shape, and I believe I am right in saying that no other form is employed by the majority of professionals. This description I consider not only perfectly unnecessary

FIG. 105

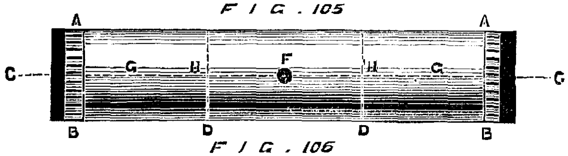


FIG. 106

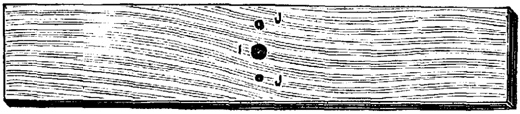


FIG. 107

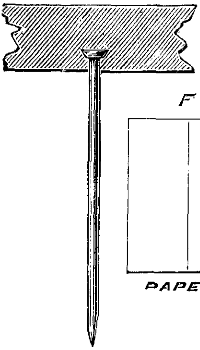


FIG. 108

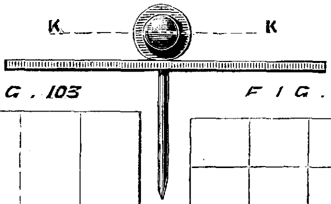
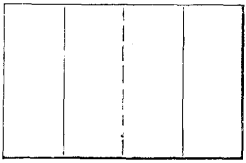
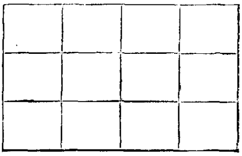


FIG. 103



PAPER 4 STRIPS

FIG. 104



BOARD 12 STRIPS

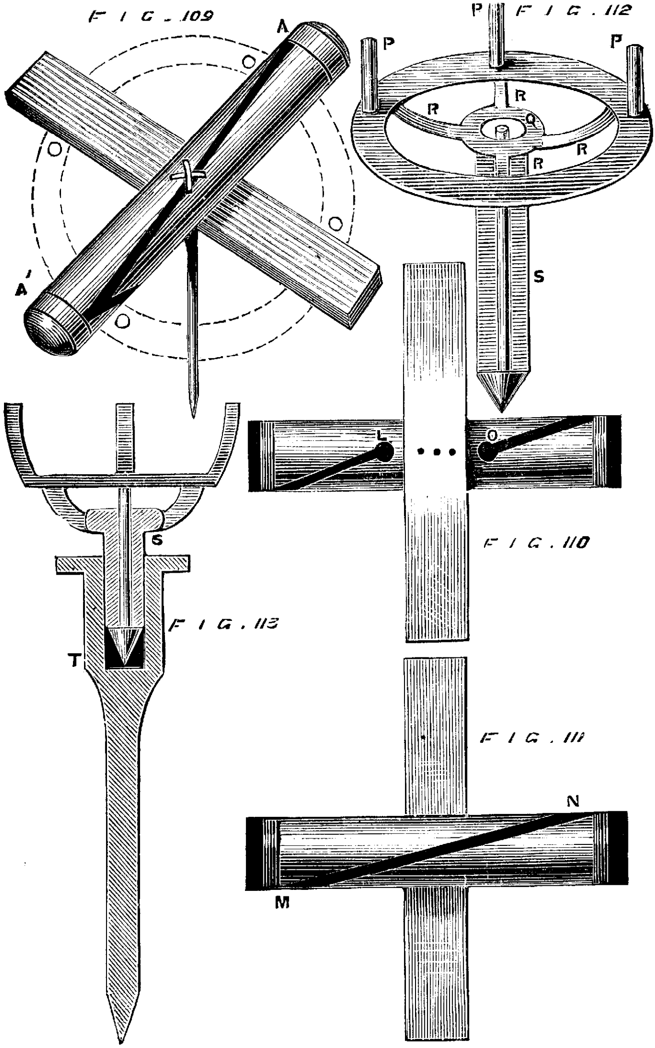
but absolutely injurious to the proper performance of this complicated piece; it not only interferes with its ascent but also has a tendency to give the tourbillion an oblique direction if the relative position of the stick to the holes be not quite perfect—a slight error not always easy to avoid. And, again, the difficulty and expense in obtaining these curved sticks has done much to retard the employment of tourbillions in exhibitions given by amateurs, who after repeated failures considered them too complicated to be meddled with. I trust that I shall be able in these papers to rectify this error, and induce those despairing amateurs who have given them up as a bad job to try my improved method of construction, and so add a notable feature to their display. I have very often heard the remark from professionals (when speaking of tourbillions) "We don't like them, for people think they are only bad rockets." This I can fully understand; a bad tourbillion is even worse than a poor rocket; but if they are properly constructed their performance is inimitable, the splendid circle of brilliant fire, concluding with a flourish of sparks is peculiar to themselves and cannot be imitated by any other means. I strongly advise their employment in exhibitions as they give a very beautiful form of decoration.

The sticks that I use are flat and can be easily obtained at any joiner's establishment. The $\frac{1}{4}$lb. size (Fig. 106) is cut out, of dry pine or white wood, and measures $7\frac{1}{2}$in. long, $1\frac{1}{8}$in. wide, and from $\frac{3}{16}$in. to $\frac{1}{4}$in. thick. In the centre of this is fixed a wire pin, Fig. 107, made from thin iron wire which is passed through the centre of the stick and made fast by slightly flattening, or this operation can be done first, by the aid of a hammer and vice, so as to form a small flat head, represented in the sketch. The proper length for these wires is 4in., and they should be about the same substance as that used in the construction of small bird cages, and should be perfectly straight.

The sticks having been made of the above dimensions, find the exact centre of each stick with a pair of compasses, and at that point make a small hole, I (Fig. 106), for the wire pin. On each side of this make two small holes, J J, for the tin tacks to fasten the stick to the case; then having placed the wire pin fast in the centre of the tourbillion stick, touch the upper surface of the holes, J I J, with melted glue, and place the stick on the lower surface of the case, making it fast by driving in two tacks, in the position given in the illustration, for which there are the holes on each side of the pin head. When the glue is perfectly dry, the case will be firmly attached to the wood-work, without any fear of becoming displaced during its performance. By referring to Figs. 108 to 111, it will be seen that the stick is placed at right angles to the case.

Fig. 108 is the end view of a finished tourbillion, showing the position of the stick, case, and wire pin.

The next thing to do is to bore the necessary holes in the case. For this purpose some kind of tool that will make a clean hole ($\frac{1}{8}$in.) through the substance of the case down into the composition for a short distance will be needed; and the leather punch employed for boring Saxons, answers equally well for tourbillion cases. Fig. 105 shows that the stick occupies the centre of the middle division of the case—the point of junction (H H) of the two lines will give the exact centre for the two lower holes. These must be bored down through the case and a short distance into the composition. Having completed these lower holes, turn the tourbillion with its stick downwards (Fig. 109), a small hole having been previously bored in the table to receive the wire pin; two upper, or rather side, holes, one at each end of the case, in opposite directions, must now be bored;



TOURBILLION APPARATUS.

these are situated at right angles to the case, in the same position as those for Saxons. A very simple plan to ascertain the proper position of the holes is to draw a pencil mark (K K) across the ends of the case, parallel with the upper surface of the stick; this will give the true angular position of each hole, which will be bored clear of the clay at each end of the case in the position given for Saxons.

For connecting or matching the holes take a perfect piece of good raw quickmatch, 9in. or 10in. long, and press the end of it in the hole L, Fig. 110, by the aid of the small priming tool, described under the head of gerbs, &c.; then lead it on round the side of the case to the nearest side hole, M, Fig. 111, and make it fast by pressing it in. The remaining part of the quickmatch should then be led obliquely across the upper surface of the case (as shown in the illustrations Figs. 109 and 111) to the side hole N, and thence to the under surface of the case, when the operation is completed by the match being pressed in the remaining lower hole, O, Fig. 110, and any surplus match cut off level with this. By these means the four holes of the tourbillion are connected with each other. The whole length of match and holes should be covered with a pasted strip of thin double-crown paper; when this is perfectly dry the tourbillion is completed, ready for firing.

Before describing the mode of firing these pieces, I will mention an improved form of cradle that I have invented for the accommodation of my flat sticks; for it will be perfectly useless to attempt to fire my tourbillion without some such kind of apparatus. Fig. 112 is the revolving portion of the cradle; the upper part consists of a thin brass circle, to the rim of which are attached four studs, P, and four arms, R, for the support of the centre, Q; this centre consists of a hollow rod, S, sufficiently long to receive the whole length of the pin of the tourbillion stick, the latter resting on the rim of the cradle, between the studs, with the case upwards. Fig. 113 is a side view of the revolving cradle, showing the position of the rod, S, in the socket of the staff, T; this staff has a brass cup or socket at the top, so that the rod of the tourbillion cradle can revolve easily in it; and it is also pointed at the end so that it may be firmly driven in the ground ready for firing the piece. The height of the whole apparatus should not exceed 2ft., and this is all that is required for the $\frac{1}{4}$lb., 6oz., or $\frac{1}{2}$lb. tourbillion; length of hollow rod, S, 5in.; height of studs, P, $1\frac{1}{2}$in.; diameter of circle of the cradle, $4\frac{1}{2}$in.; length of socket to staff, T, $4\frac{1}{2}$in.; whole length of staff, about 21in. or 22in.

The method of using this apparatus is exceedingly simple and satisfactory. Take the staff and firmly fix it in the earth or in the soil of a large heavy flower-pot the earth in which has been well pressed down. This forms a very ready and useful portable stand for the purpose, and one that is easily replaced when destroyed by accident. Next, place the cradle in the socket at the upper end of the staff, and see that it revolves easily; now take one of the finished tourbillions and place the end of the wire pin in the hole in the centre of the cradle. The case should then be lowered between the studs until the stick lies flat on the rim of the cradle, in the position shown by Fig. 109. (*Vide* dotted lines, representing the upper surface of the apparatus.) This is the proper position for firing.

To fire the piece, take a lighted portfire and burn through the quick-match on the upper surface of the case near the centre, in the position given by the × in Fig 109. This at once fires both the side holes, and the tourbillion begins to revolve, and with it also the cradle ; the remaining match then conveys the fire to the two lower holes. These give it its ascending power, and as the force of the revolutions increases, the piece gradually and majestically rises out of the cradle in its upward flight, producing a perfect spiral column of fire, concluding with a graceful flourish of sparks of great brilliancy.

CHAPTER XI.

SHELLS AND THE MORTARS FROM WHICH THEY ARE FIRED.

SHELLS (balloon or bomb shells, as they are often called) belong to the first order of fireworks. A shell may be briefly described as a hollow sphere made of thickly compacted paper, which, when filled with stars, rains, or streamers, properly fuzed and matched, and thrown from a mortar, displays its contents in the air at the extreme point of its elevation.

These shells are amongst the most satisfactory fireworks that can be used in an exhibition, and as we have no limit to their size, we are able to produce any amount of decoration suitable for the occasion.

Before I commence the subject of case-making, I would wish the reader to understand that the size of shells (external diameter of the case) given does not apply to the actual dimension of the shell case, but to the bore, or internal diameter, of the mortar from which they are fired. Thus the so-called $3\frac{1}{2}$in. shell will measure about $3\frac{3}{8}$in., or a little less, external diameter, and will be fired from a mortar having a bore of $3\frac{1}{2}$in. These shells also vary in size from the nature of the paper employed in their construction, one sheet of paper from the same ream differing slightly in thickness from another; so, whenever we speak of a $4\frac{1}{2}$in. or 10in. shell, it must be understood that this is the capacity of the mortars, and not the exact size of the shell case. The simple reason for this is obvious: shells differ slightly in size, even when made in the same mould; but the mortars are constructed on the ascending scale of $\frac{1}{2}$in., 1in., and 2in. on those above 8in. diameter. So that as the diameter of shell cases varies from $\frac{1}{8}$in. to $\frac{3}{16}$in., according to the thickness of the paper employed, it is much better to adhere to one fixed scale of measurement, and by so doing prevent confusion. The size of shells that I am in the habit of firing range from 2in. up to 12in. diameter, the latter size being capable of containing 24lb. of cubic stars; but it will be found much more satisfactory for the amateur to keep to two or three sizes, and thus simplify his work. The sizes most suitable for the tyro are the 3in., $3\frac{1}{2}$in., and $4\frac{1}{2}$in. The $3\frac{1}{2}$in. shell is the one I shall choose for my illustration.

In shell construction there are two important points to remember; first to have a perfect time fuze, capable of burning five seconds; and, secondly, to have a faultless shell case; and if these be kept in view, the task will be much easier than the operator imagines.

The first part of the practical work will be the manufacture of the case, and for this I shall give three different methods of construction, leaving the operator to adopt the plan most suitable to his taste, reminding him that unless perfect accuracy of manipulation is observed, the result will be bitter disappointment both to exhibitor and spectator.

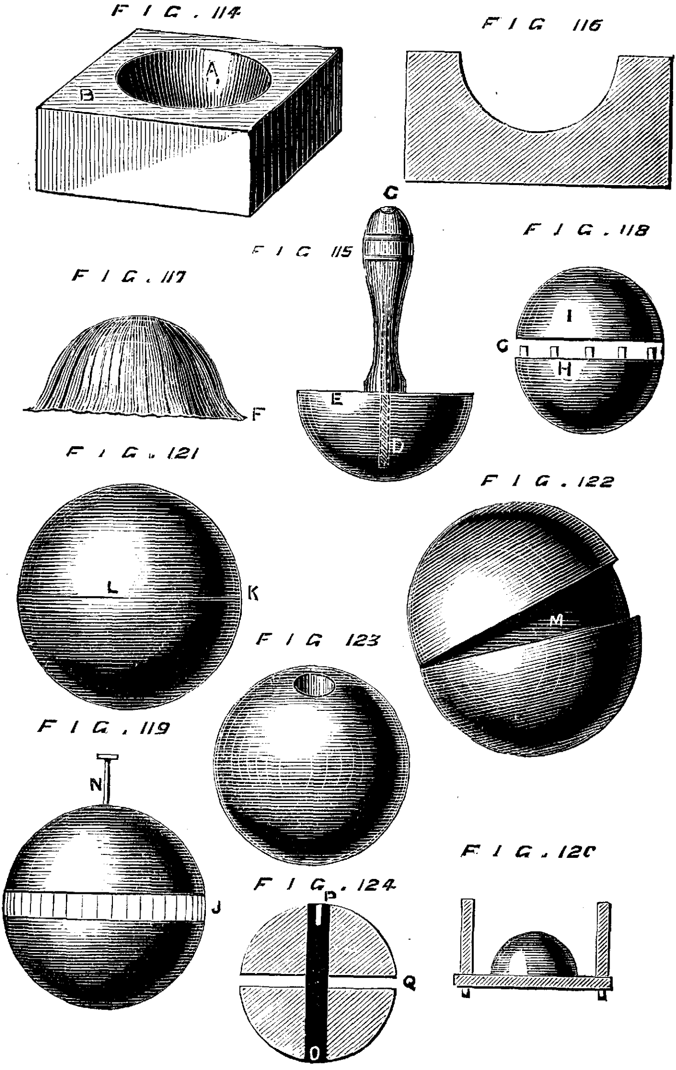
The paper required for case making is ordinary brown paper, having a substance of 70lb. to 80lb. to the ream; the 70lb. imperial brown employed for ordinary cases is too tough and fibrous in its character to work pleasantly with; a much inferior quality answers very well, and is also cheaper; a paper of less tenacity, that can be easily torn in small strips when damp, and will adapt itself to curved surfaces without the fear of becoming detached, is best. Most paper dealers will supply samples of this description, so the operator can try them in case making, and thus find out that which is most suitable for his purpose. The paper employed by some amateurs and professionals for shell cases is what is termed "grey marl," and another is thick sugar paper of a blue or grey tint; the latter description I only use for cases made in moulds for the larger shells, from 6in. to 12in. Having selected the proper kind of paper suitable for shell cases, tear (not cut) it in strips 12in. long and 5in. or 6in. broad; the quantity of paper required will of course depend on the number to be made. These strips of paper must be passed through boiling water, one or two at a time so as to thoroughly soak them, and the pieces when removed from the water lightly drained and piled in a heap on the top of each other; by this means each individual strip becomes thoroughly saturated and in a proper condition for the pasting process, which is performed in the following manner: take each piece of brown paper and paste it thoroughly on one side, then turn it over and repeat the operation, placing it on one side ready for the following pieces of pasted paper; the next strip should be pasted as it lies on the pile of damp paper; then take it up and place it, pasted side down, on the top of the first pasted strip, the upper surface of the second strip will also require a coat of paste. Proceed thus until the whole pile of damp paper is covered with paste. This is an exceedingly simple operation, and is performed in one-tenth the time that it takes to describe; but unless the paper is properly prepared it will be very troublesome to work with, and the finished case will lack that spherical finish which it ought to possess.

The first method of case making that I shall describe is what is termed "stamping," by the aid of a die and counter-sunk mould. Fig. 114 is the illustration of a mould or cup used to form the half of a shell case; Fig. 115 the die or stamp employed for pressing the pasted paper into the mould. Fig. 116, section of shell mould; Fig. 117, the half shell case removed from the mould ready for drying; Fig. 118, the two segments of the case, trimmed ready for fixing.

To those amateurs to whom money is a secondary consideration I would say, have a perfect mould and die made in gun metal by some first-class die sinker. This will last for a lifetime, and turn out perfectly faultless work; but, as I have no doubt many of my readers will not be able to purchase such a costly affair. I will give particulars of a tool that can be manufactured by the amateur or his nearest mechanical neighbour at a trifling cost.

By referring to Fig. 114, it will be seen that the mould is formed of the counterpart of the half shell case, Fig. 117. The simplest and cheapest plan to make a mould of this description for a 3½in. shell, is to have a hardwood ball turned 3¼in. diameter; this should then be divided with a sharp saw, exactly through its centre, so as to form two perfect hemispheres. Next procure a small deal box 5in. square, and 4in. deep (inside measurement), with sides ½in. thick, and with a strong bottom, which must be screwed (not nailed) on, so that it can easily be removed when required. To the bottom of this, screw, in the centre, one of the segments, flat side down, in the position given in the illustration Fig. 120, this being a section of the box with the half ball screwed in position. The inside of this and the ball should be very slightly covered with a thick solution of fire clay, and well dried; then into the box pour sufficient melted lead to reach about ¼in. above the top of the ball and completely cover it. A second running of metal can afterwards be made to suit the taste of the operator; but I do not advise a greater quantity than 1in. above the upper surface of the model. This gives a good foundation for the die when stamped in the mould. The metal having cooled, unscrew the bottom of the box and sides, and remove them; the mould will then be found to represent the sketch given at Fig. 114. The cavity A will be usually found quite smooth enough without any interference from the file or other cutting tool; should, however, any roughness be perceived, it can be removed with a little emery paper, but the less it is meddled with the better. The sides and upper surface, B, of the mould can be filed perfectly level, so that it can be let in, or cased, in a block of wood. This is certainly a good plan, and prevents injury by blows, &c.; but at the same time the metal mould will answer equally well without any such extra contrivance if only ordinary care be employed.

Fig. 115, is a sketch of the stamp or die for this mould, with wood handle, C, attached, through which passes an iron rod D, that is screwed or cast into the shell die E. To manufacture this important tool have another box made the same size (or a little less if desired) as that used for casting the mould; into this ram a bed of dry moulder's sand 1in. or 2in. deep. Next take the half model of the shell case, and screw in the base a common wood screw to serve as a temporary handle by which to lift it from the sand when necessary; place this in the centre of the box on the sand bed, flat side uppermost, round the sides of which the sand must be driven well down until it reaches a little above the top. The model should then be carefully removed



SHELL APPARATUS.

from the sand, leaving its impression accurately embedded in this material, from which a cast may be taken in lead in the manner described for the mould. The handle can either be screwed into the die when finished, or placed in the centre of the molten metal when casting; this when cool will be firmly attached.

The metallic part of the die E will have to be finished with a file and emery cloth, and should be ⅛in. less in diameter than the mould, for convenience of working. The apparatus having been properly made, and the brown paper ready for use, take some thick blue or purple sugar paper and paste it well on both sides in the manner described before for the other kind of paper. Take for the first layer some narrow strips of damp (not pasted) brown paper, about ½in. wide, and 2in. or 3in. long, and evenly line the concave portion of the mould A., pressing them well down with the fingers, so as to make them lie in an even manner; let each of these small strips project very slightly over the brim of the mould, and overlap each other; this will give the means of easily removing the case from the apparatus when finished. Having given this even coating of brown paper, take the die and stamp it well down in the mould, so as to press the paper well out and flatten it; then take strips of the pasted sugar paper and proceed in a similar manner, again stamping this down, and after this another coating of brown, followed by the sugar paper; and so on, stamping it well with the die after each coat, until there are six thicknesses of paper, viz., three of brown and three of sugar paper. When the proper number of coverings has been given to the case, remove it from the mould and place it on one side in a warm place to dry; do not hurry this process, for if the case be not slowly and carefully dried it will twist, and give an immense amount of trouble in fitting it to its fellow part. Fig. 117 is the illustration of the half of a shell case removed from the mould ready for drying; F, the flange or rim which projects over the mould.

When the half-cases are perfectly dry and ready for fitting together so as to present the appearance of a perfect sphere, as Fig. 119, which is a drawing of the united case, ready for its finishing coverings of paper, the first thing to do is to remove the flange F (Fig. 117), so as to make the two hemispheres meet in a perfect manner; a little patience and dexterity will be required to accomplish this satisfactorily, the ultimate success in this description of shell making depends in a great measure on the perfect construction of the case, and its accurate adjustment.

Having properly trimmed the edges of the case, take four or five strips of imperial board, 1in. long and ¼in. wide, and glue them inside the edge of one of the cases, Fig. 118, G, so that they shall project ½in. above the cavity of the case, H. When dry, take the other half of the case, I, and fit it on to the lower segment, H,—the strip of paper, G, inside prevents it getting out of place; the junction of the two hemispheres can then be covered with a pasted strip of newspaper, and left to dry. To complete the case, take some thin newspaper, and paste it well on both sides, and give the case an even coating of this in small strips, and over it one of brown, and again another of newspaper, and lastly one of brown paper, which completes the number required; so that after the case leaves the mould and is dried, it receives four additional coverings of paper, two of brown and two of white or newspaper. When dry, the shell case will have an external diameter of about 3⅝in. or so.

The second form of manipulation differs in several important points from the preceding, but it possesses the advantage of simplicity, counterbalanced partly, however, by the increased dexterity required to successfully perform the work. This method is a very good one for shells ranging from 2in. to 5in., but above that size it is anything but satisfactory. I shall again take the 3½in. shell as a type for my illustration, and to those who are industrious enough to master the work, I would say, let this plan be the starting-point, adopting the stamping process only where manual dexterity has to give way to numbers. The only thing required is a hard wood ball, turned out of perfectly dry wood, exactly 3⅛in. diameter, this is the capacity of the interior of the shell case. Take this ball and roll round it a single strip of thin, dry newspaper, turn the ends in, and twist it round well on the palms of the hands, so as to make the paper lie as closely and evenly as possible—this coat I shall call No. 1, white; over this place a covering of pasted brown paper in small strips, each strip slightly overlapping the other, until there is a perfectly even layer of paper—this I shall call covering No. 2, brown; over this must come another layer of pasted newspaper, coat No. 3, then brown No. 4, and so on until the ball is covered with six layers, three of these being of newspaper and three of brown; the sugar paper before described being dispensed with in this and the following plan of making shell cases. The ball having received the proper number of coverings, place it in a warm situation (the top of the oven for instance) to dry; the next operation will be removing the ball from the inside of the dry case, without injuring its spherical form. To accomplish this take the case containing the wood and make a pencil mark round the centre with the exception of ½in. (*vide* line K L, Fig. 121), then take a sharp razor or shoemaker's knife (the former I prefer) and make a clean circular cut through the paper down to the ball in the direction shown by the dotted lines L; if this does not reach it at the first cut go carefully over it with the knife a second time until the two halves can be separated in the manner shown in Fig. 122 (the ball M being still seen inside), until the ball can be removed with the fingers, that part of the case (K) which is not divided acting as a hinge, keeping the segments of the case from separating. When the ball is removed, bring the two edges of the case together and paste a strip of paper round the seam to prevent its coming undone. When this is dry place a stout common dress pin (N) in the top of the case; this will mark the position for boring the fuze hole after the remaining layers of paper are put on; this pin must also be used in the same position for the concluding covering of all stamped cases; for unless some mark to guide the boring operations be kept, the fuze hole might be made at the junction of the two hemispheres, and by so doing destroy the strength of the shell walls, which would very possibly burst in the mortar from the blowing charge when fired.

Having placed the pin, N, in the case, take some strips of newspaper, and paste them well on both sides, then cover the case with small strips of this, making a small hole in the centre of the strip that is intended to go over the pin; after this covering, take the brown paper and proceed in exactly the same manner until there are the same number of coats (viz., six—three of brown, and three of newspaper) of each kind, as were given to the ball at the first operation, so that each case when finished consists of twelve layers, six of those being composed of brown paper, and six of the newspaper coverings; each layer of paper must be well rubbed down with the fingers, so as to render it hard and compact when dry. When the concluding covering of paper is finished, remove the pin, N, and place over the spot a small piece of white paper ¼in. square, this, when dry, gives the position for boring the fuze hole; the case can then be placed on one side in a warm place until dry and hard.

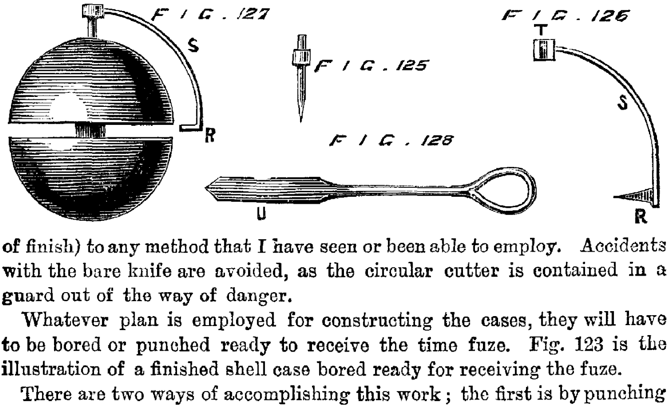
The third and concluding plan of case making is simply a modification of the above.

Fig. 124 is the sketch of a ball (or rather two hemispheres) used for this description of shell case making; by referring to the illustration it will be perceived that it consists of two halves joined together by an iron pin O that passes through its centre, on which it is turned in the lathe; the division Q in the centre of the ball is ⅛in. broad, and about 1¼in. deep. On the upper part of the pin O is a small hole P, drilled to receive the end of the taper pin (Fig. 125), which carries the cutter bar (Fig. 126). The ball is constructed out of the same material (viz., hard dry wood) as the other description, and the six primary coverings of paper are placed on it in the same manner, except that after having placed the first coat of white paper on the ball, the pin (Fig. 125) is fixed in the hole P exactly in the manner as the common pin is in the last coating of the cases before mentioned; this not only gives the position of the fuze hole, but forms the axis for the revolving centre of the cutter bar, by which the case is partially or wholly divided.

When the coverings of paper on the balls are dry, the case is ready for dividing; to accomplish this place the centre of the steel cutter bar T (Fig. 126) on the pin (Fig. 125), in the position given at Fig. 127. Then press the bar S so that the point R shall touch the surface of the case, and if this be made to revolve at the same time, a perfect circle will be traced on the outside of the case, exactly over the groove Q in the ball; the division of the case is then a very easy matter with a sharp spear-shaped knife with a double cutting edge; this should be passed into the groove through the outside mark, and the case divided with a sawing motion nearly all round, a small space being left so that the two halves cannot become detached in the manner shown at Figs. 121 and 122. The case can then be finished in the ordinary manner with three covers of white and three of brown paper.

The above plan is simply a cheap modification of my improved method of shell construction, which I have extemporised on purpose for the amateur who wishes to do work cheaply and well, and is willing to acquire dexterity with the simpler forms of apparatus.

The new shell apparatus of mine to which I refer is composed entirely of metal, the two halves of the ball (Fig. 127) are both hollow, turned out of gun metal $\frac{1}{8}$in. thick, the pin O passing through the centre of the ball is also of the same material; the groove Q in this case is a little smaller (only one-sixteenth of an inch) than in the wooden ball. The fitting of the cutter bar differs also slightly from the sketch. In the present instance the centre T is attached to the head of the pin (Fig. 125) by a movable nut, that prevents it becoming displaced, the latter also is screwed into the hole P. To the cutter end of the bar I have placed a circular cutter with a small handle, so that the perfect division of the cases is performed in a very rapid and even manner by simply revolving the case, and pressing the handle of the bar at the same time. For those purposes where a large number of shells are required to be made with unskilled labour, this method is far superior (as regards safety and quality



of finish) to any method that I have seen or been able to employ. Accidents with the bare knife are avoided, as the circular cutter is contained in a guard out of the way of danger.

Whatever plan is employed for constructing the cases, they will have to be bored or punched ready to receive the time fuze. Fig. 123 is the illustration of a finished shell case bored ready for receiving the fuze.

There are two ways of accomplishing this work; the first is by punching a circular hole in the case after it is divided, and consequently before it receives its finishing coats; and, secondly, by making the hole with the hot iron. The first plan I do not advise as the strips of paper placed on the case after the hole is made leave the edges very uneven, and do not give that solidity to the fuze obtainable by the other method.

Fig. 128 is the sketch of a round bar of iron (not unlike a poker), with a looped handle, having a pointed end; this is the simple tool that I use for boring. The diameter of the punch or boring tool should be exactly the same as the outside measurement of the fuze case. To bore a case with it, make the end nearly red hot, and place the point of the tool in the centre of the shell case that has the white paper mark for the pin; the hole should be bored directly through this mark, this being easily done by the weight of the bar alone, as it is much better not to use any pressure but just let it bore its way through, gently turning it round at the same time. When the hole is finished, place the case in a warm place to drive out any moisture that may be inside, and when dry it is ready for charging.

The shell case having been manufactured by one of the processes already described, we shall have to turn our attention to the construction of the various appendages required to complete this important firework, and the adaptation of the parts necessary to form a perfect shell.

First, the fuze, suitable for firing the contents of the shell, must be constructed; this is what is called a "time fuze," and is capable of burning from five to ten seconds, according to the range of the shell and the velocity or rapidity of its flight

The usual plan adopted for making these for very delicate shell experiments is by firmly compressing damp meal powder into suitable cases, by the aid of machinery; these, when dry, are divided into lengths, proper for each occasion—thus a case ½in. bore and ¾in. long, charged in the above manner, will burn about 4½ or 5 seconds, so that if we make the usual allowance of ⅛in. of the fuze for every second occupied by the flight of the shell (this, of course, being accurately timed), the results will not fall far short of our calculations.

The safest and best method of making shell fuzes in paper cases for pyrotechnic purposes is undoubtedly that with prepared composition, instead of meal powder; the result in the hands of the amateur is much more satisfactory and certain, and, therefore, it is the principle that I shall adopt for shell construction in this work.

The fuze case is made in exactly the same manner as the single saxon, with the same sized strip of 70lb. paper and board; or if the paper be well soaked with the paste and tightly rolled, the board can be dispensed with; a smaller hole in the shell case will then be needed. In drying the fuse cases it is essential that it should be done very gradually, as any case that is not exactly cylindrical should be condemned for shell fuzes.

Take one of these dry cases and fit one end over the point of the settle, and fill it with the following compositions:—

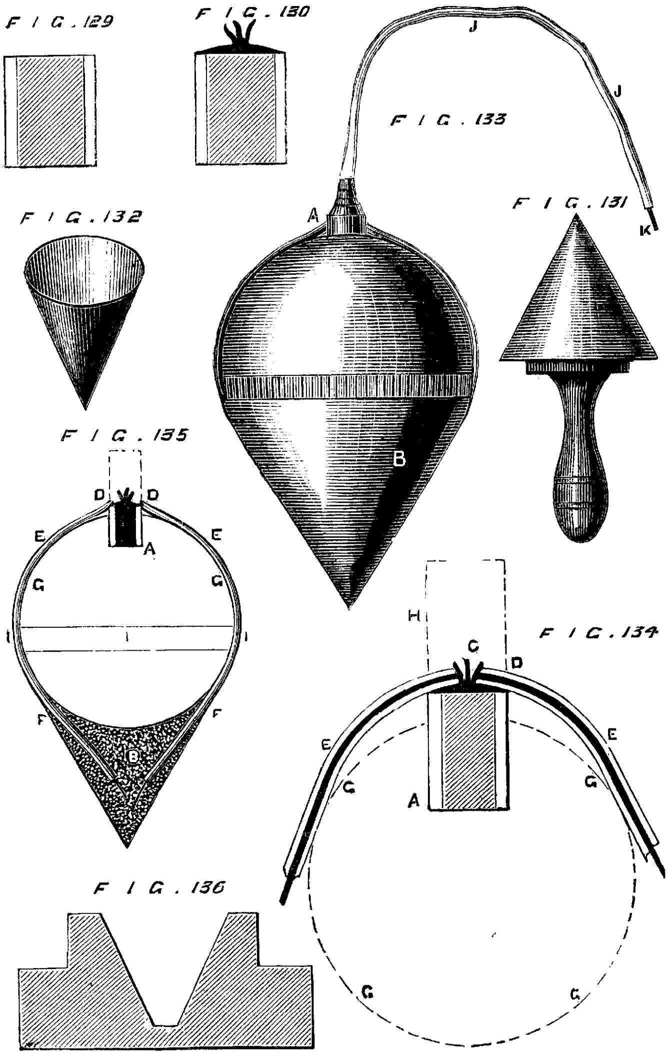
Composition for shell fuze—

Meal-powder, 10oz. Sulphur, 4oz. Nitre, 10oz.

This must be used very carefully, only a small quantity being driven in the case at one time, and the composition well consolidated; if this be properly done the contents of the case will be as hard as stone. When complete remove the case from the settle, ready for dividing; this is accomplished in the following manner: take the charged length of fuze and carefully divide it (by marking the outside of the case with a pencil) into lengths of ¾in. each, these can then be cut through with a sharp knife or fine tenon saw; each of the pieces constitute a shell fuze suitable for shells ranging from 3in. to $5\frac{1}{2}$in. diameter. The fuze will have to be primed at one end with meal-powder paste, in which is placed a tuft of quick-match, *vide* Figs. 129 and 130. This makes assurance doubly sure, and prevents the shell being thrown from the mortar without firing the fuze—blind shells as they are called.

The dried fuze, primed ready for use, must be covered with a piece of linen $1\frac{1}{2}$in. wide, and long enough to go two or three times round the case; this is for receiving the quickmatch. Next prepare a cone to receive the blowing charge of gunpowder, which is required to discharge the shell from the mortar. Fig. 131 is the sketch of a cone formerly employed for this purpose, the size of this should be about 4in. long, and $3\frac{3}{16}$in. diameter at the base, and the handle about $4\frac{1}{2}$in long.

The cone, Fig. 132, consists of two thicknesses of 35lb. bag cap brown paper made of the required shape; the fuze and cone being ready, the next question is what is to be put inside the shells? For this purpose box stars are best for all the colours, and cubic or cut stars for brilliant streamers or gold rain; this is the best order of arrangement. To fill the shell, take the case ($3\frac{1}{2}$in. size) and put in the stars that are to be used, until it will not hold any more; next weigh out $\frac{1}{2}$oz. of fine dry meal powder, and put it into the case amongst the stars; the fuze must now be firmly glued into the fuze hole, in the position shown at A, Figs. 133, 134, and 135, and should project only $\frac{1}{4}$in. on the outside, A, Fig. 133. This, when dry, is ready for the match which connects it with the blowing charge, B, Fig. 135. By referring to the illustrations, Figs. 134 and 135, it will be seen that the match crosses over the primed mouth of the fuze, piercing the linen on each side, and passing down the sides of the shell case to enter the cone cavity containing the gunpowder charge. To effect this properly take a perfect length of good quickmatch about 10in. long, and place the centre of this (C) on the upper surface (primed mouth) of the shell fuze. This is easily done by cutting a small hole in each side of the linen, at the mouth of the fuze D, and passing the end of the match through until it is exactly in the centre; when in this position cover the match and fuze mouth (C) with a little meal-powder paste, to make it secure. This, when dry, is ready for the next operation, viz., attaching the cone to the shell case. Take the dry cone, and place in it 2oz. of F F F gunpowder. A wood block with a cavity in it must be made to receive the charged cone and shell, for keeping them perfectly upright during manipulation. Fig. 136 is the section of a block employed for this purpose. Having placed the cone in the cavity of the block, fit the shell into the mouth of the cone; should it be a little too large, a small strip can be removed by the aid of the scissors, until a perfect fit is obtained. After the proper size is found, take the two ends of quickmatch, E E, Fig. 134, and bring them down the sides of the case (one on each side) until they meet in the cone B, in the manner shown at Fig. 135; they can then be cut level. These two ends of match will now require to be cased or piped with quickmatch case; this



SHELL APPARATUS.

should extend from the edge of the fuze, D case, to a little below the point of junction of the cone base and shell—which is shown by the letter F; or the quickmatch case can reach into the blowing charge, as shown in the engraving, this being simply a matter of taste, and in no way interfering with the proper performance of the shell. Fig. 134 is a diagram showing the position of the fuze and match; A, shell fuze with priming, the mouth being crossed by the quickmatch E E, which passes through the sides of the linen and down the outside of the case, dotted lines G G, into the cone, to fire the blowing charge; the ends of the match, with their cases, are shown divided for convenience of illustration, the dotted lines, H, show the position of the linen attached to the fuze, through which passes the

FIG. 137

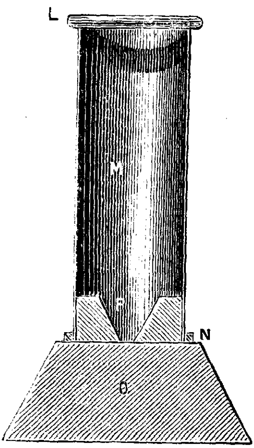
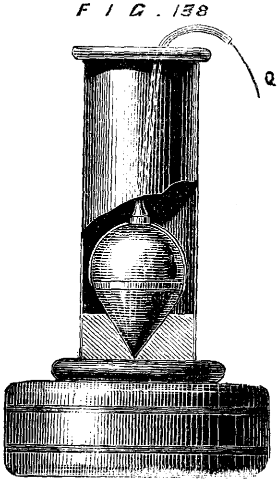


FIG. 138



quickmatch, and which is also employed for tying the leader or firing match shown at Figs. 133 and 138, by which the shell is discharged from the mortar.

Having placed the shell on the cone B (Fig. 135), and the two ends of match F F on the blowing charge, take a thin strip of double crown paper and paste it round the junction of the cone and shell case, I; this cannot be put on all in one piece; it is much better to use several small strips, and have both edges of them well nicked with the scissors, so that they will lie very evenly when pressed on the seam. The block, Fig. 136, containing the shell, should now be placed on one side to dry; when dry it is ready for finishing, and will bear handling without any fear of the cone becoming detached. Next cover the quickmatch case E E, which extends from the edge of fuze mouth D to the base of the cone I, with thin double paper, well pasted, and pressed down, care being used at the latter point that all the crevices are closed or very possibly part of the blowing charge may escape.

All that is required now to complete the shell ready for firing is to attach the leader J J to the fuze. This is a length of cased match tied in at the point A, this end of the match being left bare, so that it can lie on the priming (C, Fig. 134) before the linen is tied to secure it.

The leader should only be long enough to project over the edge of the mouth of the mortar one or two inches; the end of the raw match (K) can then be covered with a piece of touch paper, for convenience of firing. This completes the shell ready for exhibition.

With respect to preparing shells for exhibitions, I think it much better to fill each case with its proper stars, without the meal powder or bursting charge, and close the fuze-hole with a cork until they are wanted, leaving the remainder of the work until the day before they are to be used; this prevents accidents, as the explosive action of a shell in a confined space is disastrous in the extreme. When the shells are completely ready for use, place them under lock and key until they are wanted, and by so doing avoid any chance of accidents, for we must remember that shells are the most destructive fireworks that we have if they are interfered with by persons ignorant of their use or employment.

Concerning the mortars employed for firing these shells; as I have said before, the name or size by which the shells are known, does not give us their accurate external measurement, but refers more particularly to the bore of the mortar from which they are fired, so that the internal diameter of the mortar used for the shells under consideration will be 3½in., and measures about 18in. in length; this is made of best charcoal plate, not less than No. 16, iron wire gauge; this is the substance that I employ for all my mortars ranging from 2in. to 4½in.; above that size I use mortars of laminated steel, the thickness depending on the bore, the larger ones having the breach strengthened with bands of steel placed in a spiral direction, and the whole evenly covered with coils of wrought iron wire.

The 3½in. mortar (Figs. 137 and 138) consists of a perfectly cylindrical tube (M) of best charcoal plate, tested. The seam is overlapped and brazed, or carefully riveted; to the upper part is attached a strong iron rim (L) to protect it from blows, falls, &c. The base of the tube (N) has a thin flange by which it is firmly screwed to the foot, or block (O), which contains the cone cavity (P); this accurately fits on the end of the mortar, and prevents any escape of gas during the discharge of the shell. Each mortar, after having been properly tested six times, is covered with a layer of strong Manilla cord, sized and painted in the manner described under the head of "Mines."

Fig. 138 is the illustration of a mortar containing a shell ready for firing, part of the side of the tube having been removed to show the position of the shell. To the end of the match case (A) is attached a piece of touch paper, so that the operator has time to retire before the discharge takes

takes place, this being by far the wisest plan to adopt when firing these pieces.

The following is a table of shells that I fire, with a rough calculation of the weights of stars required to charge each sized case, so that the amateur can choose that size most suitable to his taste and requirements.

The numbers in this table denote the size of shell, and their diameter the bore of the mortar from which they are fired.

TABLE OF SHELLS.

No. of size.	Diameter.	Weight of stars.	No. of size.	Diameter.	Weight of stars.
1 ...	2½in. ...	3oz.	6 ...	6in. ...	3½lb.
2 ...	3in. ...	5oz.	7 ...	7in. ...	5lb.
3 ...	3½in. ...	½lb.	8 ...	8in. ...	7lb.
4 ...	4½in. ...	1lb.	9 ...	10in. ...	12lb.
5 ...	5½in. ...	2lb.	10 ...	12in. ...	23lb.

In concluding the present subject, I wish to again impress upon the amateur the necessity of having perfect mortars, for he must remember that the strain on the breech of shell mortars is much greater than that upon serpent or cracker mines, also that the power generated is much stronger, of greater duration, and more rapid in its effects than that produced in mortars of a shorter calibre and with a less weighty projectile.

CHAPTER XII.

COMPOUND FIREWORKS AND SET PIECES.

MY readers should bear in mind that unless they are perfectly master of the single fireworks already described, they had better postpone the attempt at exhibition pieces until they feel competent to carry out the work in a satisfactory manner, for it must be remembered that however private they may wish to keep their attempts in this branch of the art, "Set pieces" (as they are called) will advertise themselves in a most conspicuous manner, either to the advantage or disadvantage of their originator.

In the present section of the work I intend to give various designs for pieces coming under the head of "Compound Fireworks," *i.e.*, all pieces consisting of two or more cases burning at the same time, will be described under this heading.

For convenience of description I shall divide this subject into the mechanical and artistic; the former will describe the mechanical appliances necessary for producing the groundwork of the piece; the latter will treat of the design, and its execution for the work under consideration. Each of these will be fully described in its proper place.

The chapter will contain instructions for the construction of flights of rockets, pigeons, comets, bouquets of gerbs and Roman candles, brilliant suns, cascades, vertical and horizontal wheels, Saxon wheels, Saxon pieces of various designs, lance pieces, with gerbs, Roman candles, flights of rockets, shells, mines, &c., &c.

Flights of Rockets.—The first part will be on the flight of rockets. Fig. 139 is the illustration of a box used for this purpose; the height of this depends on the size of rocket to be fired, for any size can be employed, the 1oz. or 2oz. rocket being, however, the most economical for ordinary purposes. For a flight of asteroid rockets (8oz. magnesium) a taller box will be required, and I find it much better to make some slight additions to the flight box when firing, this sized rocket carrying such a large head.

The rocket apparatus given at Fig. 139 consists of an upright square or oblong box, having attached to it two lids, A and B; the former is used to close the mouth of the box until the proper time arrives for the performance of its contents. The latter answers a twofold purpose. First, being placed on a level with the lower tier of holes, it admits of the easy introduction of the sticks into their proper holes; and, secondly, when the flight is discharged, it gives escape to the gas or products of combustion, and thus prevents any undue strain being thrown on this fragile structure. The upper tier of holes, C, is composed of a flat piece of beech or other hard wood, with a number of holes drilled in it, at equal distances, the lower part or bottom, D, being an exact counterpart of C. The simplest plan is, after having obtained the exact size of the two pieces of wood, C and D, to take a pair of compasses and mark the upper piece, C, for the same number of holes as there are to be rockets, arranging for the holes to be in rows, and sufficiently wide apart as to give free egress to the rocket cases and sticks; next screw the two pieces together, and then bore holes with a pin bit at each mark. By this means when the upper and lower tiers of holes are fixed in the box, in the position shown by the illustration, the holes will be in a line with one another and support the sticks in a perfectly upright position. The part C must be fixed in the box in the position shown; taking care, however, that it is low enough to allow of the lid, A, closing without touching the caps of the rockets; a space of one or two inches should be left between the rocket caps and closed lid. The remaining parts (sides, lid, and stand) of the apparatus can be made of ½in. pine, painted black, and the lids A and B attached with small brass hinges.

The number and size of rockets required for the flight will, in a great measure, determine the size of apparatus to be constructed; as I have said before, the 1oz. or 2oz. sizes are the most economical, and a box made to carry sixty 2oz. rockets will be found all that the amateur is likely to require. He will then be able to fire from one to five dozen 1oz. or 2oz. flight rockets, according to his fancy and the extent of the exhibition in which they are used. The question of numbers is simply one of expense, as the flight of five hundred rockets is performed in the same space of time, and as simply (as regards mechanism) as that of one or two dozen. The next thing is to arrange the rockets in the apparatus so that their flight shall be simultaneous. In Fig. 140, the two lids have been removed, so as to give a clear view of the contents of the box. In the upper tier of holes a number of flight rockets are placed, the sticks passing through the upper and lower holes, and the mouths of the cases resting on the surface of the upper board, C, between the holes. Fig. 141 shows the position of the rocket ready for firing. The box having been constructed, the next question is, how to use it. For this I shall give two methods, that are the simplest and the best, especially if the question of electricity is left out of the subject for the present.

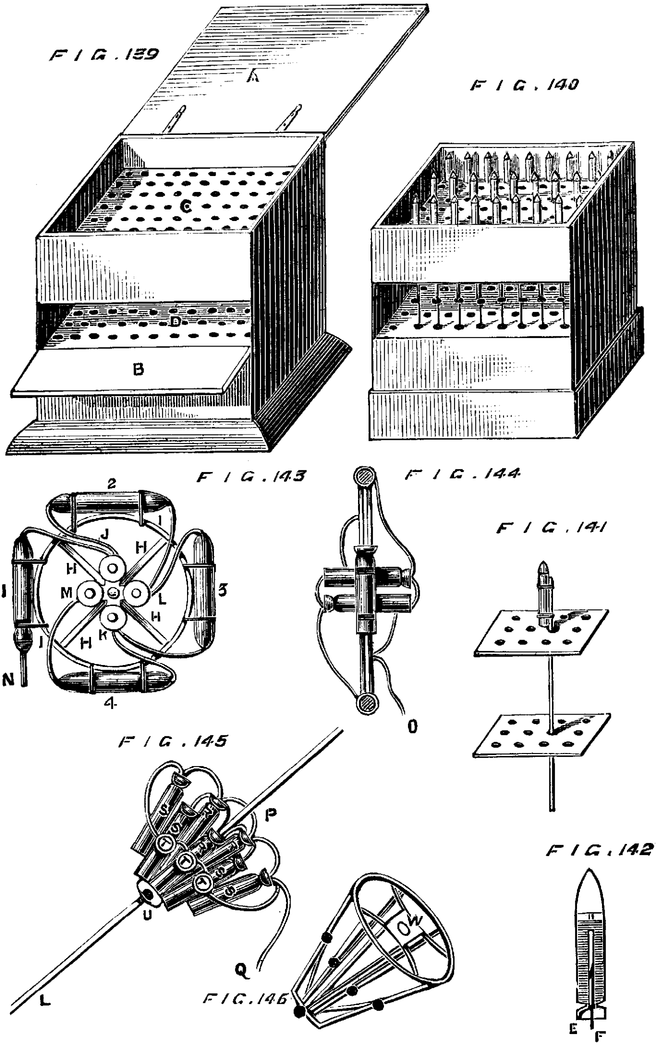
First, the rockets can be primed by covering the inside of the choked aperture, except the hole, with mealpowder paste, or better still with quickmatch and mealpowder priming, thus: take each rocket and pass a small piece of stiff match up the choke for about 2in., part of the end of the match, that enters the cavity of the rocket can be bent at right angles to prevent it falling out; the lower part of the match, which is outside the choked aperture, should then be split into two equal parts; one of these ends can then be made fast with mealpowder paste, to the inside of the cup or choked end of the rocket, the other end will be in a straight line with the cavity of the rocket, the lower part of which rests on the surface of the board which supports the case. Fig. 142 is a sketch of a primed case, showing the position of the quickmatch in the interior of the rocket. Having primed all the flight rockets in the above manner, they must be connected, so as to fire the whole batch at the same time, and the simplest plan is the following: Take the dry flight box (Fig. 139) and open the lid, A, as shown in the engraving; then cover the upper surface of the top tier, C, with a thin layer of dry meal powder; after this open the lid B, so as to allow a full view of the lower tier of holes; next take each rocket and slide the stick first through the upper and then through the lower hole, until the mouth of the case and match, E F (Fig. 142), rest on the surface of the meal powder between two of the holes, as shown in the illustration Fig. 141. After all the rockets are in position nothing else remains to be done but to close both the lids, A and B, until the time comes for their performance; and as this is usually the *finale* of an exhibition, the apparatus is much better placed out of the way of danger from stray sparks.

To fire the flight during the performance of a large fixed piece (usually lance work), place the box at a distance of 10ft. or 12ft. behind the framework, and open both the lids ready for action, and when the appointed time arrives the rockets can be fired simultaneously by the application of a portfire to the meal powder, or a piece of uncased match can be hung over the edge of the box, communicating with the contents.

This, I believe, is the usual plan adopted by the majority of the professionals; but we still have another that I have no doubt some of my readers would like to know; this is simply spreading a layer of short bits of match all over the upper part of the holes, C, the rockets being placed in the position before mentioned.

Both these principles give a very rough and ready method of firing flights of rockets, but not in a perfect stream, for however careful we may have been in this arrangement, some of the rockets will hang fire for a few seconds and produce a series of short breaks in their performance; but for ordinary purposes one of the above methods will be found satisfactory to the amateur.

Before concluding the present subject, I wish to give the principle I employ for firing flights of rockets by the aid of electricity. Instead of the box, given at Fig. 139, I use an open square or oblong framework, with a lower set of holes resembling D; the upper part is hollow metallic lattice work, through which passes insulated copper wire, to convey the electric current; at the centre of each bar of the laths a small hole is



FLIGHT OF ROCKETS, PIGEON, AND COMET APPARATUS.

drilled, which communicates with the insulator; this receives a thin platinum wire loop that is placed in contact with the cup of the rocket, with its priming of gunpowder. By passing a strong current of electricity through this apparatus, the platinum points are all made white hot instantaneously, and each rocket priming is fired at the same time; so that by this means I am able to obtain the most perfect flight of a large number of rockets. To the above apparatus is also attached a contact break, by which the flight is fired.

Should any of my readers wish to astonish their friends by firing flights of rockets by electricity, they can do so very simply by connecting a platinum wire with the meal powder on the upper tier of the box (Fig. 139), this being attached to the copper terminals of a small battery of half a dozen cells.

Pigeons.—I now pass on to the description of a very simple and amusing piece, known by the name of the pigeon, Figs. 143 and 144. This name is one usually employed by pyrotechnists, so that, however unsuitable it may appear to my readers, I also must use it, although I consider the term "line rocket" more correct and descriptive. For the construction of this piece, manufacture a small wheel, 12in. or 14in. diameter, having a square nave 2in. in diameter, with a hole, S, through its centre, to this will be attached four wooden spokes, H, to support the thin beech rim I; this is the wheel that forms the framework of the pigeon. To complete the piece four ½lb. rockets and four 2oz. wheel cases of sparkling, brilliant, or Chinese fire are required. The latter cases are bound to the circumference of the wheel, at equal distances, with soft iron wire or string, in the position given at Fig. 143; the cases are shown numbered 1 to 4. Whether brilliant or gerb cases are used for these must be left to the taste of the operator.

Having fastened the cases in position, with their primed mouths all in one direction, take the four half-pound rockets, and securely fix them to the square nave of the wheel, one to each segment, the choked ends of two of them pointing to the right hand, J and K (*i.e.*, when the piece is held with the rim directly towards the operator, in the position given for firing at Fig. 144), the remaining cases, L and M, having their primed ends placed in the opposite direction; this completes the piece ready for matching.

To accomplish this, take a piece of cased match 10 or 12 inches long, and connect it with the primed mouth of the wheel case, No. 1. See that the end of the bare match is in contact with the priming at the cup end of the case, then secure it firmly by tying it with twine round the outside of the clothing paper that projects over the mouth of the case; this is simply a leader to fire the piece with; next match the tail end of the same case with another piece of quickmatch, securing it in the above manner; this leader should now be connected with the primed mouth of the rocket, J, which is attached to the nave of the wheel; then tie in another leader at the clay end of this rocket, and lead it on to the mouth of the second wheel case, so that it can fire it after the rocket is spent. Next, connect the tail end of the second wheel case with the mouth of the rocket, L; this match will pass on the other side of the framework, as the choked aperture of this case is placed in opposition to that given at J. Each of these rockets will be seen to act in antagonism to each other. The remaining cases on the pigeon are connected in exactly the same manner as the others. The tail end of the third wheel case fires the rocket, K; this in its turn fires (from its other end) the fourth wheel case, which, when nearly burnt out, ignites the last rocket, M, and this returns the piece to pretty nearly its original position on the line. This piece is usually fired on a cord or copper wire, sufficiently long to allow of the pigeon travelling from end to end. A brief description of its performance will, no doubt, give my readers some idea as to its capabilities and effect when employed in a display.

Having procured about 100yds. of thin copper wire or fine rope, pass one end of this through the hole in the centre of the nave; the ends of this must then be attached to two poles fixed in the ground, and the wire or rope (whichever it may be) tightly stretched, so that it is perfectly straight; the height at which it should be fixed from the ground will depend upon the situation of the place, position of the spectators, and taste of the operator, but a lesser distance than 12ft. or 14ft. will not be found advisable. I shall now suppose that the "pigeon" is on the copper wire (this having been rendered taut), and the operator ready for firing; for this purpose he must place himself directly in front and underneath the line, and slide the piece into position by the aid of his portfire rod, if this be long enough; this will be about 3yds. or 4yds. from the right-hand post or starting point of the line, for it must be remembered that the first rocket, J, will propel the wheel from right to left, therefore if this position be neglected in starting the piece will be utterly ruined. To fire the pigeon, ignite the end of the match, N, Fig. 143, by the aid of a portfire fixed to a long rod; this at once sets the wheel revolving, by the aid of the No. 1 wheel case; when this is exhausted the quickmatch fires the first rocket, J, this drives the piece swiftly along the wire, until the propelling power is exhausted; when the flight is finished the second wheel case is fired by the match, which passes from the perforated clay end of this rocket to the mouth of the No. 2 wheel case; the piece again revolves rapidly until the second rocket, L, ignites, when the pigeon traverses the line again, but in the opposite direction, *i.e.*, from left to right; the same result follows when the remaining cases are fired by their leaders. It will be observed that I advise the piece being placed three or four yards from the right hand pole; the object in this is, that as every case is consumed the piece becomes lighter, so that the propelling power of the rockets has less resistance to overcome, consequently the range of flight is extended, and, if some allowance be not made for this increased range, the last rocket will carry the "pigeon" beyond its proper destination, and so mar the effect of its performance.

Fig. 144 is an edge view of the piece on the wire ready for its performance; the firing point is shown at O.

I now come to the question of illuminating the "pigeon," but it is more often fired without this extra addition than with it; this is, however, a very simple matter, and accomplished by binding short 2oz. colour cases on the edges of the wheel at right angles to the wheel cases. These can be fired at any point of its performance, but the best plan is to match them so that they shall burn only with the last two (third and fourth) wheel cases.

These pieces are very simple in construction, and give great amusement, especially to the juvenile portion of the spectators.

Comets.—This is simply a modification of the "pigeon," or line rocket. By referring to the illustration, Fig. 145, it will be observed that the piece is constructed somewhat in the form of a cone, the base being represented by the mouth of the cases, P. The framework of the comet, Fig. 146, is best constructed from thin light ironwork after the manner shown in the sketch, the piece itself is made up of the following cases: Four $\frac{1}{2}$lb. rockets, six $\frac{1}{2}$lb. Chinese gerbs or $\frac{1}{4}$lb. brilliant cases, and six short $\frac{1}{4}$lb. cases with magnesium or coloured fire—the former, of course, having the most brilliant effect.

The rockets, R, are placed one on each side of the nave, through the centre of which the wire passes, the mouth of the cases pointing all in one direction, as shown in the engraving, Fig. 145. The six gerbs (or brilliant cases), S, are attached at an angle to the circumference of the framework, so that the mouth of each case inclines outward; by this means a much wider stream of fire is obtained. Between the gerbs are fixed small iron pins, to which are attached the magnesium or coloured fires that burn during the descent of the comet. The cases are all connected with one another by the aid of quickmatch, a long leader, Q, being left to fire the piece. As all these cases are usually intended to burn at the same time, it matters very little to which gerb case the match is first led, providing that all the rockets have been connected together; the leaders are shown by the letter P, the lower hole, U, is the framework through which passes the wire, V. By the above arrangement the gerbs and colour cases must last exactly the same time as each other, when they are fired simultaneously. But if the comet be discharged from a great height, the gerbs and colour cases are fired first, and when half of these have been consumed, the rockets are ignited and the comet then commences its descent in a brilliant cloud of fire.

The wire used for this purpose is the same as I described for the pigeon, but the fixing of it will give the operator very much more trouble than the former, for the chief aim of the comet (or rather the maker) is to commence the descent from the highest point possible to within a few feet of the earth.

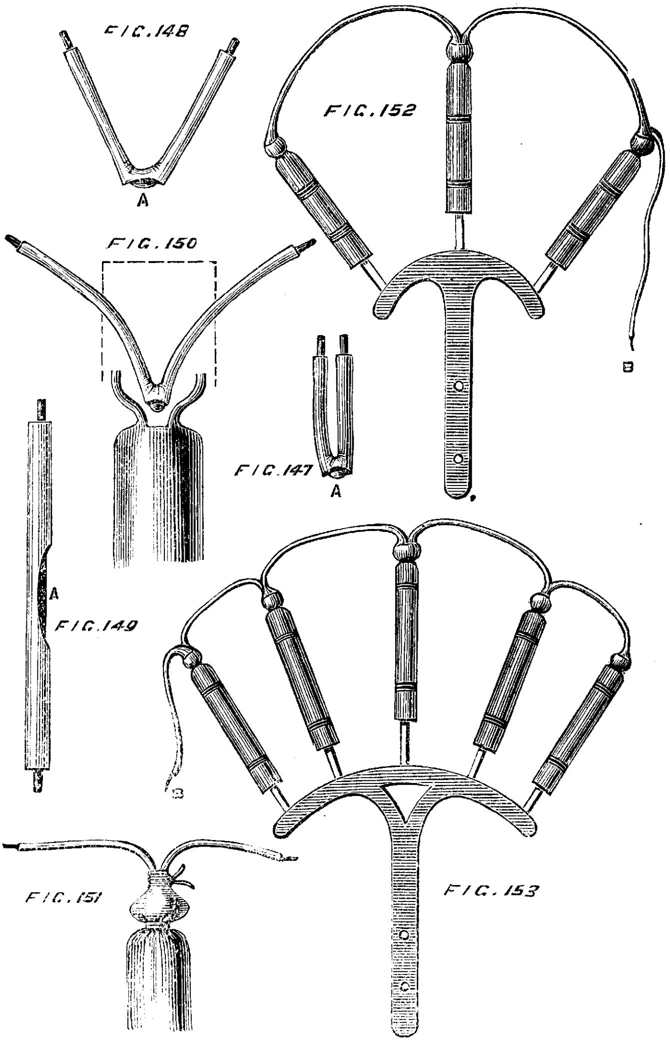
The two principal starting points likely to be employed by the amateur are either the top of a tall scaffold pole or chimney—the latter is the one usually selected by the tyro. Into this a stout iron hook should be driven, on which is hung the looped end of the wire carrying the piece; the lower end can then be staked down and tightly stretched by the aid of a lever, until the proper degree of tension is obtained; the length of the wire will depend in a great measure on the height of the starting point, but this can only be obtained by actual experience.

A much smaller comet can be manufactured (for trial experiments), carrying 2oz. rockets and gerbs, but it is an understood thing in pyrotechny, that if comets be attempted, it is more satisfactory to employ large cases, and thus really produce a fair resemblance of that astronomical wonder we wish to imitate.

When the finished piece is placed ready for action, it must be kept in position until it is ready for firing, and the simplest thing is to pass one or two of the loops formed by the rocket leaders over a nail or hook driven in a plug of wood at the end of the wire, and when the match is fired the comet is set at liberty, and descends not only by the propelling power of the cases, but also by its own gravitation.

Clothed Quickmatch.—Before I begin with the construction of bouquets of gerbs, &c., I think it will be much better to give the improved method of making quickmatch, and clothing this ready for matching large fixed pieces. In the first part of the work I gave instructions for making match for stars, but for the present purpose a stronger description will be required, and this will also have to be in much longer lengths.

To manufacture this kind, take ordinary lamp cotton from four to six strands (according to the thickness of match required), and make one end of this fast to a hook in the wall, then run out the ball of cotton to the full extent it is wished the match to be, and fasten the other end to another hook, the distance between these two points depending on the place or situation in which it is manufactured. In the summer (and this is undoubtedly the best time to prepare it), this can be done in the open air on a fine day, but in winter some warm room will have to be selected, in which the finished match can remain undisturbed until it is quite dry and stiff. Next make a paste of meal powder, and thin starch or gum water (the strength of the latter should be 1oz. of gum to 20 fluid ounces of water), and thoroughly mix them; then take the bowl containing the mixture to the starting point of the cotton, and let an assistant hold this underneath it; then, having taken up a quantity of the paste in the palm of the hand, draw the cotton gently through it, so as to give it a thick and even coating of the composition, working gradually towards you. After the whole length of cotton is finished, it should be carefully examined to see that it is well covered, and if any bare or thin places are observed, they must be gone over again with the meal powder paste, until a smooth even coating of the material is obtained. The quickmatch when dry should be cased, or piped as it is called, the tubes for this purpose being made from thin demy or cap paper; strips from 12in. to 16in. long and 4in. wide are sufficient. The former on which they are rolled consists of a steel wire, 18in. long



CLOTHED QUICKMATCH, AND PRINCE OF WALES'S PLUME AND BOUQUET APPARATUS.

and three-sixteenths of an inch diameter, having one end slightly larger than the other, so that when these pipes are threaded on a long length of match the ends will fit in each other, the joint being farther secured by a thin strip of blue double-crown pasted round the juncture. If the match be made according to these directions, and is perfectly dry before it is clothed, there will not be the least difficulty in successfully connecting any large piece, however intricate the design, and there need be no apprehension as to the results when the piece is fired. I shall now pass on to give a brief description of the principle employed in using this cased quickmatch in connecting a large number of cases, arranged in the form of a design or pattern as a set piece. I must suppose that there are a number of gerbs to connect either in a straight line, like a cascade, or in a circle representing a brilliant sun, each of these having to be connected by the aid of leaders, so as to fire all of them at the same time. Take one of the lengths (say 8ft. or 10ft.), of cased quickmatch, and expose the raw match at the end of the case, pass this down into the mouth of the gerb on to the priming, and secure it by tying it in with twine; next lead the match to the second case, and then double it as shown in the illustration, Fig. 147. The point of the case A must be cut with the scissors, so as to remove a portion of the covering, and leave an oblong slip, which exposes the raw match (*vide* Figs. 148 and 149). If this doubled end be then connected with the priming of the second case, the point, A, of exposed black match will fire the gerb. Fig. 150 shows the position of the doubled quickmatch before it is secured; Fig. 151, after it is tied in ready for firing; the remaining number of cases are connected in exactly the same manner. This principle is the one employed for connecting all large pieces, with the single exception of lancework, which I have described under that heading.

Prince of Wales's Plumes.—The first design that I shall introduce is what is called the "Prince of Wales's Plume," Fig. 152; this consists of a light framework made of thin iron or wood, the lower part or stem having two holes, by which it is screwed to the firing post. In the illustration, Fig. 152, I have represented it as consisting of three Chinese gerbs, reported, but these can be replaced with Roman candles at the taste of the operator. Fig. 153 is another sketch of five cases, this is termed a "Bouquet."

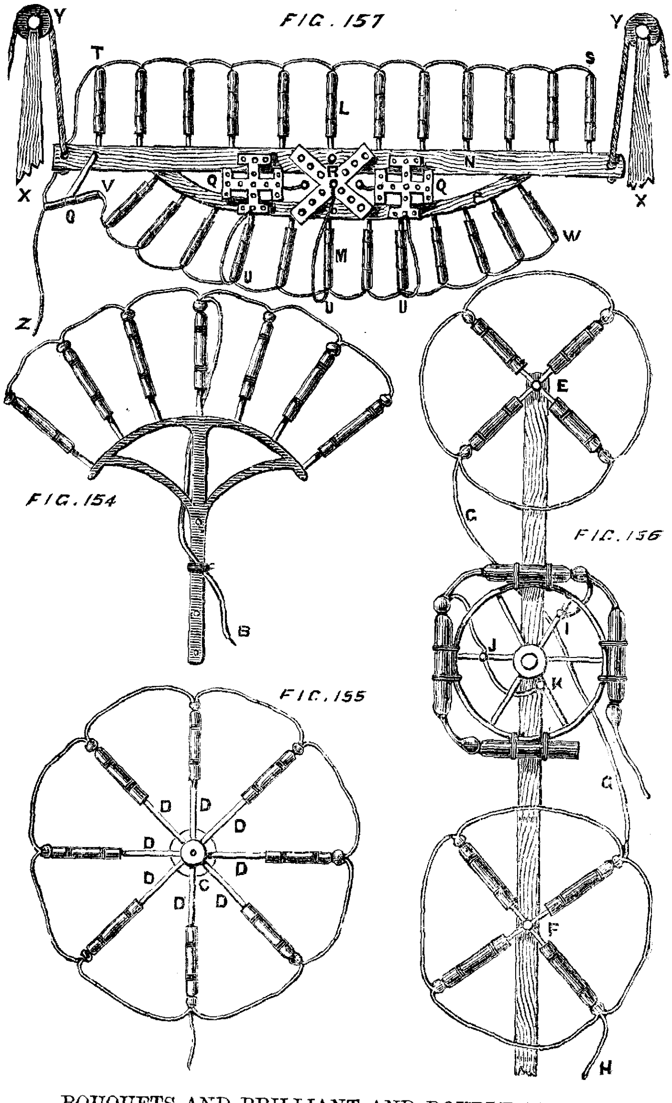
Bouquets.—The last piece I have to describe of this kind is that given at Fig. 154, this is usually of a much larger size than the others, the cases being placed wider apart; these can either be gerbs, brilliant cases, Roman candles, or coloured gerbs; the latter having a most beautiful effect, especially if fired at the upper part of a large vertical wheel.

These "Bouquets" are exceedingly simple in construction, and should be the first upon which the amateur should try his matching skill. The leader B is shown, by the aid of which it is fired, that given at Fig. 154 is seen secured to the stem, this is on account of the height at which it is fixed. I have only thought it necessary to give three illustrations of this description of work, as there is no limit to the number of cases which can be applied to the "Bouquet;" for instance, a perfect curtain of fire in the form of a crescent, can be constructed (for grand occasions) carrying three or four dozen 1lb. Chinese gerbs and Roman candles, but such pieces as these belong more to the work of the professional than to the amateur pyrotechnist.

Brilliant Sun.—The next illustration (Fig. 155) is for a brilliant sun, the framework of which consists of a circular disc of wood carrying eight arms; to the ends of these are fixed eight brilliant cases, reported, of the 1oz. or 2oz. size. The centre, C, is a circular piece of wood 1in. thick and 4in. diameter, grooved to receive the eight spokes shown in the illustration. This piece is not only simple in construction, but pleasing in effect, and will give the operator a good lesson in matching; the beauty of this, however, is very much increased by adding a double or single saxon, or triangle wheel to its centre, this being made to carry a changing colour case. If a double saxon be used, this and the brilliant cases must be fired at the same time, but with the single saxon these cases must burn with the second half and colour case; should, however, a triangle wheel with three 1oz. or 2oz. cases be employed, let two of these be brilliant and one sparkling fire. Fire first the No. 1 sparkling case; when this is finished it should ignite the colour (carrying three changes, green, crimson, and blue) and first brilliant case, and when the half of this is consumed fire the brilliant cases, and the result will be an exceedingly pleasing piece, one worthy of concluding a small display, especially if the brilliant cases are well reported with Tower-proof powder instead of the ordinary F F F gunpowder.

Double Sun.—The design given at Fig. 157 is what I shall designate by the name of the double sun (or, as *Punch* would say, the Siamese twins) with vertical rainbow wheel; this is a piece that I have repeatedly used, and from the ready manner with which it can be put together in localities removed from the professional help of the joiner, makes it a general favourite of the amateur. This piece is composed of eight 1oz. or 2oz. brilliant cases reported, three 2oz. brilliant, and two sparkling wheel cases, and three 1oz. colour cases, blue, crimson, and green. The only woodwork required for this is an upright pole about 14ft. long. To the upper part, E, are nailed two cross-pieces of thin lath, to which the four brilliant cases are fixed; 4ft. below this (at the point F) another cross-piece is fixed, and the remaining cases are fastened in the same manner; between these two suns a hole should be bored to receive a $\frac{1}{4}$in. iron spindle, 6in. long, on which the rainbow-wheel revolves; this wheel must be from 12in. to 14in. diameter, having six spokes supporting the beech rim, for carrying the four wheel-cases; these vertical wheels will be more fully described in their proper place. The design, Fig. 156, gives the plan of connecting this piece; the match G from the upper sun crosses at the back of the pole to connect the lower set of cases; the leader H, for firing the suns, is at the lower part.

The wheel cases are matched in the manner described in the chapter on



BOUQUETS AND BRILLIANT AND DOUBLE SUNS.

colour cases and small wheels, but the centre is illuminated with three colours instead of one; the first colour case, I, is crimson, and fires with the second wheel case; the remaining colours, blue and green, J and K, both fire with the third wheel case.

If these brilliant reported and wheel cases are prepared from the formulæ that I have given in the early part of this work, it will be found that the 1oz. brilliant case will last during the combustion of two 1oz., or one and a half 2oz. wheel cases; so that if 2oz. cases be employed on the wheel, the leader, H, for the brilliant cases should be fired when a quarter of the third wheel case is consumed, a little time being given so as to allow of the suns properly igniting. The firing of the blue and green colour case being the signal for the commencement of the third case on the wheel, by this means the piece can be most accurately timed; and let me strongly impress upon the amateur the necessity of having all his pieces perfect in this respect. It is a very easy matter, and shows the operator to be perfect master of his work, for it matters very little, however beautiful the piece may have been, if the finish be not perfect it destroys the intended effect, and gives the critical spectators the idea that the design is thrown together and left to perform its work by chance, be that good, bad, or indifferent. Remember that the results of all these fixed laws of to-day will be the same to-morrow, and if the perfect piece be imitated a year hence the performance must be the same in every respect, if the work be correctly executed; so that the operator must have the power of producing a pyrotechnic design, as easily in reality as the artist is able to draw it on paper by the aid of his pencil. His theory should be the counterpart of his practical work, each complete, each perfect in itself.

CASCADES.—The next class of design that I shall illustrate will be what is called the "cascade" piece. The simplest plan for forming one of these is to take a long piece of deal, 12ft. or 14ft. long, and 3in. square, to which must be nailed strips of wood at equal distances, at right angles to the length of the wood work. (Fig. 157 is the sketch of a new cascade piece of mine, which will give some idea as to the principle of working this design.) To the upper strips of wood are attached Roman candles with coloured stars, at equal distances, the number of strips depending on the number of cases to be fired, but it is not advisable to place them more than 10in. or 12in. apart. The lower strips of wood are screwed to the under part of the bar N, in a perfectly straight line with the above, to carry the gerbs.

The same number of cases (Chinese gerbs) as there are Roman candles above will be used, only the latter are placed closer together, so as to occupy only two-thirds the length of the wood work, this group of gerbs being placed exactly in the centre of the framework. The upper, or Roman candle cases, when secured in their proper position, are all connected with one another by quickmatch, and a leader 8ft. to 10ft. long left at the end to fire them with. The lower, or gerb cases, are also matched n the same manner, and a leader left to fire them with, this being placed at the opposite end of the piece, so that there is one at each end, and by this means mistakes are avoided.

The order of firing the cascade will depend, in a great measure, on the length of the Roman candles employed. If $9\frac{3}{4}$in. case, containing five stars, be used, they will burn about the same length of time as the gerb cases, and the whole piece can then be matched altogether from end to end, and fired with one leader; but, as change is desired in the displays, this is not the order I would advise, for it should be remembered that in compound fireworks, variety must be the order of the day; therefore, if Roman candle cases $11\frac{1}{2}$in. long, containing seven stars, be used they will be found quite large enough to give that change that cascade pieces ought to possess, so that I shall suppose that this length of case has been adopted for the Roman candles, and $9\frac{3}{4}$in. Chinese gerbs. To fire the cascade apply the portfire to the leader that connects the Roman candles, and when two of the stars have been discharged from each of the cases, fire the leader attached to the gerbs, and a perfect cascade of fire will fall to the earth, while above this, a stream of fiery jets will discharge stars of various colours. This simple form of cascade is very pleasing, and one that I can most conscientiously recommend to the notice of the amateur. I have left the subject of fixing this piece until I fully describe the illustration given at Fig. 151. This is my improved form of the above, which I shall designate by the title of the "Jewelled Cascade." This differs in several important particulars from the last named. First, the Roman candles are placed a little closer together, either by increasing the number of cases, or by using a shorter piece of woodwork. The former I prefer. Secondly, by placing a curved piece of wood between the bar, N, to which is attached the group of gerbs, these being placed in an oblique direction radiating from the centre case, so that by this means a perfect fan-shaped sheet of fire is produced, having a much more natural resemblance to the piece it is intended to imitate. Thirdly, to the centre of this is fixed the jewelled part, consisting of three stars, in 2in. colour cases of the 1oz. size, the whole being connected by the aid of a time fuze, O. By this means the piece can be fired with one leader and left to perform its work on the self-acting principle, and the operator is then at liberty to introduce flights of rockets or shells from the back part of the framework during the performance of the cascade.

The bar, N, is represented as carrying one dozen $11\frac{1}{2}$in. Roman candles on its upper part; but if the amateur wish to employ this piece to advantage, I would strongly advise him to use from eighteen to twenty-four cases of each kind on the upper and lower part of the framework. Thus a bar divided into twenty-four divisions will support the Roman candles, L, in the position given in the illustration; the second part of the framework P, will also carry the same number of Chinese gerbs (not reported), arranged in the oblique position given in the sketch.

The gerbs and Roman candles having been fixed, two small Maltese crosses, Q, Q, of 12in. diameter each, must now be obtained, carrying twenty-one 1oz. colour cases, 2in. long ; these are best attached by boring holes in the wooden framework of the crosses at equal distances, and fastening the clay end of the case with glue. The centre cross is a plain one, 16in. or 18in. diameter, also carrying colours of the same size. The number of cases for this will depend on the position they are placed in.

Now, as regards colours for this centre, crimson, blue, and green, will have a brilliant effect; thus, let the centre cross be crimson and green, and the two side pieces crimson and blue, remembering, however, that the colours must be properly arranged. Or again, let the cross work be in two colours only, blue and gold. This will give a magnificent appearance, as both these colours have a more decided effect when employed with gerbs.

The size of colour case that I have given is the 1oz., 2in. long; these should have good foundations of clay at the end (about ½in.), the remaining part of the case (1½in.) being filled with the proper coloured composition given under colour cases for wheels, and primed as directed in that chapter.

Having all the cases ready for connecting, take one of the 2oz. wheel cases, fill it three parts full with sparkling wheel composition and prime it, this will give an excellent time fuze, by the aid of which the gerbs and colours are fired; attach this to the framework in the position given at O, so that the fire from the mouth of the case is away from the piece. Next match all the Roman candles, starting at S and finishing at T, then connect a leader from the last case to the mouth of the fuze, O, and from this a longer leader by which the piece can be fired. The next part of the operation is, first matching all the colour cases in exactly the same manner as I described for lancework, taking care that the mouth of these cases are well protected from sparks by pasted strips of thin paper. One leader, V, from each of the crosses must be left long enough to connect with the Chinese gerbs, so that they are ignited at the same time as the latter. When the colours are matched and the three leaders V, V, V, attached temporarily to the gerbs, take the length of quick match and commence at the tail end, V, of the fuze case, O, and connect the whole number of Chinese gerbs, not forgetting to secure the three leaders from the colours, and finishing at the point W. By this means the cascade is most accurately timed, and its performance worthy of the time and trouble bestowed upon it by the operator. We must now consider as to the best means of fixing the piece, and, undoubtedly, this is by hoisting the whole framework up to the summit of two tall poles, by means of a cord and pully fixed at each end of the apparatus.

The ends of poles, X, X, are shown carrying a pulley, over which passes a short rope, fastened to each extremity of the bar, N, by which simple means it is drawn up to the proper height; this should not be less than 18ft. or 20ft. from the ground, for, should a shorter distance be employed, much of the beauty of the gerbs will be destroyed. In the illustration I have shown the two poles outside the framework, so as not to interfere with the design, but these should be placed so that the bar, N, extends 2ft. behind each upright, to steady the apparatus when drawn up. The ropes by which this is done can be made fast to the pole on each side, so as to be out of the way.

The jewelled cascade is fired by igniting the end of the leader, Z; this fires the fuze, O, and Roman candle, the former burning during the discharge of two stars from each case, this then fires the remainder of the piece by the aid of the tail end of the case, O, being connected with the gerbs and colour cases, and thus the accurate performance of the cascade is secured. The above design is one that I have repeatedly used, and can most strongly advise the amateur to try, illuminated in blue and gold.

Vertical and Horizontal Wheels.—The first illustration, Fig. 158, is for the triangle wheel carrying three cases; this consists of a nave A through which is bored a hole to admit a quarter-inch spindle on which it revolves. The spokes B are of light wood, broad at one end, and are hollowed out, so as to admit the cases, which are tied firmly in position by string or soft iron wire.

The cases usually employed to furnish this wheel are one sparkling and two brilliant cases, of the 1oz. or 2oz. capacity, and 1oz. or 2oz. colour case, with three changes. They are matched on the same principle as that given in the directions for the single triangular wheel; these are very easily introduced into large designs in the place of Saxons, with marked improvement to the display, as by this means, magnificent circles of brilliant fire are produced, rivalling in beauty any form of Saxon that can be introduced. The next wheel design is known as the "Rainbow wheel" (Fig. 159); this is the illustration of a small vertical wheel, constructed of wood, with a light beech rim to which the cases are fixed; this kind of wheel is usually twelve or fourteen inches diameter, and made to carry four 2oz. wheel cases, two sparkling and two brilliant, and three 2oz. colour cases, crimson, green, and blue. The principle on which this wheel works, will be seen by referring to the sketch; the leader C fires the first case, this afterwards fires the second wheel, and first colour case D When the former is consumed, the third case (brilliant fire) commences to burn, and, with it, the two colour cases, E. F.; the ignition of these colours will be the signal for firing the other parts of the piece, when this is used as a centre to any design, and it is principally for this purpose that the operator requires it.

The next illustration will be for the large vertical wheel, Fig. 160. This can be fired alone as a concluding piece to a small display, or, if desired, two or three of these can be used with different centres, one being replaced by another after the first is over. They have the advantage of being very portable, easily put up and taken down, and can be kept in a dry place until the time comes for their performance. The chief use of such wheels is for the centre of large fixed pieces, and they are also employed in conjunction with Saxons, or small triangle wheels and gerbs.

The usual size of the large vertical wheel is from 24in. to 28in. diameter,

FIG. 159

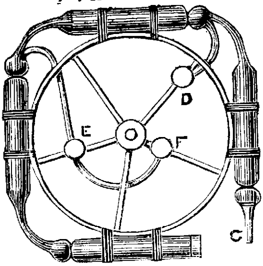


FIG. 158

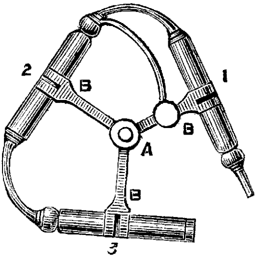


FIG. 160

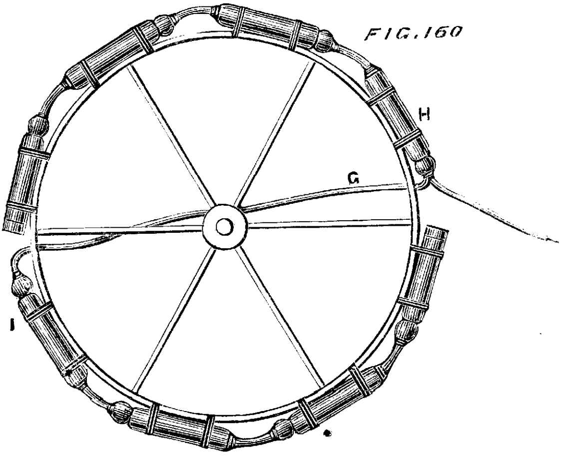


FIG. 163

FIG. 162

FIG. 164

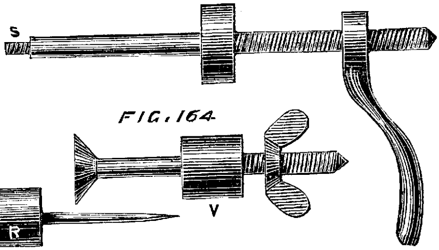


FIG. 161

VERTICAL AND HORIZONTAL WHEELS.

constructed on the principle given for that at Fig. 159, only with this exception, that I make use of a rim of very thin hoop iron (painted) instead of wood; by this simple addition the increased strength of the wheel is obtained, without adding materially to its weight; and lastly, but certainly not least of all, it gives an indestructible surface to which the cases are attached, and one not likely to lose its form, or take fire from the heat of the burning cases.

I usually make this wheel to carry eight cases of the 2oz. size, burning two *at a time*; by referring to the sketch it will be seen that each half of the circle is occupied by four cases, and that the match, G, from the first case, H, on the upper half is connected to the first case, I, on the lower segment; by this means both sets of cases fire at the same time. It will also be noticed that the mouth of these two cases and those following (top and bottom) are placed in an opposite direction, so that the motive power obtained by their combustion is all in one direction. I have no doubt but that the operator will find some little difficulty in placing all these cases in the exact position given in the illustration, when he first commences to make the large wheels; but he will find the best plan is to carefully and equally divide the rim of this piece into the proper number of divisions for the cases, making a mark with a file at each point; this will give the position for the centre of each wheel case. With respect to illumination, they can be simply used as an ordinary "Rainbow wheel," or, better still, with a small fixed design, such as a Maltese cross, monogram, or star, executed in ½oz. or 1oz. colour cases, or even in lance work; this must be left to the pleasure of the operator, but should he adopt the latter plan, he must remember that the framework carrying these colour cases must not only be less in diameter than the wheel itself, but will also have to be a perfect fixture, and must not in any way interfere with the easy revolution of the wheel. The method that I employ for this purpose is to have the wheel spindle of the shape given at Fig. 165; this is an ordinary spindle with two arms or prongs, at the end of which are two small nuts and screws, so as to carry the light monogram framework well forward from the rest of the piece, the large vertical wheel, LL, is seen in position for revolving on the centre of the spindle M. The boss, N, in front prevents its coming in contact with the colour work, the movable nut O is used for placing the wheel securely on the spindle; P, thread part passing through the framework of the piece, or firing post Q lever screw for tightening the spindle.

I have used this form of spindle for a number of years, and can speak highly of it for the purpose I have just described. It certainly requires a little extra trouble in taking the wheel on and off; but the steady manner in which the piece works, after it is fixed, amply repays for the labour expended on its manipulation. Fig. 161 is the sketch of the common form of spindle used for Saxons and small wheels; this is usually driven into the framework after the piece is on, a piece of wood or cork, R, being fixed on it to keep the revolving Saxon away from the framework. Fig. 162 is another illustration of a spindle, which is employed for the larger vertical wheels, and can be fixed in the wood work at any time, the piece being afterwards placed on the spindle, when required to be used; the small end S is tapped to receive the nut, Fig. 163.

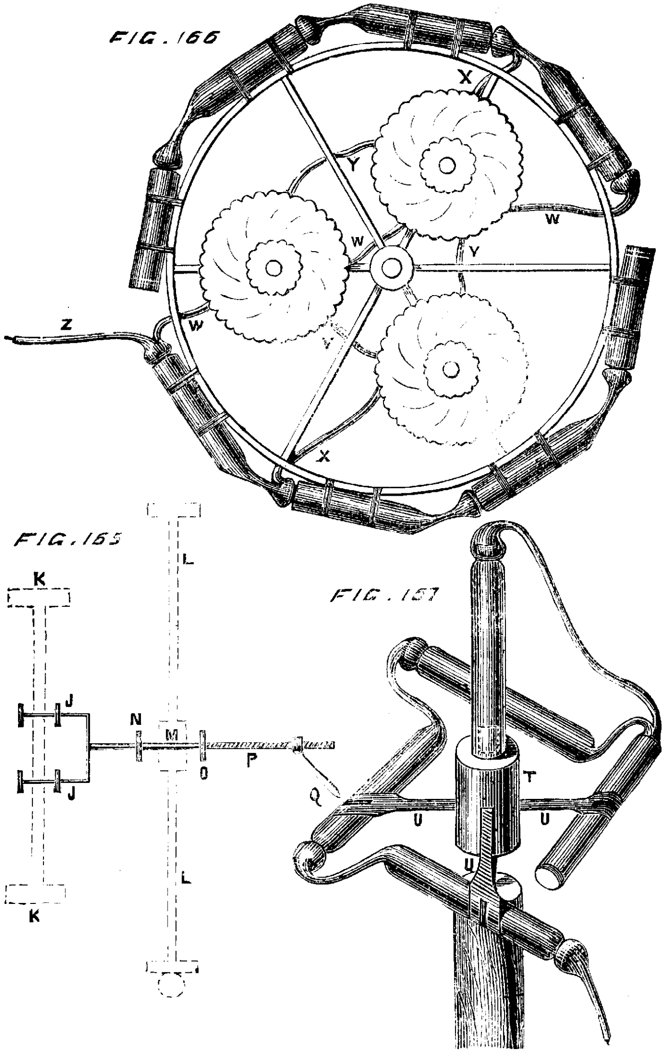
The sketch, Fig. 164, is for my improved spindle for Saxons and triangle wheels; this is used in large designs, where a number are required, these being kept ready with the spindles through the centres; so that all the amateur has to do, when he comes to prepare his piece, is to open the box containing them, and screw all of them into his framework (this is the work of a few minutes) and they are then ready for connecting to the rest of the piece.

The spindles are usually forged from ¼in. or ⅜in. rod iron, the thickness of spindle depending on its length and the diameter of the wheel it has to carry. As I have said before, any of these wheels can be fixed separately as a small piece; for this purpose the amateur will require a firing post, this should be a pole 3in. square, standing out of the ground 10ft., firmly fixed, having suitable holes bored in the upper part to receive the spindles, so that by this means the operator can fix or take down any of the small pieces in a few minutes.

Fig. 167 is the illustration of a simple form of horizontal wheel, consisting of a hollow nave (through which passes an upright iron spindle) carrying four arms or spokes U, to the ends of which are fixed the wheel cases, of the 2oz. or ¼lb. capacity; to the upper part of the nave also, a turned piece of wood is left that fits into the end of a 2oz. gerb case.

The cases required to complete one of these wheels are four 2oz. or ¼lb. wheel cases of brilliant fire, and one Chinese gerb of the same size; these are connected on nearly the same principle as the four cases on the vertical wheel, *i.e.*, the mouth of one communicates with the tail end of the other, in rotation, until the whole number have been consumed; the only difference being, however, that the mouth of the last case fires a gerb, placed upright on the centre of the piece, this must last exactly the same time as the wheel case that fires it, and, in addition, should be well reported.

Horizontal wheels can (like the vertical description) be made to any design; their name is legion. The most beautiful form is what is termed the rocket wheel, and, as this is a very beautiful feature in any display, I shall briefly sketch its construction, before concluding my present subject. The framework for this piece consists of a hollow nave 16in. deep and 4in. diameter; to the upper part of this are attached six square spokes, and to the lower part a similar number, both these sets of spokes support two thin hoop iron rims, to which the wheel cases are attached; the upper and lower rims are further strengthened and held together by strips of wood, fastened inside, and passing from the upper to the lower one, one piece of wood being placed opposite each spoke. On the upper rim are also six strips of wood placed in an oblique



VERTICAL AND HORIZONTAL WHEELS.

direction, inclining outwards. These are placed at equal distances on the wheel, and project about 6in. above the edge of the top rim. To these are attached half a dozen $11\frac{1}{2}$in. Roman candles. The twelve spokes of the two wheels are placed perfectly parallel to each other, six above to the same number below. In each of these are fixed two small staples or wire loops to carry two 2oz. rockets, so that it will be readily perceived that the spokes of this wheel not only support the rim, with its wheel cases, but act the part of a small revolving rocket stand. To the upper part of the nave a small mortar is screwed to discharge a mine of serpents or crackers, which is fired with the finish of the piece.

The cases required to construct the rocket wheel consists of twelve $\frac{1}{4}$lb. wheel cases, of sparkling or brilliant fire, twelve 2oz. rockets, six Roman candles, $11\frac{1}{2}$in. long, and one mine of serpents or crackers. These are arranged in the following manner:—First, six of the $\frac{1}{4}$lb. wheel cases are attached to the upper rim at equal distances, next the six remaining wheel cases are fixed to the lower rim in the same manner; then to each of the strips of wood projecting above the upper rim of the wheel must be fixed the six Roman candles, the mouth of these cases having an oblique direction, so that the stars are fired away from the piece when it is revolving. The twelve 2oz. rockets are placed in the staples fixed to the wheel spokes in the same way as they are placed in a rocket stand, two to each felloe; the concluding fixture is the mine, this being screwed on to the top of the nave.

There will not be the least trouble in matching all the cases properly, if only ordinary care and judgment be used. First, it must be understood that the upper and lower sets of cases are intended to burn together—*i.e.*, two at a time—and will be matched on the principle given for the large vertical wheel, Fig. 160, a leader being led from the first top case, across the wheel to the first bottom case, this being opposite to the one above. The cases are then connected all round, in the manner shown at Fig. 160; but the quickmatch case is not tied in the upper cases until the additional leaders have been introduced. These are for the remaining cases. From the tail end of the first upper wheel case, connect a leader to the mouth of the two first rockets, and so on round the wheel. The Roman candles are all fired by a leader from the mouth of the third upper wheel case and the mine from the tail end of the last case, this concluding the performance of the piece. The piece is fired by the aid of a leader from one of the first cases; when two of these (one upper and one lower) have been consumed they immediately fire both rockets on the spoke near them, and so on until the fire reaches the leaders connecting the Roman candles, when these begin to play, throwing out the coloured stars in all directions, while the piece is revolving. With the tail end of the last case the mine is sprung, and so the piece terminates to the delight of the spectators and self-satisfaction of the operator. I do not know of any piece more amusing or brilliant for the amateur to make, considering the simplicity of its construction and the ease with which it is put together.

The concluding wheel design is what is known as the "Saxon wheel," Fig. 166. This consists of a large vertical wheel, 3ft. 6in. diameter, constructed on the same principle as the others I have just described, carrying six arms or spokes, on the centre of three of these a hole is bored to admit the spindle given in the illustration, Fig. 164. V is a piece of turned wood through which the spindle is screwed, after the Saxon is placed on it. This being in front of the wheel spoke and the winged nut behind, there is a very ready means of screwing it up perfectly tight; the wood V also keeps the revolving Saxon clear of the wheel during its performance. By referring to the illustration, the method of constructing a Saxon wheel will be seen. This piece is not only a very old one but exceedingly simple to make, and beautiful in its effects. The cases required are eight or ten ¼lb. wheel cases, 7¼in. long; two of these being of sparkling, and the remainder of brilliant fire; also three single Saxons, with 1oz. colour cases, crimson, green, and blue; these are matched to burn with the second half of the Saxon. The sketch shows that the wheel cases are connected again so as to burn two at a time, the first pair being the sparkling fire; the quickmatch W connecting these is seen passing at the back of the piece.

Having placed all the cases on the rim of the wheel and properly secured them with fine iron or brass wire, connect them in the manner shown in the engraving, only leaving the choked end of the second case on each side unscrewed, so as to be ready for the Saxon leaders; but if five wheel cases are used on each side, this latter leader must be connected to the mouth of the third case, as the Saxons are intended to last during the combustion of three pairs of brilliant cases. Next take the three spindles and place on each of them one of the illuminated Saxons with its colour case. All that is required now is to screw them firmly into the three spokes, and see that they revolve freely. Then let them be connected by leaders all round, starting from the mouth of the second wheel case on each side, XX, the match leading from these cases, YYY, the leaders connecting the Saxons with one another; the addition of the firing leader Z completes the piece ready for exhibition.

The order of firing is as follows: After igniting the leader Z, the two sparkling cases fire and the wheel commences to revolve. When these are consumed the first pair of brilliant cases ignite, and with them one end of each single Saxon, the colours firing with the second half of this piece, so that by this means three distinct changes are obtained, each beautiful in itself: and from the easy manipulation of the piece, I would advise the amateur to place this on his list of compound fireworks.

Saxon and Lance Pieces.—The concluding part of this chapter will be devoted to the subject of Saxon and Lance pieces.

First, then, I shall take Saxon pieces, as being foremost on the list;

these are designs in which the revolving part of the work is principally composed of Saxons. Fig. 168 is the illustration of one of these designs and one which will be found very satisfactory in its performance.

The framework for this design is composed of a central part or nave, to which are attached eight strong arms or spokes, 5ft. or 6ft. long, and 3in. wide; these are fastened into the nave (which is grooved to receive them) by means of bolts and nuts, so as to be readily taken to pieces after the piece is fired, and for the convenience of packing in a small compass. To the outer end of these arms there is a strong wooden rim, 2in. wide and ¾in. thick, into which is screwed the strips of wood for the brilliant cases, the Saxons being fixed about 4in. from the ends of the arms. In the centre is a forked spindle carrying a small lance frame, such as a star or monogram piece, in white or coloured lances; this should be about 2ft. 6in. diameter, and the vertical wheel not less than 3ft. with double sets of 2oz. or 4oz. cases.

The usual number of cases required to complete this design is: sixteen 1oz. brilliant reported cases, or 2oz. Chinese gerbs, eight single or double Saxons with colours—four crimson, A A A A, two blue, B B: and two green, C C; this will give a good arrangement of colours.

The large vertical wheel should be made to carry ten cases of the 2oz. or 4oz. capacity burning two at a time, six of these being in brilliant and four in sparkling fire. The centre of lancework can be composed either of ¼in. or ⅜in. colour cases, 2½in. or 3in. long; this will depend on the time they are to be fired These lances should be the white or brilliant sort that I have previously described.

The brilliant fixed cases are placed between the Saxons (in pairs) at the ends of the strips of wood fastened to the rim of the framework, as represented in the illustration, and matched all round. The Saxons are fixed about 9in. nearer the centre of the piece, and are likewise connected all round; a long leader from each of these should be brought down so as to be readily secured to the firing post, out of the way of stray sparks, and ready for firing when the proper time arrives. The centre or vertical wheel is connected in the manner I have given before, and a leader left for firing, and the lance or colour work is also matched separately.

The order of firing one of these pieces is the following: let the vertical wheel be fired first, and when one pair of cases have been consumed fire the centre lancework. After the second wheel case is exhausted, the brilliant wheel cases commence, then fire the single Saxons. When one half of these have been consumed the second half fires, and with it the colour case; this will be the signal for lighting the brilliant fixed cases. There will then be a magnificent brilliant sun nearly 20ft. in diameter, with an illuminated centre in revolving colours and lancework.

The illustration, Fig. 168, is intended to give the appearance of the piece, just before the fixed brilliant cases are fired, these being shown connected with their quickmatch leaders.

Fig. 168

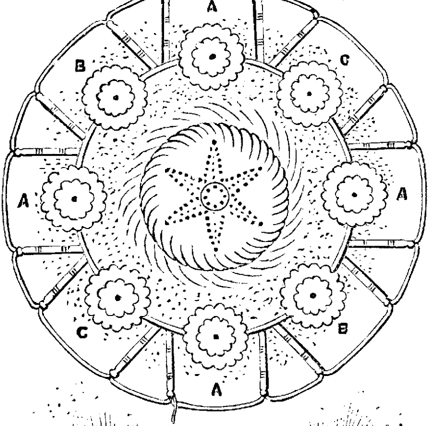
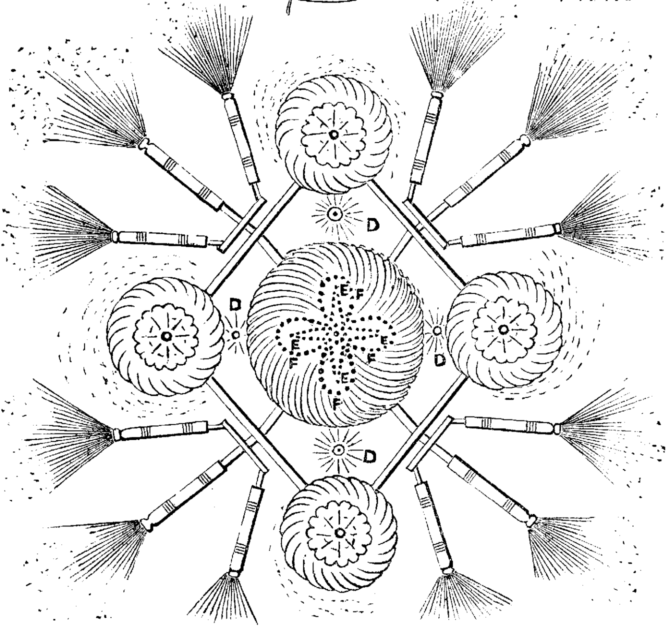


Fig. 169



SAXON AND LANCE PIECES.

This piece is not at all a difficult one for the amateur to make, and if it be properly put together and matched, the beauty of its performance leaves nothing to be desired by the most critical spectator. Another modification of the above is produced by employing triangle wheels in brilliant fire instead of Saxons; but as this is essentially a Saxon piece, I have given it as such, and shall leave the operator to make what alterations he may think fit. The second design, Fig. 169, for this description of work, is known by the name of the diamond Saxon piece, this being simply a square framework in light wood carrying four Saxons, one at each corner; and between these, three brilliant reported cases arranged as a Prince of Wales's plume; in the centre of this is a vertical wheel and lance work, as shown in the illustration; or the latter can be dispensed with, and the work simplified by making use of an ordinary rainbow wheel carrying four 2oz. cases. By referring to the sketch it will be seen that the framework is fixed with the point downwards (diamond-wise), this giving the best effect; the cases on this can be connected in exactly the same manner as in the last piece; and the same sized vertical wheel and lancework employed for the centre. But for the sake of variety I shall describe this as consisting of double Saxons instead of the single variety, and thus give the principle of working these in combination. I shall now suppose that the centre is chosen, fixed, and properly arranged, and there is only the other part of the work to complete. Now fasten the Saxons into the four points of the framework, and the brilliant cases between these as shown in the design, the latter will have to be attached to a piece of wood carrying three laths, and screwed securely to the woodwork of the piece. Next take four 2oz. colour cases D D D D, (with $\frac{1}{2}$in. or $\frac{5}{8}$in. of colour composition), the same length and size as the colours on the double Saxons; these will have to burn exactly the same length of time. Then connect the brilliant fixed cases all round, and carry a leader from these to each of the Saxons, and another to the four colour cases, D D D D; by this means all these cases are fired at the same time by the aid of one leader, this being carried down and fixed to the bottom of the framework or firing post.

This piece can be fired in the following manner: If an ordinary rainbow wheel with four cases be employed, let two of these wheel cases burn out, and when part of the third is consumed ignite the leader, connecting the rest of the piece, and the whole design will immediately become developed, producing a very pleasing effect.

The colours that I advise for this (with rainbow wheel) are four crimson cases on the Saxons, four blue at D D D D, and crimson, green, and blue on the wheel. If, however, the lancework design given in the illustration be attempted, let the centre part (E) be blue, and the outer part crimson, the four colour cases, D D D D, green, and the four Saxons colours crimson, or two crimson and two blues. By this means any arrangement that fancy may dictate, can be made, but it must be borne in mind, that the colours must be complementary to give the best effect.

My concluding design will belong to that class known as lance pieces. It is not my intention to give more than one illustration for this description of work, as the number and variety of these pieces are so great, that a complete work of no small dimensions might be written on this subject alone. Therefore, I have selected but one design from my store, easy of construction, brilliant in effect, and worthy of being employed as the *finale* to any exhibition that the amateur may be capable of producing.

The design in question is that given at Fig. 170. The woodwork for this is best composed of a light oval framework, having two flat bars passing through the centre from end to end. To these are attached the large wooden letters that carry the spikes or studs to which the lances are fixed. These letters are usually 18in. high and 3in. wide, the lance case being placed along each edge or border of the letter, 1½in. or 2in. apart. The lances for the border are also fixed at an equal distance to the above. To the outside rim of the framework must be screwed strips of wood 7in. long and ⅝in. wide, to which the gerbs or brilliant cases are attached. The beauty of this piece is, however, very much increased by employing two sets of cases, *i.e.*, coloured gerbs in front, and Chinese gerbs (well reported with Tower proof powder) behind them. These fixed cases are generally placed 12in. apart all round the border of the piece, the number of them depending on its size.

The colours to employ for this piece are: white for the letters, green for the border, and blue for the scroll-work above and below the letters. This is the most economical plan to adopt; and, if variety be wished for, the coloured gerbs (if these are used) should contain only blue and crimson stars.

This piece is matched so that all the cases (gerbs and lancework) fire at the same time, and some little practical experience will have to be acquired before the operator is able to accomplish this satisfactorily. Lance pieces themselves have a certain bare appearance, and to counteract this tendency Roman candles, gerbs, and other fireworks are introduced, so as to take off this nakedness, and give effect and brilliancy to what would otherwise be a tame performance of the most inoffensive description of fireworks that the amateur can construct. Therefore, it must be considered how to produce the greatest amount of display during the combustion of these lances, independent of the piece, and under the perfect control of the operator.

First, I shall treat of those pieces that are fired at the same time as the lancework; and, secondly, of those fireworks that have an independent origin, and are fired at the will of the operator, at any time during the performance of the design.

To the first class belong Chinese or coloured gerbs, and brilliant cases, these being used to form a border to the design; also batteries of Roman

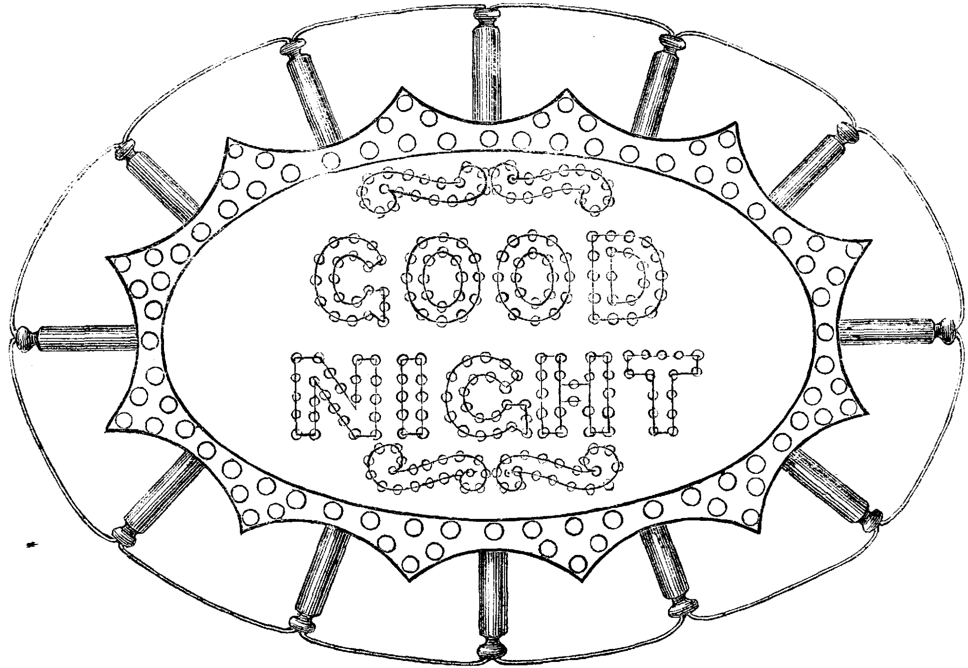


FIG. 170. LANCE PIECE.

candles (E) which are placed in an oblique direction on each side of the lance framework, so as to throw the coloured stars across the front of the piece in opposite directions. In the second order are flights of rockets saucissons, or shells and mines of serpents and crackers.

The lance piece having been fixed ready for exhibition, and the time nearly arrived for its display, those accessories that I have just mentioned must be arranged in their position and order for firing. First, two short posts, 4ft. high, will be required, to place on each side of the lance framework. Let these be fixed firmly in the ground, about 8ft. from the centre of the piece, one on each side, and a little in front, of the design. To each of these uprights must be nailed four or six Roman candles, with coloured stars. Both these sets of cases are fired at the same time as the lancework; they are also placed at an angle, so that the coloured stars are thrown across the front of the piece. Next place in the centre, at the back part of the design, the box with its flight of rockets ready for action. This should be fired with the finish of the gerbs, the first report from one of these cases being the signal for firing. The next question is, What is to be fired during the performance of the piece, before the rocket flight is called into play? and to this question I can only give this answer, viz., fire a flight of small self-coloured shells or saucissons, if the operator be fortunate enough to possess a shell battery—and I most strongly advise the amateur to have one, for it is quite impossible to obtain this grand effect by any other means; in default of this, however, fire two shells from separate mortars, and one serpent and one cracker mine, the whole concluding with the flight of rockets. This will give the best effect. It is most desirable that the operator should have the help of one or two assistants when using this piece, as the labour is then divided, being easier, and the work done much more satisfactorily, without hurry and bustle, and all chances of accidents are avoided.

Suppose, for instance, the operator is fortunate enough to command the help of two assistants, let one be placed on each side of the lance-piece, armed with a lighted port-fire ready for firing the Roman candle batteries, which must be done at the same time as the operator fires the lances. When all these are in full play assistant No. 1 fires a shell, then No. 2 fires a serpent mine. The operator himself can then ignite the second shell, leaving the cracker mine for one of the assistants, while he retires to the flight box and watches the gerb cases ready to fire the flight of rockets as the finale to the piece.

Should the amateur possess a shell battery let this be the conclusion, the rockets being fired in the middle of the display. The amateur will see from these directions that the work of each man must be properly arranged beforehand, and if this be carefully done everything will work smoothly and correctly throughout the performance, without any of those mishaps (the result of gross neglect) that have done the profession so much harm, and have led people to imagine that the amateur pyrotechnist is little short of a fire king, and the professional one who daily and hourly tempts Providence by his works, and is shrouded in a temple of mystery, an object of wonder and dread. My task is nearly ended; the labour—if such I may call it—has been to me one of pleasure and amusement, and often brought back vividly to my imagination the various little incidents of an early life—the boyish struggles in an almost unbeaten track—the numerous failures and accidents that befel me in my humble attempts to familiarise the art of pyrotechny.

In conclusion let me again impress upon my readers the value of purity of chemicals, careful manipulation, proper apparatus, and methodica operation. Let the amateur understand that order leads to perfect work and credit to the performer, while, on the other hand, disorder is fraught with danger and destruction; mperfect work, with its marvellous performances, is produced, to the disgust of the maker; dirt and increased labour the result of this neglect. The pyrotechnic laboratory should be a model of neatness—with a place for everything and everything in its place, so that the operator is able at any time to readily place his hand on the too he wants, without being "at sea" when he wishes to commence work.

If all these little trifles (that make perfection) are borne in mind the workshop will not only be a place of amusement, recreation, and instruction, but the atelier in which works of beauty are fashioned—the birthplace of new designs and cunning artifices—and the amateur pyrotechnist, the master who presides over all these mysteries, a worthy follower of the science of Pyrotechny.

INDEX.

*** Reference is made only to the subjects of the chapters and to the various compositions mentioned therein. It is believed that such an index will answer all practical purposes, and be more generally useful than if more elaborate or made in any other style.

SUBJECTS OF CHAPTERS.

COMPOSITIONS.

GENERAL LIST OF CHEMICALS

AND OTHER ARTICLES USED IN THE

MANUFACTURE OF FIREWORKS,

PREPARED AND SOLD BY

JOHN PAGE,

WHOLESALE CHEMICAL WAREHOUSE,

47, BLACKFRIARS ROAD, LONDON.

In submitting the present List, and in thanking my friends for their largely increasing support, I would call especial attention to the fact that great care is given to the purity of the various Chemicals (ordinary commercial preparations causing disappointment); and that all are dry, finely powdered, and ready for immediate use.

* Special quotations will be given where large quantities are required.*

PYROTECHNIC CHEMICALS.

Ammonia, Picrate, 6s. per lb.
Antimony, Regulus, Fine Powder, 1s. 4d. per lb.
Antimony, Black Sulphide, Fine Powder, 9d. per lb.
Asphaltum, Fine Powder, 1s. 6d. per lb.
Baryta, Nitrate, Pure, Fine Powder, 9d. per lb.
Baryta, Chlorate, Pure, Fine Powder, 6s. per lb.
Baryta, Carbonate, Pure Precip., 2s. per lb.
Calomel (Mercurous Chloride), 6d. per oz.
Charcoal—Coarse, Medium, Fine, 4d. per lb.
Copper, Chertier's (Chlorate of Potash and Copper), 5s. per lb.
Copper, Arsenite, 2s. per lb.
Copper, Black Oxyde, 3s. 6d. per lb.
Copper, Oxychloride, 4s. per lb.
Copper, Powder, 6d. per oz.
Copper, Sulphate, Fine Powder, 1s. per lb.
Copper, Ammon.-Sulph., 3s. per lb.
Copper, Sulphide, Fused and Precip., 4s. per lb.
Dextrine, Fine White Powder, 1s. per lb.
Iron Borings and Turnings, 6d. per lb.
Lamp Black, 4d. per lb.
Lead, Chloride, Fine Powder, 2s. 6d. per lb.
Lead, Nitrate, Fine Powder, 1s. 4d. per lb.
Lead, Oxyde, Fine Powder, 6d. per lb.
Lycopodium, 4s. per lb.
Magnesium Ribbon and Wire, 5d. per yd.; 13s. 6d. per oz.
Magnesium, Filings, 7s. per oz.
Manganese, Black Oxyde, 18s. per cwt. 3d. per lb.
Mercury, Sulpho-Cyanide, 1s. per oz.
Methylated Spirit, 6s. gall.
Orpiment, 1s. per lb.
Phosphorus Stick, 4d. per oz.
Phosphorus Amorphous, 8d. per oz.
Potash, Chlorate, 1s. 4d. per lb.
Potash, Nitrate (Saltpetre), Dry Powder, 6d. per lb.
Prunella, Pure, 8d. per lb.
Realgar, 1s. per lb.
Saltpetre, 6d. per lb.
Shellac, Extra Fine, Powder and Flake, 3s. per lb.
Soda, Nitrate, Pure, 1s. per lb.
Soda, Oxalate, 3s. per lb.
Stearine, Fine Powder, 2s. per lb.
Steel Filings, 1s. per lb.
Strontia, Carb., Pure Precip., 2s. 6d. per lb.
Strontia, Chlorate, 1s. 4d. per oz.
Strontia, Chloride, 1s. 4d. per lb.
Strontia, Nitrate, Pure, 10d. per lb.
Strontia, Oxalate, 3s. 6d. per lb.
Strontia, Sulphate, Precip., 2s. 6d. per lb.
Sugar of Milk, Fine Powder, 2s. per lb.
Sulphur, Flowers, 3d. per lb.
Sulphur, Washed, 6d. per lb.
Sulphuric Acid, Tubes and Bulbs, 12s. per gross.
Zinc Powder, Pure, 4s. per lb.

Chemicals not enumerated in this List, specially prepared.

Every Description of Paper, Pasteboard, &c.

All the necessary Tools, &c, supplied at a short notice.

N.B.—As a rule, where the price is quoted per lb., smaller quantities will be charged as many pence per oz. as shillings per lb.